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by
G. VERNON HOOKER
MABEL H. DUFFNER
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DORIS C. YATES

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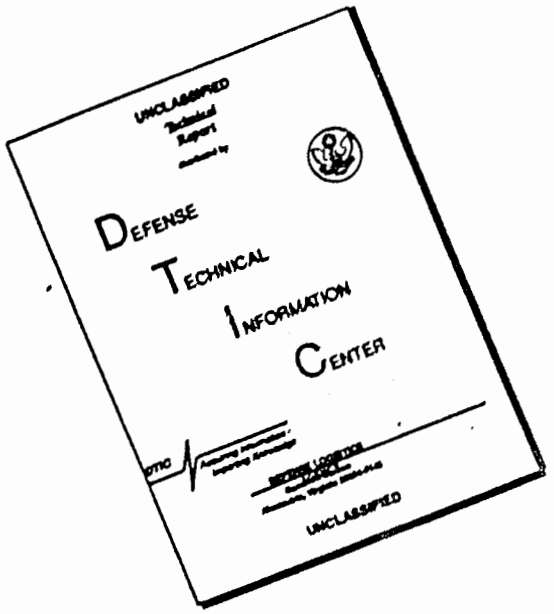

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FOREWORD

Any organization which has been granted the privilege of supporting basic research with public funds has a triple responsibility: to use those monies well and wisely, buying only the best; to observe, without unduly influencing, the progress and accomplishments of its investigators; and to strive to make the results of its research program freely available to the scientific community.

The Air Force Office of Scientific Research became an independent organization in August of 1955, and the principal agency through which the United States Air Force supported basic research outside its own laboratories. For some five years prior to this, the precursors of AFOSR—first in the Office of Air Research at Wright Field, then as a staff office in the Headquarters of the Air Research and Development Command in Baltimore, Maryland—had been supervising basic research contracts with universities and industry. These contracts formed the nucleus of the AFOSR program.

Since its beginning, AFOSR has encouraged, aided, and abetted its investigators in broadcasting the results of its studies. This they have done in diverse ways: in journal articles, in symposium papers, in books and monographs, and, when urgency could not brook the leisurely delays of scholarly publication, as "unpublished" research reports. Those reports, all too often regarded as ephemeral by their authors and by their recipients, produced in limited quantities, spurned until lately by standard abstracting services and even libraries, have all too recently been recognized, not just as transient clues to work in progress, but also as invaluable guides to work that has already been done. Despite the services of the Armed Services Technical Information Agency (ASTIA) and the Department of Commerce Office of Technical Services (OTS), discovery of such reports, particularly for the period spanned by this book, has not been easy. Nor, for that matter, are some of the journals in which our work has been published readily available in this country.

This book, then, brings together in one place, for the first time, abstracts of all publications produced during six years of research support by one agency, the Air Force Office of Scientific Research. It may be regarded, at the very least, as a report of our stewardship of some sixty million dollars of public monies. We hope it is more than that. We have supported the best of the scientists who sought our aid. These are the fruits of their labors. If this bibliography can provide clues to research that has already been done, if it can save precious laboratory time for doing new work rather than repeating old, it will amply repay the time and effort spent in its preparation.

KNOX MILLSAPS
Executive Director

PREFACE

Prolegomenon

"In science", wrote Lord Rayleigh in 1884, "by a fiction as remarkable as any in law, what has once been published is spoken of as known, and it is often forgotten that the rediscovery in the library may be a more difficult and uncertain process than the first discovery in the laboratory."*

A proper library, in those halcyon days, consisted of books and journals (preferably bound in calf), with a small clutch of pamphlets, feuilletons and the like relegated to the decent obscurity of some dark corner. What would Rayleigh have said, some sixty years later, of the invasion of such serene domains by a disorderly raggle-taggle of "documentary reports", pushing and crowding their elders from the shelves, defying regimentation, wearing neither uniforms nor badges of rank and, unfortunately, carrying too many messages from the front lines to be overlooked.

This book represents, in microcosm, such a library of the twentieth century—that curious melange of marks on variegated pieces of paper by which one of the basic drives of science, the urge and need to communicate, wells past and through the lags and lacunae of classic publication methods.

There are (at least) two sorts of library users: those who prefer to rummage through the stacks, and those who prefer first to paw through the card catalog. Many approaches to the problem of handling documentary reports have stopped, at least figuratively, with the card catalog, not even, in many cases, letting the customer use it but keeping it behind the reference desk. This bibliography attempts to provide the interested user access to the complete products of one agency over a six year period, appropriately indexed, to search as he will. This, in the Shavian dichotomy, is not a researching library, but a researchable library. Bonne chance!

Scope

This bibliography includes, within the limitations of the law of diminishing returns, abstracts of all technical notes, technical reports, journal articles, books, symposium proceedings, and monographs produced and published by scientists supported in whole or in part by the Air Force Office of Scientific Research during the period 1954 through 1956. It also includes all earlier reports supported by AFOSR or its anlage found during this search back through 1950.

The Air Force Office of Scientific Research supports fundamental research in the five major scientific disciplines: physics, chemistry, engineering sciences (subsuming mechanics and propulsion), life sciences (both biological and behavioral, but not medical), and mathematics. Thus, these abstracts are multi-disciplinary, their common link being their support by AFOSR.

Sources Searched

References, reports, and clues to the existence of reports were found by searching the indexes and report collection of the Air Force Office of Scientific Research Technical Library, and the collection of the ASTIA Document Center. Detailed searches were made of each contract file in the several AFOSR Directorates and Divisions.

* The quotation is borrowed from B. C. Vickery's "Classification and Indexing in Science", 2nd ed., Butterworths, London, 1959.

In addition, cover-to-cover searches were made of the following scientific journals for the specified time periods:

Acta Crystallographica	1953-1957
Acta Metallurgica	1953-1957
Aeronautical Engineering Review (Aero/Space Engineering)	1952-1958
American Journal of Mathematics	1954-1957
American Journal of Physics	1955-1957
Analytical Chemistry	1953-1957
Annals of Mathematical Statistics	1953-1958
Annals of Mathematics	1953-1958
Annals of Physics	1957-1958
Bulletin of the American Physical Society	1954-1958
Canadian Journal of Chemistry	1953-1957
Canadian Journal of Mathematics	1953-1957
Canadian Journal of Physics	1953-1957
Communications on Pure and Applied Mathematics	1953-1958
Duke Mathematical Journal	1953-1958
Faraday Society Discussions	1955
I. R. E. Transactions of Professional Group	
on Aeronautical and Navigational Electronics	1951-1956
on Antennas and Propagation	1950-1955
on Circuit Theory	1954-1957
on Electron Devices	1955-1956
on Information Theory	1954-1956
on Instrumentation	1956
on Medical Electronics	1956
I. R. E. Transactions on Microwave Theory and Techniques	1953-1956
Jet Propulsion	1953-1957
Journal of the Acoustical Society of America	1953-1957
Journal of the Aeronautical Sciences (Journal of the Aero/Space Sciences)	1953-1958
Journal of the American Chemical Society	1953-1958
Journal of Applied Physics	1953-1958
Journal of Chemical Physics	1952-1958
Journal of Metals	1953-1957
Journal of the Optical Society of America	1953-1958
Journal of Organic Chemistry	1956-1957

Journal of Physical Chemistry	1953-1958
Journal of Research of the National Bureau of Standards	1953-1958
Pacific Journal of Mathematics	1952-1957
Physica	1954-1956
Physical Review	1952-1957
Physice and Chemistry of Solids	1953-1958
Proceedings of the American Mathematical Society	1953-1957
Proceedings of the Conference on Differential Equations, Maryland U., College Park, Mar. 17-19, 1955; AFOSR-TR-56-51	
Proceedings of the Institute of Radio Engineers	1952-1956
Proceedings of the (2nd, 3rd, 4th, and 5th) Midwestern Conference on Fluid Mechanics	1952, 1953 1956, 1957
Proceedings of the National Academy of Sciences	1953-1956
Proceedings of the Ninth International Congress of Applied Mechanics, Brussels (Belgium) (Sept. 5-13, 1956)	
Review of Scientific Instruments	1953-1958
(4th, 5th, and 6th) Symposium (International) on Combustion	1952, 1954, 1956
Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956	
Transactions of the American Mathematical Society	1954-1957
Transactions of the American Society of Mechanical Engineers	1954-1956
Zeitschrift für Angewandte Mathematik und Physik (Journal of Applied Math. and Physics) (ZAMP)	1953-1958

Form of Entry and Arrangement

Inherent in the organization of this book is the concept of the reports within a contract as an unanalyzed monographic series. Reports are posted chronologically and/or alphabetically under contracts, these in turn under laboratories, and these under contractors. This does, in fact, provide a rough subject grouping, with the detailed subject index leading into clusters of like reports.

The abstracts are coded for possible future machine searching. A three letter mnemonic code designates the contractor; two digits are reserved for the contract; and three for the report within the contract. The lexicographer's trick of running page headings is used to indicate the scope of each page so that the searcher may home in on the proper area.

The form of entry is, in general, that being used for ASTIA catalog cards, i.e.: source of the document; title; personal author, if any; date; pagination; report number; contract number; and accession number.

Caveat Lector

The principal accession or control numbers, which indicate the location of the report in collections, are:

AD — ASTIA Document: available at ASTIA (Armed Services Technical Information Agency), Arlington Hall Station, Arlington 12, Virginia.

TIP — Technical Information Pilot: available at above address.

ATI — Air Technical Index: available at above address.

PB — Publication Board: for sale by the Office of Technical Services, Department of Commerce, Washington 25, D. C.

The fact that a report is abstracted in this book means that a copy of this report existed at the time the abstract was written; it should not be construed to imply that AFOSR necessarily has a copy available for distribution. Those seeking reports should do so from the cited agencies, not from AFOSR.

Indices

A detailed subject index, arranged alphabetically, has been provided. Because of the high percentage of mathematical papers included in this volume, a separate mathematical classification, made possible through the close cooperation of members of the Directorate of Mathematical Sciences, AFOSR, has been included. In addition to the subject indices, a contract index, an AFOSR control number index, and a personal author index are provided. A Code Guide, for identifying individual corporate entries, is included in three places.

Acknowledgements

Many people have made this book possible. The work has been fostered and encouraged by the previous Commanders of the Air Force Office of Scientific Research: Brigadier Generals H. F. Gregory and B. G. Holzman, and Colonel A. P. Gagge. Invaluable assistance has been given by AFOSR's own professional librarians, John Hetrick, Catherine Quinn and Eleanor Cipps. Alex Nagy, chief designer, and staff artist, Pat Shealy, of the Office of Aerospace Research drew the chapter end-plates (with the usual disclaimer about resemblances to persons living or dead being purely coincidental). And, perhaps most important of all, has been the cheerful and willing cooperation of the scientific staff of the Air Force Office of Scientific Research, both in locating the reports and in indexing them.

The bibliographic team has worked under the guidance and leadership of Dr. Clement R. Brown, Section Head of the Bibliography Section, Science and Technology Division, Library of Congress. The chief workers have been G. Vernon Hooker, Mabel H. Duffner, Aaron S. Dann, and Doris C. Yates; only their enthusiasm and untiring energy have carried them through a long task, made doubly arduous by the difficult pick-and-shovel chore of unearthing reports, and the intellectual skills required in developing new subject headings in advanced scientific areas.

Many other members of the professional and clerical staff of the Bibliography Section have participated in this effort. A special note of gratitude is due to those who have aided in abstracting and subject indexing, especially Jack R. Gibson, Thomas C. Goodwin, Vincent G. Waldron, Joseph W. Enke, and Bruce M. Blankenhorn. Recognition is also due for the invaluable work in the preparation of this manuscript done by Mrs. Marion S. Carr, assisted by Miss Mary Evelyn Briscoe, Mrs. Patricia Gravatt, Mrs. Loretta L. Franklin, Mrs. Beatrice T. Treese, and Mrs. Virginia Sims.

This bibliographic effort has been supported and supervised by the Information Sciences Division, Directorate of Mathematical Sciences, AFOSR, as part of a continuing research program to study and devise new and better ways of handling scientific and technical information.

Harold Wooster

Washington, D. C.
June, 1961

Harold Wooster
Chief, Information Sciences

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AIA - American Inst. of Aerological Research, Pasadena, Calif. 7

AMF - American Machine and Foundry Co., Pacotma, Calif. 9

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Code Guide

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AIA American Inst. of Aerological Research Pasadena, Calif.
ALF Alfred U., New York
AMF American Machine and Foundry Co., Pacoima, Calif.
AMS American Mathematical Soc., Providence, R. I.
ANS Aeronutronic Systems, Inc., Glendale, Calif.
ANT Antioch Coll., Yellow Sprtngs, Ohio
ARD ARDE Associates, Newark, N. J.
ARK Arkansas U., Fayettevtlle
ARN Arnold, Lee, Associates, New York
ASM American Soc. of Mechanical Engtneers, New York
ATE Ateliers de Constructions Elecirtques de Charlerot (France)
ATL Atlantic Research Corp., Alexandria, Va.

BAN Baños, A., Jr., Los Angeles, Calif.
BAT Battelle Memortal Inst., Columbus, Ohio
BCU Brttish Columbia U., Vancouver (Canada)
BEL Bell Aircraft Corp., Buffalo, N. Y.
BJO Bjorksten Research Foundation, Madison, Wis.
BMB Bureau of Mtnes, Bartlesvtlle, Okla.
BMP Bureau of Mtnes, Pittsburgh, Pa.
BOS Boston U., Mass.
BRI Brigham Young U., Provo, Utah
BRO Brown U., Providence, R. I.
BUT Butler U., Indianapolis, Ind.

CAL California U., Berkeley
CAR Carnegie Inst. ,of Tech., Pittsburgh. Pa.
CAT Catholic U. of America, Washington, D. C.
CDC Chicago Development Corp., Riverdale, Md.
CER Carter Labs., Pasadena, Calif.
CHA Charyk, J. V., Prtnceton, N. J.
CHI Chicago U., Ill.
CIN Cincinnatt U., Ohio
CIT California Inst. of Tech., Pasadena
CLA California U., Los Angeles
COA Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
COL Colorado U., Boulder
CON Connecticut U., Storrs
COR Cornell U., Ithaca, N. Y.
COU Columbia U., New York

DEL Delaware U., Newark
DET Detroit U., Mich.
DUK Duke U., Durham, N. C.

EAS Eastern Research Group, Brooklyn, N. Y.
EMO Emory U., Atlanta, Ga.
ESC Escher Wyss, Ltd., Zurich (Switzerland)
EXP Experiment, Inc., Richmond, Va.

FLA Florida State U., Tallahassee
FLU Florida U., Gainesville
FOR Forest Products Lab., Madison, Wis.
FRA Franklin Inst., Philadelphia, Pa.
FRB Freiburg U. (Germany)
FRD Frederick, Carl L. and Associates, Bethesda, Md.
FRE Free U. of Brussels (Belgium)
FRS Fresno State Coll., Calif.

GEC Geckler, R. D., Arcadta, Calif.
GEN General Electrtc Co., Schenectady, N. Y.
GEO George Washington U., Washington, D. C.
GIT Georgia Inst. of Tech., Atlanta
GOT Göttingen U. (Germany)

HAM Hamburg U. (Germany)
HAR Harvard U., Cambrtdge, Mass.
HEI Hetdelberg U. (Germany)
HER Hermann Föttinger Inst. für Strömungstechnik, Technischen Universität, Berltn (Germany)
HOR Hortzons, Inc., Cleveland, Ohio

IAS Institute for Advanced Study, Prtnceton, N. J.
IIT Illtnois Inst. of Tech., Chicago
ILL Illinois U., Urbana
INN Innsbruck U. (Austria)
INS Institute of the Aeronautical Sctences, Inc., New York
INT Instituto Nactonal de Tecnica Aeronautica Esteban Terradas, Madrtd (Spain)
IOW Iowa State Coll., Ames
ISG Illinois State Geologtcal Survey, Urbana
IST Istituto Naztonale dt Ottica, Florence (Italy)

JHU Johns Hopkins U., Baltimore, Md.

KAN Kansas U., Lawrence
KAR Karoltnska Inst., Stockholm (Sweden)
KOF Koftnk, W., Karlsruhe (Germany)
KUE Kuessner, H. G., Göttingen (Germany)

LAV Laval U., Quebec (Canada)
LEH Lehigh U., Bethlehem, Pa.
LEY Leyden U. (Netherlands)
LIE Liège U., Brussels (Belgtum)
LIT Litton Industries, Beverly Hills, Calif.
LOC Lockheed Atrcraft Corp., Palo Alto, Calif.
LOU Louvain U. (Belgtum)
LSU Loutstana State U., Baton Rouge

MAR Marseille U. (France)
MAS Massachusetts U., Amherst
MAU Maudsley Hospital, London (Great Brttatn)
MDU Maryland U., College Park
MED Méditerranéen de Recherches Thermodynamiques, Nice (France)
MET Metalectro Corp., Bladensburg, Md.
MIC Michigan U., Ann Arbor
MIN Minnesota U., Minneapolis
MIS Missouri U., Columbta
MIT Massachusetts Inst. of Tech., Cambrtdge
MML McMillan Lab., Inc., Ipswich, Mass.
MMU McMasters U. Hamilton Coll., Ont. (Canada)
MPP Max-Planck-Institut für Physik der Stratosphare, Itechingen (Germany)
MPS Max-Planck-Institut für Strömungsforschung, Göttingen (Germany)
MUF Miami U., Coral Gables, Fla.
MUO Miami U., Oxford, Ohio

NAA North American Aviation, Inc., Downey, Calif.
NBS National Bureau of Standards, Washington, D. C.
NCU North Carolina U., Chapel Hill

NEB	Nebraska U., Lincoln
NEL	Nelson, W. C., Ann Arbor, Mich.
NHU	New Hampshire U., Durham
NOL	Naval Ordnance Lab., Corona, Calif.
NOR	Northwestern U., Evanston, Ill.
NOT	Notre Dame U., South Bend, Ind.
NRC	National Research Council, Washington, D. C.
NYU	New York U., N. Y.
ODI	Odin Associates, Pasadena, Calif.
OKA	Oklahoma A. & M. Coll., Stillwater
OKU	Oklahoma U., Norman
ORL	Orlando Research, Inc., Fla.
OSU	Ohio State U. Research Foundation, Columbus
OXF	Oxford U. (Great Britain)
PEN	Pennsylvania U., Philadelphia
PIB	Polytechnic Inst. of Brooklyn, N. Y.
PIO	Pioneer Industries, Inc., Reno, Nev.
PIS	Pisa U. (Italy)
PIT	Pittsburgh U., Pa.
POL	Politecnico di Milano (Italy)
POM	Pomona Coll., Claremont, Calif.
PRF	Purdue Research Foundation, Lafayette, Ind.
PRI	Princeton U., N. J.
PRO	Propulsion Research Corp., Santa Monica, Calif.
PSM	Pennsylvania Salt Mfg. Co., Philadelphia
PSU	Pennsylvania State U., University Park
PUR	Purdue U., Lafayette, Ind.
RCA	Radio Corp. of America, Princeton, N. J.
RIC	Rice Inst., Houston, Tex.
ROC	Rochester U., N. Y.
ROM	Rome U. (Italy)
ROS	Ross, Chandler C., West Covina, Calif.
ROY	Royal Inst. of Tech., Stockholm (Sweden)
RPI	Rensselaer Polytechnic Inst., Troy, N. Y.
RRI	Reed Research, Inc., Washington, D. C.
RUT	Rutgers U., New Brunswick, N. J.
SAN	Sandberg-Serrell Corp., Pasadena, Calif.
SCL	Santa Clara U., Calif.
SCU	South Carolina U., Columbia
SOC	Southern California U., Los Angeles
SOU	Soundrive Engine Co., Los Angeles, Calif.
SRI	Southwest Research Inst., San Antonio, Tex.
STA	Stanford U., Calif.
STL	St. Louis U., Mo.
STR	Stanford Research Inst., Menlo Park, Calif.
SYR	Syracuse U., N. Y.
TAI	Tennessee Agricultural and Industrial State U., Nashville
TAM	Texas A. and M. Coll., College Station
TEM	Temple U., Philadelphia, Pa.
TEN	Tennessee U., Knoxville
TEX	Texas U., Austin
THB	Technische Hochschule, Braunschweig (Germany)
TIH	Technion - Israel Inst. of Tech., Haifa
TOI	Technical Operations, Inc., Arlington, Mass.
TOL	Toledo U. Research Foundation, Ohio
TOR	Toronto U. Inst. of Aerophysics (Canada)
TRG	Technical Research Group, New York
TRI	Trinity Coll., Hartford, Conn.
TUS	Tuskegee Inst. George Washington Carver Foundation, Ala.
UTA	Utah U., Salt Lake City
VIS	Virginia Inst. for Scientific Research, Richmond
VIT	Vitro Corp. of America, West Orange, N. J.
VPI	Virginia Polytechnic Inst., Blacksburg
WAL	Walz, A., Emmendingen (Germany)
WAR	Warner and Swasey Research Corp., New York
WAS	Washington U., St. Louis, Mo.
WAU	Washington U., Seattle
WAY	Wayne State U., Detroit, Mich.
WES	Wesleyan U., Middletown, Conn.
WHE	Westinghouse Electric Corp., East Pittsburg, Pa.
WIS	Wisconsin U., Madison
WSC	Washington State Coll., Pullman
WUR	Würzburg U. (Germany)
YAL	Yale U., New Haven, Conn.
ZUR	Zurich U. (Switzerland)
ZWI	Zwicky, F., Pasadena, Calif.

Advisory Group for Aeronautical Research and Development, Parts (France). (AGARD). see North Atlantic Treaty Organization. Advisory Group for Aeronautical Research and Development, Paris (France).

AER. 01:001

Aerojet-General Corp., Azusa, Calif.

THE ABSOLUTE THERMAL DECOMPOSITION RATES OF SOLIDS. PART I. THE HOT-PLATE PYROLYSIS OF AMMONIUM CHLORIDE AND THE HOT-WIRE PYROLYSIS OF POLYMETHYLMETHACRYLATE (PLEXIGLAS 1A), by R. D. Schuttz and A. O. Dekker. Nov. 1954 [15]p. incl. illus. diagrs. (Rept. no. TN-2) ([AF]OSR-TN-54-127) (AF 18(600)1026) AD 48403 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y. Reinhold, 1955, p. 260-267.

Two new techniques are described for the direct measurement of linear decomposition rates of solids by pressing specimens of the solid against a hot surface maintained at constant temperature. Preliminary results on the thermal decomposition of pressed tablets of ammonium chloride at 300° - 600°C and the pyrolysis of polymethylmethacrylate (Plexiglas 1A) at 450° - 500°C are interpreted in terms of absolute reaction rate theory. These new methods may yield information useful in interpreting burning rates of solid propellants. (Contractor's abstract)

AER. 01:002

Aerojet-General Corp., Azusa, Calif.

THE ABSOLUTE THERMAL DECOMPOSITION RATES OF SOLIDS. PART II. THE VACUUM SUBLIMATION RATE OF MOLECULAR CRYSTALS, by R. D. Schultz and A. O. Dekker. Nov. 1954 [17]p. (Rept. no. TN-3) ([AF]OSR-TN-54-367) (AF 18(600)1026) AD 53166 Unclassified

The linear rates of sublimation of rhombic benzene and rhombic sulfur have been calculated by use of absolute reaction rate theory in reasonable agreement with rates derived from published experimental data. Required mean torsional oscillation and translational oscillation frequencies for the molecules in the crystal lattice were obtained by an analysis of the available heat capacity and Raman spectral data. (Contractor's abstract)

AER. 01:003

Aerojet General Corp., Azusa, Calif.

THE ABSOLUTE THERMAL DECOMPOSITION RATES OF SOLIDS. PART II. THE VACUUM SUBLIMATION RATE OF MOLECULAR CRYSTALS, ADDITIONAL DISCUSSION, by R. D. Schultz and A. O. Dekker. [1954] 7p. (Rept. no. TN-6) ([AF]OSR-TN-54-367a) (AF 18(600)1026) AD 62537 Unclassifted

A comparison is made of the authors' theory of the sublimation process (see item no. AER. 01:002) with that developed by S. S. Penner (Jour. Phys. Chem., v. 52, 1948: 950 and 1262; and v. 56, 1952: 475).

AER. 01:004

Aerojet-General Corp., Azusa, Calif.

THE LINEAR VAPORIZATION RATE OF SOLID AMMONIUM CHLORIDE, by K. Bills, M. Therneau and others. July 1955 [8]p. incl. diagrs. (Rept. no. TN-10) ([AF]OSR-TN-55-117) (AF 18(600)1026) AD 67747 Unclassifted

The linear vaporization rate of compressed strands of ammonium chloride has been measured by an improved version of the hot-plate pyrolysis technique of Schultz and Dekker. ("The Absolute Thermal Decomposition Rates of Solids, Part 1," in Fifth International Combustion Symposium, Pittsburgh, 1954, Reinhold, 1955). Between 393°K and 807°K in vacuum the rate data correspond to the Arrhenius equation $B = 1.2 \times 10^2 \exp(-13,500/RT)$ $cmsec^{-1}$. At atmospheric ambient pressure, rates corresponding to this equation are obtained only above the 629°K temperature at which the equilibrium decomposition pressure of NH_4Cl is exactly 1 atmosphere. Below 629°K at atmospheric ambient pressure, the vaporization rate is limited by diffusion of NH_3 and HCl vapor away from the decomposition interface. (Contractor's abstract)

AER. 01:005

Aerojet-General Corp., Azusa, Calif.

THE ABSOLUTE THERMAL DECOMPOSITION RATES OF SOLIDS. PART III. THE VACUUM SUBLIMATION RATES OF IONIC CRYSTALS, by R. D. Schultz and A. O. Dekker. July 1955 [33]p. incl. illus. tables, refs. (Rept. no. TN-7) ([AF]OSR-TN-55-138) (AF 18(600)1026) AD 67864 Unclassifted

The linear vacuum rates of sublimation of NaCl, NaBr, NaI, KCl, KBr, KI, RbCl, RbBr, CsCl, CsBr, CsI, BeO, MgO, CaO, CdO, NiO, SrO, BaO, ZrO_2, and ThO_2 have been estimated by use of absolute reaction rate theory. For those compounds which do not decompose during vaporization, reasonable agreement is obtained with rates measured directly, as in the case of KCl, or with rates derived from vapor pressure data by means of Knudsen's equation with the accommodation coefficient [α] assumed to be unity. The calculation from first principles of the activation enthalpy of sublimation is possible, at present, only for the alkali metal halides. An absolute rate treatment, very similar to that used for sublimation, is given for the linear rate of advance of the $CaO:CaCO_3$ interface during the decomposition of $CaCO_3$ crystal. (Contractor's abstract)

AER. 0t:006 - AER. 02:002

AER. 01:006

Aerojet-General Corp., Azusa, Calif.

THE ABSOLUTE THERMAL DECOMPOSITION RATES OF SOLIDS. PART IV. TRANSITION-STATE THEORY OF THE LINEAR RATES OF EXCHANGE AND DECOMPOSITTON OF CRYSTALLINE AMMONIUM CHLORIDE, by R. D. Schuttz and A. O. Dekker. July t955, t3p. (Rept. no. TN-8) ([AF]OSR-TN-55-t4t) (AF t8(600) 1026) AD 67749 Unctassifted

The equilibrtum rate of exchange of crystalline NH_4Ct with gaseous NH_3 and HCt is formutated according to the Laidler-Glasstone-Eyring treatment of the absolute rates of surface reactions ("The Absotute Rates of Surface Reactions", in Catalysis, P. H. Emmet, ed., v. t, pt. t: 195-243, Reinhold Publishing Co., N. Y., t954). This formutation is shown to be essentialty equivalent to that previously given for the maximum absotute rate of decomposition of crystalline NH_4Cl. The equivalence resutts from the use of the same modet for the activated comptex for each reaction, and provides support for the concept that the rate-controtling step tn the thermal dissociates of crystalline NH_4Ct is the desorption of gas motecules from a physicatly absorbed NH_3-HCt comptex. (Contractor's abstract)

AER. 0t:007

Aerojet-General Corp., Azusa, Calif.

TRANSITTON-STATE TttEORY OF THE LINEAR RATE OF DECOMPOSITTON OF AMMONIUM PERCHLORATE, by R. D. Schultz and A. O. Dekker. July 1955, 3tp. diagrs. refs. (Rept. no. TN-9) ([AF]OSR-TN-55-t42) (AF t8(600)1026) AD 67748 Unctassified

Also published in the Sixth Symposium (International) on Combustion, Yate U., New Haven, Conn. (Aug. t9-24, t956), N. Y. Reinhold, t957, p. 6t8-626.

The experimental data of Bircumshaw and Newman (Proc. Roy. Soc. (London), v. 227A: tt5-t32, 228-24t, 1954) are anatyzed in terms of a linear rate of progression of the interface between residue and undecomposed crystal. Linear decomposition rates corresponding to given temperatures are derived directly from the maximum rate portions of the sigmoid curves of product pressure vs time. A proposat is made that tn the temperature range of 220° to 280°C, the decompositton interface travels exclusively through the disordered materiat between the mosaic blocks of the crystat and does not penetrate the interior of the blocks. Absotute rate treatments tn the manner of Laidler, Glasstone, and Eyrtng ("The Absotute Rates of Surface Reactions" in Catalysis, P. H. Emmet, ed., v. 1, pt. 1: 195-243, Reinhold Publishing Co., N. Y., 1954) are presented for each of the 2 crystal forms (orthorhombtc and cubic). These treatments are similar to those proposed for the sublimation of tonic solids and the vaporization of solid NH_4Cl, respectively. (Contractor's abstract)

AER. 0t:008

Aerojet-General Corp., Azusa, Calif.

ADVANCES IN THE KINETICS OF DECOMPOSITtON, FUSION, AND SUBLIMATION OF SOLIDS, by R. D. Schuttz and A. O. Dekker. Ftnal rept. Apr. 30, 1955 [35]p. inct. tabte, refs. (Rept. no. 961) ([AF]OSR-TR-55-t2) (AF t8(600)t026) AD 67865 Unclassified

The kinetics of solid decomposition, fusion, and sublimation are corretated by means of transition-state theory. The fottowing aspects are discussed: (t) the solid decomposition interface; (2) lattice vibration theory for the vetoctty of a decomposition or sublimation interface; (3) the retationship between decomposition pressure and the velocity of a decomposition interface; (4) the rote of crystal imperfections in solid decomposition; and (5) transition-state theory for the linear burning vetocity of a monopropellant, the linear velocity of fusion, the linear velocity of sublimation in vacuo, the velocity of a solid decomposition tnterface, and the linear decomposition rate of HN_4Cl. (ASTIA ahstract)

AER. 02:001

Aerojet-General Corp., Azusa, Calif.

AN ANALYTtCAL APPROACH TO THE PROBLEM OF CONVECTIVE HEAT TRANSFER TO A BURNING SOLID PROPELLANT, by T. P. Torda. Nov. 1954, 8p. (Rept. no. TN-t) ([AF]OSR-TN-54-327) (AF 18 (600)t048) AD 48558 Unctassified

A method is proposed for the analysis of the influence of tntensive vetocity variations upon the rate of heat transfer from the hot burning gases to the surface of the propettant in the rocket chamber during periods of oscittatory combustion. The heat transfer probtem is idealized as a nonsteady, 3-dimensional boundary-tayer probtem with fluid injection at the boundary. The first phase of the investigation comprises treatment of the probtem assuming incompressibte, tamtnar flow. The second phase treats compressibte flow. (ASTtA ahsiract)

AER. 02:002

Aerojet-General Corp., Azusa, Calif.

UNSTABLE BURNtNG tN SOLID-PROPELLANT ROCKET MOTORS. A COMPARISON OF EXPERIENCE AND THEORY (Unclassified title), by L. Green, Jr. Mar. t955 [32]p. incl. tttus. refs. (Rept. no. TN-5) ([AF]OSR-TN-55-90) (AF t8(600)t048) AD 65520 Confidentiat

Presented at t1th meeting of the JANAF Solid Propellant Group, Redstone Arsenal, May t8-20, 1955.

AER. 02:003

Aerojet-General Corp., Azusa, Calif.

BALLISTIC PROPERTIES OF FOUR EXPERIMENTAL SOLID PROPELLANTS FOR COMBUSTION STABILITY STUDIES, by C. O. Brown, L. Green, Jr., and D. M. Meehan. Mar. 23, 1955 [13]p. incl. diagrs. table. (Repl. no. TN-4) ([AF]OSR-TN-55-90(a)) (AF 18 (600)1048) AD 72530 Unclassified

The severity of the irregularities in chamber pressure attending unstable burning in solid-propellant rocket motors is known to be dependent in some fashion on the propellant composition and the configuration of grain and chamber. The objective of the present research is to investigate the effect of these variables. In the present study the specific impulse of the propellant is varied but not the general type of propellant system. For this purpose it was considered best to employ a propellant system using ammonium perchlorate as an oxidizer, and an organic resin as fuel. Then by varying the weight fraction of oxidizer in the mixture, the specific impulse of the propellant can be varied over a considerable range without changing the nature of the oxidizer. The experimental propellants are described and the calculated propellant properties are compared. (ASTIA abstract)

AER. 02:004

Aerojet-General Corp., Azusa, Calif.

AN EXPERIMENTAL STUDY OF COMBUSTION INSTABILITY IN SOLID-PROPELLANT ROCKET MOTORS, by L. Green, Jr., M. Lipow, and K. L. Nail. July 1955, iv. incl. illus. diagrs. tables, refs. (Repl. no. TN-11) ([AF]OSR-TN-55-233) (AF 18(600)1048) AD 68446 Unclassified

The results obtained during the first 12-month period of an experimental investigation of unstable burning of solid-propellant charges are presented and briefly discussed. A comparison of four experimental, composite propellant formulations tested in internal-burning, tubular charges indicates that the tendency toward irregular reaction increases as the energy content of the propellant is raised, as long as the propellant burning rate is held constant. However, the highest-energy formulation showed a smooth reaction, owing to a lower burning rate than was desired, or, ultimately, to the coarse oxidizer grind employed in that formulation. The results suggest that a nominal rate of energy release (the product of burning rate, density, and heat of explosion) may possibly afford a measure by which the relative stability of various formulations may be estimated. (Contractor's abstract, modified)

AER. 02:005

Aerojet-General Corp., Azusa, Calif.

STEADY-STATE PROPERTIES OF A SIMPLIFIED MODEL OF SOLID-PROPELLANT BURNING, by L. Green, Jr. Sept. 1955 [18]p. incl. diagrs. (Repl. no. TN-12) ([AF]OSR-TN-55-334) (AF 18 (600)1048) AD 77424; PB 140356 Unclassified

A model of solid-propellant burning is postulated, in which the complex chemical-reaction and heat-conduction problem in the gas phase is replaced by a simplified boundary condition which assumes convective heat transfer to the surface from a parallel flow of gas at flame temperature. The effective heat-transfer coefficient is assumed to be an inverse function of propellant burning rate, which in turn is assumed to be an Arrhenius function of the surface temperature. The model permits calculation of steady-state surface temperatures, burning rates, and temperature gradients which show the proper qualitative dependence upon the propellant and gas-flow parameters, and which, for the assumed values of these parameters, appear to be of the proper order of magnitude. (Contractor's abstract)

AER. 02:006

Aerojet-General Corp., Azusa, Calif.

PRESSURE-MEASURING INSTRUMENTATION FOR COMBUSTION STABILITY STUDIES, by L. Green, Jr. Dec. 1955 [42]p. incl. illus. diagrs. refs. (Repl. no. TN-14) ([AF]OSR-TN-55-474) AD 81081 Unclassified

A description is given of the operation of the 2 pressure-measuring instrumentation systems employed in investigating solid propellant combustion stability. One of the systems utilizes a low-frequency response to record the mean chamber pressure, while the other uses a high-frequency response to detect fluctuations around this mean value. The limitations of the low-frequency-response system are fairly well defined, but the limitations of the high-frequency-response system have not been determined accurately. This dual system is considered to be advancement over conventional pressure-measuring instruments; recommendations are made, however, for the use of further improved pressure-sensing elements and a tape recording system, as well as refined methods of determining the dynamic response of the pickups.

AER. 02:007

Aerojet-General Corp., Azusa, Calif.

NONSTEADY BEHAVIOR OF A SIMPLIFIED MODEL OF SOLID-PROPELLANT BURNING, by L. Green, Jr. Nov. 1955 [21]p. incl. diagrs. (Repl. no. TN-15) ([AF]OSR-TN-55-473) (AF 18(600)1048) AD 81082 Unclassified

An analysis is presented of the nonsteady behavior of a previously proposed thermal model of solid-propellant burning (item no. AER. 02:005) in an effort to solve the

AER. 02:008 - AER. 02:011

problem of pertodic deflagration. The assumption ts made that a small time inlerval is required for completion of the phase change of the propellant malter from the solid to the gaseous stale tn a thin zone (burning surface). The results tndicate thal when the simplifted lransfer coefftctent, assumed to govern heat flow to lhe surface, fluctuates al high frequenctes, conditions can exist under which a coupling between the heat-transfer fluctuation and the decomposition reaction can cause large amplitude osctllations of the surface lemperalure; consequently, signiftcant deviations appear tn the mean effective burning rate from tts nominal steady-stale value. The predicled dependence of the model behavior upon the propellant and the operating condition paramelers appears to be tn qualitative agreemenl with the known behavior of actual propellants.

AER. 02:008

Aerojet-General Corp., Azusa, Calif.

STUDIES ON THE REACTION STABILITY OF SOLID PROPELLANT CHARGES, by L. Green, Jr. Ftnal repl. Apr. 1, 1954-Jan. 31, 1956. Mar. 9, 1956, 1v. incl. tllus. diagrs. tables, refs. (Rept. no. 1077) (AFOSR-TR-56-10) (AF 18(600)1048) AD 86012 Unclassifted

Research was conducted to acquire a clearer understandtng of the phenomenon of resonant burning tn solid-propellant rocket motors. An analysis of the effecl of transverse velocity fluctuations upon the rale of heat transfer from a gas to a solid, wtth fluid tnjection at lhe wall, indicated that the effect ls small when the flow conditions are lamtnar; the effect may be signiftcant when turbulent conditions prevail. An analysis of a simplifted thermal model of solid-propellant burning indicated that small fluctuations in heat-transfer rate can cause signiflcant vartations tn propellant burning rate. Tests of one propellant at 170°F in 4 different charges sbowed that charge conftguratton influences reaction stability. A comparison of 4 experimental composite propellant formulations with nominally constant burning rates tested at 170°F in internal-burning tubular charges indicated that the tendency toward irregular reaction increases as the energy content of the propellant ts increased, as long as the propellant burning rate is constant. Tests of the rod-in-sheil charge were made with the aid of 2 high-frequency-response pickups tn order to detect phase or amplitude differences tn the pressure-time traces; results tndicated that the observed oscillations corresponded to stationary wave patterns.

AER. 02:009

Aerojet-General Corp., Azusa, Calif.

CHARGE-CONFIGURATION EFFECTS IN SOLID-PROPELLANT COMBUSTION, by L. Green, Jr. [Apr. 1956] 1v. incl. illus. diagrs. tables, refs. [AF 18(600)1048] Unclassifted

Static tests of a high-energy, composite solid propellant al 170°F tn four different types of charge tndicated a strong influence of charge conftguration upon the stability of the propellanl reaction, as manifested by the regularity of the mean chamber pressure vs time history. The relative tendency of short, internal-burning charges with annular and cylindrical cavities to exhibtt "resonant" burning was found to be in disagreement with the behavior predicted by Cheng's analysis of the "sonant" burning phenomenon. The several lypes of charge also exhibtled different average burning rale vs average chamber pressure characterlstics. Qualilative observations suggest that the relative reaction stabtlity of different solid propellant charge conftgurations may be delermined by viscosily effects, rather than tn the mechanisms postulaled ln Cheng's ldeal-fluid analysis. Tests of rod-in-shell charges, using two pressure ptckups in an effort to observe phase differences tn the pressure-time traces oblained, tndicaled that the observed osctllations probably corresponded to stationary wave patterns. (Contractor's abstract, modifted)

AER. 02:010

Aerojel-General Corp., Azusa, Calif.

OBSERVATIONS ON THE IRREGULAR REACTION OF SOLID PROPELLANT CHARGES, by L. Green, Jr. [1956] [5]p. tncl. illus. diagrs. refs. [AF 18(600) 1048] Unclassified

Presented at annual meeting of the Amer. Rockel Soc., Chicago, Ill., Nov. 14-18, 1955.

Published in Jet Propulsion, v. 26: 655-659, Aug. 1956.

A review of development expertence and research studies concerning reaction lrregularities tn solid propellant rocket motors emphasizes a difference in usage of the equivocal lerm "unstable burning" by the rocket designer on the one hand and the theoretical tnvestigator on the other. Evtdence ts presented indicating that high frequency pressure osctllations of ftnite amplitude can prevail tn the charge cavity durtng outwardly "stable" operation. A possible coupling mechanism by which gas phase osctllations may effect exaggerated rales of solid phase decomposition ls suggested in qualitative terms. (Contraclor's abstract)

AER. 02:011

Aerojet-General Corp., Azusa, Calif.

SOME PROPERTIES OF A SIMPLIFIED MODEL OF SOLID-PROPELLANT BURNING, by L. Green, Jr. [1956] [46]p. Incl. illus. diagrs. refs. [AF 18 (600)1048] Unclassified

Published as Amer. Rocket Soc. preprint no. 339-56, Nov. 1956.

A thermal model of solid-propellant burning is postulated, in which the complex chemical-reaction and heat-conduction problem in the gas phase is replaced by a simplified boundary condition which assumes convective heat transfer to the surface from a parallel flow of gas at flame temperature. The effective heat-transfer coefficient is assumed to be an inverse function of propellant burning rate, which in turn is assumed to be an Arrhenius function of the surface temperature. This model permits calculation of steady-state propellant temperatures, burning rates, and temperature gradients which show the proper qualitative dependence upon the propellant and gas-flow parameters and which, for the assumed values of these parameters, appear to be of the proper order of magnitude. The non-steady behavior of the model is analyzed. It is indicated that, when the simplified transfer coefficient assumed to govern heat flow to the surface fluctuates at high frequencies, conditions can exist under which a coupling between the heat-transfer fluctuation and the decomposition reaction can cause large-amplitude oscillations of the surface temperature, and, consequently significant deviations in the burning rate from its nominal steady-state value. The predicted dependence of the model behavior upon the propellant and operating-condition parameters appears to be in qualitative agreement with the known behavior of actual propellants. (Contractor's abstract)

AER. 03:001

Aerojet-General Corp., Azusa, Calif.

ASPECTS OF HIGH FREQUENCY COMBUSTION INSTABILITY (Unclassified title), by H. B. Ellis. [1955] [23]p. incl. illus. diagrs. [AF 18(600)1155] Confidential

AER. 03:002

Aerojet-General Corp., Azusa, Calif.

HIGH-FREQUENCY COMBUSTION INSTABILITY (Unclassified title), by H. B. Ellis and R. S. Pickford. Sept. 1956 [49]p. incl. illus. diagrs. (Rept. no. TN-17) (AFOSR-TN-56-547) (AF 18(600)1155) AD 110366 Confidential

AER. 03:003

Aerojet-General Corp., Azusa, Calif.

BASIC RESEARCH ON COMBUSTION IN LIQUID ROCKET THRUST CHAMBERS (Unclassified title), by R. S. Pickford, H. C. Kreig, Jr. and H. B. Ellis. Final technical rept. Jan. 1957, 1v. incl. illus. tables, refs. (Rept. no. 1193) ([AF]OSR-TR-56-61) (AF 18(600)1155) AD 115015 Confidential

AER. 04:001

Aerojet-General Corp., Azusa, Calif.

THERMAL DECOMPOSITION OF SOLID NITRO COMPOUNDS (Unclassified title), by A. J. Bauman and K. H. Sweeney. Oct. 3, 1955 [39]p. incl. illus. tables. (Repl. no. TN-13) ([AF]OSR-TN-55-441) (AF 18(600)1215) Confidential

AER. 04:002

Aerojet-General Corp., Azusa, Calif.

AN IMPROVED AUTOMATIC RECORDING TALIANI APPARATUS, by J. M. Flournoy and A. J. Bauman. Sept. 5, 1956 [10]p. incl. illus. diagrs. (Repl. no. TN-18) (AFOSR-TN-56-430) (AF 18(600)1215) AD 96512 Unclassified

In the Taliani test for determining the thermal stability of explosives and propellants under storage conditions, a sample is heated under N_2 or air in a closed system of constant volume and its stability is evaluated in terms of the rate of pressure increase in the system. The standard apparatus used in this test has been improved by (1) preventing condensation of decomposition products are contained entirely within the heated zone at the temperature of the test. The decomposition zone is isolated from the measuring portion of the apparatus by means of a Hg column which is confined between 2 porous glass discs. These discs permit the passage of gases, but do not allow the passage of Hg. Pressure in the decomposition zone is transmitted by the Hg column to a sensitive pressure transducer through an intervening column containing air and a fluorocarbon oil. (Contractor's abstract)

AER. 04:003

Aerojet-General Corp., Azusa, Calif.

THERMAL DECOMPOSITION OF SOLID NITRO COMPOUNDS (Unclassified title), by J. M. Flournoy, K. H. Sween, and A. J. Bauman. Sept. 1956 [58]p. incl. illus. diagrs. tables, refs. (Rept. no. 1176) (AFOSR-TR-56-57) (AF 18(600)1215) AD 110392 Confidential

AER. 05:001

Aerojet-General Corp., Azusa, Calif.

A VERSATILE, 1000-CURIE, COBALT-60 GAMMA-RAY SOURCE, by E. Hermats and G. Moe. July 1956 [35]p. incl. diagrs. tables. (Rept. no. TN-16) (AFOSR-TN-56-339) (AF 18(600)1216) AD 95215 Unclassified

A description is presented of the design and installation of a 1000-c Co^{60} source for conducting γ radiation studies. The installation consists of a movable source

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shielded by earth, concrete, and otl. The Co^{60} ts divided into 5 capsules of 200 c each, which may be moved individually or in selecied grouptngs from storage at the bottom of a 2t-fi concrete-lined shaft. This is accomplished by making the capsule a part of a sprocket-and-chain assembly which ts driven by an electric motor. When the capsule reaches the operating position, 8 ft below the ground level, tt actuates a switch which stops the motor drive. The calculated dose rate of this source ts approximately 14,000 r/hr at 1 ft, 300 r/hr on the roof tnside the fence. Personnel safety ts provided by interlocks, alarms, a remole area monitoring system, safety steps in operating procedure and the weartng of pocket dosimeters. The tnitial loadtng and the routine starting, trradiation and shuttingdown procedures are detailed for the Co^{60} source. Brief descriptive data are furnished in table form for 15 other Co^{60} irradiation sources as reported in the literature. The γ ray source described here was consiructed for a study of the possibility of producing higher-energy propellanls based on recombination of free radicals. Published observations had lead to calculations which indicated that if a slurry of 90 wt-% NH_3 in liquid H were irradialed until 50% decomposed to N + 3H, the resultant system would have a specific impulse of 600 lb-sec/lb. (ASTIA abstract in part)

AER. 05:002

Aerojet-General Corp., Azusa, Calif.

RESEARCH ON ULTRA-ENERGY FUELS FOR ROCKET PROPULSION, by L. Baum, H. Graff and others. Final rept. July t, 1954-June 30, 1956. July 31, 1956 [47]p. incl. diagrs. tables, refs. (Rept. no. 1149) (AFOSR-TN-56-346) (AF 18(600)1216) AD 95432 Unclassified

Research was underiaken lo determine the applicability of free radicals and atoms as high-energy subsiances. A theoretical consideration of tne relation of energy to thrust indicated that high specific impulse in rockets can best be achieved by using low-molecular-wetght gases, e.g., H or He, as working fluids. A method was conceived for using free radicals as a means of heating liquid H to the operating temperature. Methods of preparing and siabilizing free radicals are discussed, and the results of some experimental studies are given. A study of the stabtlization of the tmine radical indicated that the blue material reported to be NH ts probably electronically excited HN_3, and that the association of the blue material with NH is unitkely. Measurement by means of a new described microcalorimeter, indicated that irradtation of azomethane at -t96°C resulted in about t% decomposition, giving methyl radicals which may be stable at thal temperature. Several olher systems were explored using photolysis at liquid-N temperature. No decomposition products were observed for samples of acetone, nitrogen dioxide, cyanic acid, and chlorine. For diazomethane, a strongly exothermic reaction was noted. For ketene, little noncondensable material was observed, and ketene and diketene were found tn the product. Proposed work includes use of a 1000-c Co^{60} γ-ray source, described elsewhere, for trradiation al low temperatures. In this connection, it was estimated that by trradiation at 400-c of solid NH_3 about $t0^3$ radical pairs/γ-ray are produced. (ASTIA abstract tn part)

ANS. 0t:00t

Aeronutronic Systems, Inc., Glendale, Calif.

PRELIMINARY REPORT ON PROJECT FAR SIDE PHASE I. (Unclassified title) Dec. 15, 1956, tv. Incl. Illus. diagrs. tables. (Rept. no. C-009) (AFOSR-TN-56-580) (AF 49(638)55) AD tt5003 Confidential

ANS. 0t:002

[Aeronutronic Systems, Inc., Glendale, Calif.]

THE DESIGN OF A MULTICHANNEL TRANSISTORIZED FM/FM TELEMETERING SYSTEM WITH A COSMIC RAY DIRECTION CHANNEL, by R. C. Elton (Maryland U. Dept. of Physics). May t956 [62]p. incl. illus. diagrs. refs. (Md. U. Physics Dept. technical rept. no. 38) [AF 49(638)55] Unclassified

The design of a multichannel transistorized FM/FM telemetering system suitable for use in upper atmosphere experimenls is descrtbed. The system consists of four subcarrier aduio osctllaiors whose signals are combined to form the composite signal used to frequency modulate the radio frequency transmitter; plus a geiger tube and its associated circuitry consisting of a + 900 vdc supply, a scale-of-t6 stage, and a preamplifier. A transistorized version of the familiar Colpttis oscillaior is used to generate the subcarrier audio signals, which are frequency modulated by the information delected. A discussion of the exiensive temperature tesis on the audio oscillaiors and the resulting stabilization ts included. Also two basic methods of frequency modulating the subcarrier audio oscillators have been analyzed. A transistorized inductive kick method of generating the + 900 vdc necessary for the geiger tube from 15 vdc is discussed including regulation characierlstics; the scale-of-16 stage used is composed of cascaded scale-of-two stages and is also transistortzed. Due to the relatively low input impedance of the geiger tube, it was necessary to incorporate a preamplifier between these two stages. This amplifier consists of a buffer siage followed by an emitter follower stage. A hrief outline of transistor ctrcuit principles has been included to assist the reader in understanding the discussion of the transistor circuits involved tn the system. (Author's abstract)

AGARD, Paris (France). (Advisory Group for Aeronautical Research and Development) see North Atlantic Treaty Organization. Advisory Group for Aeronautical Research and Development, Paris (France).

ALF. 01:001

Alfred U. New York State Coll. of Ceramics, N. Y.

STUDY OF BASIC MECHANISM OF DIFFUSION OF METALS INTO CERAMIC MATERIALS, by R. C. Turnbull. Technical rept. no. 1 for period Jan. 10, 1953 - Jan. 11, 1954. 7p. diagrs. (Rept. AU no. 1) ([AF]OSR-TR-54-9) (AF 18(600)591) AD 29788 Unclassified

Three techniques are discussed for evaluating the concentration changes of radioactive tracers in a diffusion experiment: (1) assays of slices removed from the specimen; (2) measurement of the change of radioactivity at the surface; and (3) photographic means. In this experimental study, samples of optically clear periclase were prepared by splitting large single crystals along crystal planes into specimens 1 cm on a side and .5 cm high. The sides of the specimens were covered with a strippable organic coating. The radioactive metal was condensed on the crystal face. The diffusion coefficients were determined for Fe, Co, and Ni in MgO at different temperatures. The activation energy was obtained by plotting the log of the diffusion coefficient against the reciprocal of the absolute temperature.

AIA. 01:001

American Inst. of Aerological Research, Pasadena, Calif.

ON SEVERAL EXTENSIONS OF THE TAYLOR-GOLDSTEIN THEORY OF DIFFUSION BY DISCONTINUOUS MOVEMENT, by I. Michelson. [1953] [50]p. (AF 18(600)476) Unclassified

This contribution is a development of the work of Taylor and Goldstein in which mathematical models were considered representing diffusion by discontinuous movements. The meritorious features employed by them and those used by the author are discussed. Appropriate mathematical techniques for the analysis of each type of problem considered are indicated. The structure of solutions of the several equations derived is discussed in terms of "dispersion" of progressive waves which are regarded as fundamental elements of all propagation processes. (Extracted from rept.)

AIA. 01:002

American Inst. of Aerological Research, Pasadena, Calif.

THE ENERGY SPECTRUM OF TURBULENCE FOR THE ENTIRE RANGE, by R. W. Davies. Feb. 26, 1954, 13p. incl. refs. (Rept. no. AR-2) ([AF]OSR-TN-[54]-49) (AF 18(600)476) AD 30152 Unclassified

Also published in Phys. Rev., v. 95: 912-913, Aug. 15, 1954.

The wave number spectrum

$$F(k) = \frac{\overline{(14\nu U^2)}^{2/3} C k^4 e^{\frac{14\nu\bar{U}^2k^2}{\bar{\varepsilon}}}}{\left[\overline{14\nu U^2} + 2k^{13/2}C^{3/2}\left(1-e^{\frac{-21\nu U^{-2}k^2}{\bar{\varepsilon}}}\right)\right]^{2/3}}$$

is derived by curve fitting from two limiting laws. The technique is very similar to that employed in black body radiation. (Contractor's abstract)

AIA. 01:003

American Inst. of Aerological Research, Pasadena, Calif.

DISCUSSION AND EXTENSION OF GOLDSTEIN'S MATHEMATICAL MODEL REPRESENTING DIFFUSION WITH HYPERBOLIC PARTIAL DIFFERENTIAL EQUATION [PART I], by I. Michelson. Technical rept. Jan. 11, 1954, 58p. (Rept. no. AR-1; rept. no. 193) ([AF]OSR-TN-54-53) (AF 18(600)476) AD 27865 Unclassified

The random walk problem examined by S. Goldstein is given an orientation convenient for comparison with well understood problems, and also for extension to the case in which diffusion is not assumed isotopic. The relationship of the several processes so considered, with the corresponding cases of continuous movements, is explored to determine the necessary modifications required in Fick's Law. The proper formulation of a complete mathematical problem is next considered, and further consequences of the use of hyperbolic equations are pointed out. General properties of solutions are discussed and the detailed analytic procedure given for giving representations of solutions in one case of interest. (Contractor's abstract)

AIA. 01:004

American Inst. of Aerological Research, Pasadena, Calif.

A MATHEMATICAL TREATMENT OF TURBULENT DIFFUSION, by R. W. Davies, R. J. Diamond, and T. B. Smith. Mar. 15, 1954, 68p. incl. diagrs. refs. (Rept. no. AR-3; rept. no. 201) ([AF]OSR-TN-54-62) (AF 18(600)476) AD 32814 Unclassified

Theoretical analyses of turbulent diffusion are presented to emphasize the following points: (1) diffusion phenomena are more accurately described by hyperbolic than by parabolic partial differential equations; (2) the modified telegraph equation has a natural connection with the statistical characteristics of homogeneous isotropic turbulence of very high Reynolds number; and (3) the solution of the diffusion equation is a genuine probability density. (ASTIA abstract)

AIA. 01:005 - AIA. 01:009

AIA. 01:005

American Inst. of Aerological Research, Pasadena, Calif.

THE CONNECTION BETWEEN THE SMOLUCHOWSKI EQUATION AND THE KRAMERS-CHANDRASEKHAR EQUATION, by R. W. Davies. [1954] [2]p. [AF 18(600)476] Unclassified

Published in Phys. Rev., v. 93: 1169-1170, Mar. 15, 1954.

It is known that the probability density, W(x, v;t), in phase space, of a particle describing Brownian motion is governed by the differential equation

$$W_t + vW_x = \{[\beta v - K(x)]W\}_v + (kT\beta/m)W_{vv},$$

where K (x) is an external force, T is the temperature, m is the mass and k is Boltzmann's constant. From this equation one readily obtains by integration $\rho_t + (\rho\bar{v})_x = 0$, and $(\rho\bar{v})_t + (\rho\langle v^2\rangle)_x + \beta\rho\bar{v} = K(x)\rho$, where $\rho(x,t) = \int_{-\infty}^{+\infty} W(x,v;t)dv$ and $\rho\langle v^2\rangle = \int_{-\infty}^{+\infty} v^2 W dv$. Eliminating $\rho\bar{v}$ from the foregoing two equations we obtain

$$\frac{1}{\beta}\rho_{tt} + \rho_t + \left(\frac{K(x)\rho}{\beta}\right)_x = \left(\frac{\rho\langle v^2\rangle}{\beta}\right)_{xx}$$

On the other hand, it has been stated in the literature that for times $t \gg \beta^{-1}$, the probability density ρ is governed by the Smoluchowski equation

$$\rho_t + \left(\frac{K(x)\rho}{\beta}\right)_x = \frac{kT}{m\beta}\rho_{xx}.$$

The author discusses the sense in which solutions of equation (4) may be considered as the limiting forms of the solutions of (3); and shows, in particular, that in order to obtain equation (4) in the limit $\beta \to \infty$, we must let $\langle v^2\rangle$ and K (x) also approach infinity in such a way that $\lim_{\beta\to\infty}(\langle v^2\rangle/\beta) = kT/6\pi a\eta$, $\lim_{\beta\to\infty} K(x)/\beta = U(x)$, where U (x) is the "drift" velocity, η is the absolute viscosity of the liquid surrounding the particles and a is the particle radius. (Math. Rev. abstract)

AIA. 01:006

American Inst. of Aerological Research, Pasadena, Calif.

TURBULENT DIFFUSION, PART I, by R. W. Davies. [1954] [25]p. incl. diagr. (Bound with its Rept. no. 201; AD 32814 as Part I of AFOSR-TN-54-62) (AF 18(600)476) AD 32814(a) Unclassified

Various methods of obtaining a diffusion equation are discussed, and an attempt is made to extend the simplest model of turbulence and turbulent diffusion to new types of diffusion equations which are the result of refinements of the physical approach, continuous stochastic processes, and random walks. Discussions are appended on (1) the Ornstein-Uhlenbeck process and the Fokker-Planck equation, (2) the extension of the Fokker-Planck equation to phase space, and (3) the density in a smoke plume.

AIA. 01:007

American Inst. of Aerological Research, Pasadena, Calif.

ON DIFFUSION MODELS LEADING TO HYPERBOLIC PARTIAL DIFFERENTIAL EQUATIONS, PART II, by R. W. Davies and T. B. Smith. [1954] [17]p. (Bound with its Rept. no. 201; AD 32814 as Part II of AFOSR-TN-54-62) (AF 18(600)476) AD 32814(b) Unclassified

Refined diffusion equations are derived from various 1-dimensional random-walk models. Consideration is given to the random-walk models of R. Furth (Z. Physik., v. II: 244-256, 1920) and G. I. Taylor (Proc. London Math. Soc., v. 20: 196-212, 1921-22). Goldstein's model (Quart. J. Mech. Appl. Math., v. 4: 129-156, 1951) is extended so that the presistence probability is not isotropic, and several diffusion equations are derived from this model. A more complicated model is treated by using essentially the same probabilistic technique as Goldstein, Furth, and Taylor. In the first model particle velocities may exist, but particle accelerations do not exist. In the second model the particle accelerations may exist, but the rate of change of acceleration does not exist. (ASTIA abstract)

AIA. 01:008

American Inst. of Aerological Research, Pasadena, Calif.

A SOLUTION OF A HYPERBOLIC DIFFUSION EQUATION FOR WHICH PROBABILITY IS CONSERVED, PART III, by R. J. Diamond and R. W. Davies. [1954] [20]p. (Bound with its Rept. no. 201; AD 32814 as Part III of AFOSR-TN-54-62) (AF 18(600)476) AD 32814(c) Unclassified

Two derivations are presented of the diffusion equation $\rho_{tt} + \beta\rho_t = c^2(\rho_x + \rho_{xx} + \rho_{yy} + \rho_{zz})$ where t is time, and x, y, and z are the 3 rectangular coordinates of physical space. One derivation is based on physical reasoning, and the other is based on probability considerations. An initial-value solution for the equation is obtained in the 3 sets $r<ct$, $r>ct$, and along the characteristic cone $r^2 = c^2t^2$. The solution for $r>ct$ is zero so that any modification of it alters the initial values. The solution for $r<ct$ can be multiplied by any constant N without changing its value at $t = 0$, so that the initial conditions are found on the characteristic surface.

AIA. 01:009

American Inst. of Aerological Research, Pasadena, Calif.

ON THE CONNECTION BETWEEN SMOLUCHOWSKI'S EQUATION AND THE KRAMERS-CHANDRASEKHAR EQUATION, PART IV, by R. W. Davies. [1954] [4]p. (Bound with its Rept. no. 201; AD 32814 as Part IV of AFOSR-TN-54-62) (AF 18(600)476) AD 32814(d) Unclassified

Also published in Phys. Rev., v. 93: 1169-1171, Mar. 15, 1954.

Consideration is given to the equations $W_t + vW_x = \left[(\beta v - k(x))W \right]_v + \left(\frac{kT\beta}{m} \right) W_{vv}$ and $\rho_t + \left[K(x) \rho / \beta \right]_x = (kT/m\beta)\rho_{xx}$. The first equation is satisfied by W(x, v;t), the probability density for a Brownian particle in the phase space x, v where it is assumed that the Brownian motion is a simple Markov process in phase space. The second equation is satisfied by the probability density $\rho(x,t) = \int_{-\infty}^{\infty} W(x, v;t)dv$, where it is assumed that the Brownian motion is a simple Markov process in the configuration space x. The first equation when transformed into a diffusion equation in configuration space is shown to differ from the second equation by the term $(1/\beta)\rho_{tt}$. Solutions of these 2 equations are discussed. (ASTIA abstract)

AIA. 01:010

American Inst. of Aerological Research, Pasadena, Calif.

A MATHEMATICAL TREATMENT OF TURBULENT DIFFUSION. II. DIFFUSION OF PARTICLE PAIRS, by R. W. Davies and R. J. Diamond. Final technical rept. Jan. 2, 1953-Dec. 31, 1954. 49p. incl. diagrs. (Rept. no. 235) ([AF]OSR-TN-55-15) (AF 18(600)476) AD 59040 Unclassified

A theory of the diffusion of particle pairs is developed and applied to turbulent diffusion in homogeneous isotropic turbulence. The theory makes it possible to describe the shape of smoke plumes in terms of the von Kármán-Howarth velocity correlation tensor. The random walk of particle pairs is treated in considerable detail. Models are developed for diffusion in 1 dimension and in 3 dimensions and, in both cases, telegraph-type equations are obtained in the continuous limit. (See item no. AIA. 01:003 for Part 1.) (Contractor's abstract)

AMF. 01:001

American Machine and Foundry Co. Turbo Div., Pacoima, Calif.

FUNDAMENTAL ROCKET RESEARCH, by E. B. Zwick, G. R. Morgan, and H. H. Cover. Summary rept. for period July 1, 1954-July 1, 1956. Aug. 10, 1956, 1v. incl. illus. diagrs. tables. (Rept. no. AMF/TD-QA-104) [AFOSR-TR-56-55] (AF 18(600)1192) AD 110375 Declassified

The results of a combined analytical and experimental investigation into combustion phenomena in liquid propellant rocket motors are presented. The first of two analyses presented treats the rocket motor as a homogeneous reactor in which maintenance of combustion is provided by violent mixing and heating of the incoming propellants with the combustion products within the motor; the second deals with a recirculating reactor in which heating of the incoming propellants is obtained by a large-scale recirculation of exhaust products within the combustion chamber. Reaction times predicted from the analysis of the recirculating reactor were verified experimentally in a reaction chamber with simulated recirculation. The analysis of homogeneous reactor indicates that a rocket motor, with violent mixing in which chemical processes are rate-controlling, has a minimum characteristic length which varies inversely with p^{n-1}, where p is the chamber pressure and n is the order of reaction. The analysis is shown to agree generally with experimental data from ethylene oxide gas generators. The analysis of the recirculating reactor indicates that a rocket motor in which stable combustion is maintained by mixing and heating of the injected propellants with recirculated exhaust products has a minimum chamber stay time for steady operation. This minimum stay time depends on the fraction recirculated and for a given fraction recirculated varies inversely with p^{n-1}. Reaction times determined experimentally from a reaction chamber with simulated recirculation are in good agreement with reaction times predicted from chemical kinetic theory. Difficulties in procedure limited the range of experimental data. The applicability of chemical kinetic theory to the investigation of combustion processes in liquid propellant rocket motors is deemed justified. (Contractor's abstract)

AMF. 02:001

American Machine and Foundry Co. [Turbo Div.], Pacoima, Calif.

ON THE DEVELOPMENT OF RATIONAL SCALING PROCEDURES FOR LIQUID-FUEL ROCKET ENGINES, by S. S. Penner. Sept. 19, 1956, 27p. (Rept. no. AMF/TD TR-101; technical note no. 1) (AFOSR-TN-56-383) (AF 18(603)107) AD 95819 Unclassified

Also published in Jet Propulsion, v. 27: 156-161, Feb. 1957.

A critical summary is presented of recent theoretical studies concerning similarity analysis and the scaling of liquid-fuel rocket engines. The similarity parameters for the steady aerothermochemistry of motor operation are defined. The discussion of a general formulation of scaling procedures is restricted to a fixed bipropellant mixture which is injected at the same temperature in both model and large-scale experiments. The special features of the bipropellant operation are emphasized. The Penner-Tsien scaling rule of fixed chamber pressure is developed, with the analysis illustrated by an example of a simplified combustion process. A discussion of the occurrence of high-frequency oscillations follows. The method of engine scaling as presented by Crocco (Scaling of the Liquid-fuel Rocket Engines, paper presented at the 2nd AGARD Combustion Colloquium, December 1955) is developed. This method considers design restrictions arising if similarity is maintained with respect

AMF. 02:002 - ANT. 01:001

to the cooling system, low-frequency oscillations, and nozzle design. It includes the rule for a fixed Mach number and the invartant Damköhler ftrst similarity group. A rational experimental program for the study of scaling procedures is suggested with spectal considerations to be given to diagnostic modeling, expertments concerning effects of pressure on operation, and effects of tnjection velocity and droplet size on motor performance.

AMF. 02:002

American Machine and Foundry Co. Turbo Div. [Pacotma, Calif.]

ON GENERALIZED SCALING PROCEDURES FOR LIQUID ROCKET ENGINES, by S. S. Penner and A. E. Fuhs. Oct. 10, 1956 [23]p. incl. tables. (Rept. no. AMF/TD TR-104; technical note no. 2) (AFOSR-TN-56-510) (AF 18(600)107) AD 110325 Unclassifted

Also published in Combustion and Flame, v. 1: 229-240, June 1957.

The scaling procedures of Penner and Tsien, of Crocco and of Barrere have been generalized by using the assumption that the mean drop size is proportional to the product of powers of the Weber number and the Reynolds number, together with the hypothesis that the total conversion time vartes as a power (usually the second) of the drop diameter. The results obtained for the steady aerothermochemtstry and for unstable motor operation (low-frequency and high-frequency osctllations) are shown to reduce to previously pubitshed rules when suitable simplifying assumptions are made. (Contractor's abstract)

1S. 01:001

Amertcan Mathematical Soc., Provtdence, R. I.

MATtIEMATICAL REVIEWS, ed. by J. V. Wehausen and S. tt. Gould. 1949-1958. (AF t8(600)132 and AF 49(638)239) Unclassifted

Unavailability of the German comprehensive reviewing and abstracting servtce for mathematics during World War tI caused the American Mathematical Society to start tts own abstracting service. This effort was supported in part by the Office of Naval Research (1946-t949) and then by the Air Force Research and Development Command (1949-1958) under what eventually became the Mathematical Sciences Directorate of the Air Force Office of Scientific Research. A yearly rate of over 5,000 abstracts has been maintained, amounting to 1t volumes each year. Mathematical Reviews is the only comprehensive English language mathematical ahstracting service. It covers all fields of mathematics from topology and advanced algebra to mathematical physics and mechanics. tt obtains and abstracts all the major and most of the minor mathematicat pubtications in the worttd, and deliberately stresses papers written tn Russian and tess accessible languages by providing more comprehensive reviews of these papers. Mathematical Reviews at the present time uses over 750 reviewers who are the recognized authorities in their respective fields to provide useful, authoritative and complete reviews. These reviewers and the elected offtcers of the Soctety carry out their duties as a service to sctence and for the prestige involved.

AMS. 02:001

American Mathematical Soc., Providence, R. I.

MATHEMATICS ADVISORY AND EVALUATION SERVICES. Oct. 1, 1953-Sept. 30, 1957. (AF 18(600) 994; continued by AF 49(638)204) Unclassified

In October 1953 the Air Force negotiated a contract with the Amertcan Mathematical Soctety, by means of which that organization administers a reviewing panel of mathematictans, who evaluate proposals and the research accomplished under Air Force contracts. This contract was recently enlarged to tnclude a continuing panel of 6 mathematicians, which will provide an over-all appraisal of the Air Force Offtce of Scientific Research's research program tn mathematics. The present members (Aug. 1958) are Professor M. Morse, chairman, and Professors S. Bochner, S. Goldstein, M. H. Stone, J. L. Walsh, and tt. L. Wilder.

ASM. 01:001

Amertcan Soc. of Mechanical Engineers, New York.

APPLIED MECHANICS REVIEWS, ed. by M. Goland. 1951-1956. (Sponsored jointly by Air Force Office of Scientiftc Research and Office of Naval Research under AF 33(038)21398; continued by Nonr-2248(00)) Unclassifted

Current world ltterature ts reviewed in theoretical and applied mechanics and related engineering science to make available monthly the results of such review in the form of suitable edited abstracts. Information tncludes domestic and foretgn expertmental developments tn mechanics, acoustics, geophysics, metallurgy, and related subjects. It is published by the American Soctety of Mechanical Engineers at Easton, Pa., and edited by the Southwest Research Inst., San Antonio, Tex., with the cooperation of Linda ttall Library.

ANT. 01:001

Antioch Coll. Dept. of Chemistry, Yellow Springs, Ohio.

THE PREPARATION OF SUBSTITUTED HYDRAZINES. I. ALKYLHYDRAZINES VIA ALKYLSYDNONES, by J. Fugger, J. M. Tien, and t. M. Hunsberger. [1955] [6]p. (AF 33(038)22909) Unclassifted

Published in Jour. Amer. Chem. Soc., v. 77: 1843-

1848, Apr. 5, 1955.

The conversion of an alkylamine to an alkylhydrazine via the corresponding N-alkylglycine, N-nitroso-N-alkylglycine and N-alkylsydnone ts shown to constitute an acceptable preparative method tn the case of benzylhydrazine, n-butylhydrazine and n-hexylhydrazine. The infrared specira of N-benzylsydnone, N-(n-butyl)-sydnone and N-(n-bexyl)-sydnone are presented.

ANT. 01:002

Antioch Coll. Dept. of Chemistry, Yellow Springs, Ohio.

THE PREPARATION OF SUBSTITUTED HYDRAZINES. II. 3-PYRIDYLHYDRAZINE VIA THE PHOTOTROPIC N-(3-PYRIDYL)-SYDNONE, by J. M. Tten and l. M. Hunsberger. June 7, 1955 [4]p. lncl. diagr. (AF 33 (038)22909) Unclassifted

Published in Jour. Amer. Chem. Soc., v. 77: 6604-6607, Dec. 20, 1955.

The successful conversion of 3-aminopyrtdine via N-(3-pyridyl)-sydnone to 3-pyridylhydrazine has further demonstrated the generality of thts method of converting a primary amine (RNH_2) to a monosubstituted hydrazine ($RNHNH_2$). Up to the present this method has been applied successfully lo compounds tn which R ts alkyl, cycloalkyl, aralkyl, aryl and heteroaryl. N-(3-pyrtdyl)-glyctne hydrochlortde has been prepared by hydrogenation of a mixture of ethyl glyoxylate and 3-aminopyrtdine tn hydrochlortc acid, a method presumably general for other N-substituted glyctnes. Dehydration of N-nitroso-N-(3-pyridyl)-glyctne afforded N-(3-pyrtdyl)-sydnone, which was hydrolyzed to 3-pyrtdylhydrazine. All reactions proceeded quickly and gave excellent yields of pure producls. N-(3-pyrldyl)-sydnone, the first uncondensed heterocyclic dertvative of a sydnone, unexpectedly proved to be phototroptc. Infrared spectra of the sydnone and tts precursors are discussed. (Contractor's abstract)

ANT. 01:003

Antioch Coll. Dept. of Chemistry, Yellow Sprtngs, Ohio.

THE PREPARATION OF SUBSTITUTED HYDRAZINES. III. A GENERAL METHOD FOR PREPARING N-SUBSTITUTED GLYCINES, by J. M. Ttea and l. M. Hunsberger. Aug. 26, t955 [2]p. (AF 33(038)22909) Unclassifted

Published in Jour. Amer. Chem. Soc., v. 77: 6696-6698, Dec. 20, 1955.

Anilline and n-hexylamine were reduced tn either glactal acettc acid or 95% ethyl alcohol and the glyctne ethyl ester was produced. The ethyl ester of N-(n-hexyl)-glyctne was saponified and N-(n-hexyl)-glyctne was isolated as its hydrochloride salt. The ethyl ester of N-phenylglyctne was converted to N-phenylglyctne hydrochlortde by treatment wtth hydrochloric actd. The yields of the hydrochlorides of N-(n-hexyl)-glyctne and of N-phenylglycine were 58 and 78% respectively.

ANT. 01:004

Antioch Coll. Depl. of Chemislry, Yellow Springs, Ohio.

THE PREPARATION OF SUBSTITUTED HYDRAZINES. IV. ARYLHYDRAZINES VIA CONVENTIONAL METHODS, by l. M. Hunsberger, E. R. Shaw and others. [1956] [6]p. tncl. tables, refs. (AF 33(038) 22909) Unclassifled

Published in Jour. Org. Chem., v. 21: 394-399, Apr. 30, 1956.

The properties and preparation by conventional methods of salts of 28 substituted phenylhydrazines, 3 substituted naphthylhydrazines, 2-hydrazinofluorene, 9 phenanthryl-hydrazine, 3-hydrazinopyrene, and 6-quinolylhydrazine are described. Only low yields of the polycyclic aryl-hydrazines were obtained. Hydrazines whose hydrochlortde salts appeared unstable were converled usually to the more stable hydrogen oxalate, which sometimes changed to the neutral oxalate durtng recrystallizatlon. (Contractor's abstract)

ANT. 02:001

Antioch Coll. Fels Research Inst., Yellow Sprtngs, Ohio.

COMPARISON OF PINCH-CALIPER AND X-RAY MEASUREMENTS OF SKIN PLUS SUBCUTANEOUS FAT, by S. M. Garn. July 27, 1956 [1]p. lncl. diagr. (AFOSR-TN-56-133) (AF 18(600)1566) AD 86009 Unclassifted

Also published in Sctence, v. 124: 178-179, July 27, t956.

The thtckness of the fat-plus-skin layer, at the level of the lowest rtb at the midaxillary line, was determined by both roentgenogramnetrtc- and sprtng-loaded ptnch-caliper measurements. Ptnch calipers, exerting a force of 300 g over a 30 sq mm area, were used to measure a double "fatfold", while measurements of the single-thickness shadow were made on standardized teleoroentgenograms. For 65 young men aged 2t to 22 yr, the medtan pinch-caliper value and roentgenogram-metric measurement were 12.0 and 9.3 mm, respec-ttvely. The actual pinch-caliper values were 65% of the true double thickness (t8.6 mm). Percentage compression appeared to be constant over the full range of pinch-caliper values obtained.

ANT. 02:002 - ARD. 01:002

ANT. 02:002

Antioch Coll. Fels Research Inst., Yellow Springs, Ohio.

COMPARISON OF PINCH-CALIPER AND TELEOROENTGENOGRAMMETRIC MEASUREMENTS OF SUBCUTANEOUS FAT, by S. M. Garn and E. L. Gorman. Dec. 1956 [7]p. incl. diagrs. tables, refs. [AFOSR-TN-56-185] (AF 18(600)1566) AD 115069 Unclassified

Also published in Human Biol., v. 28: 407-413, Dec. 1956.

Roentgenogrammetric and pinch-caliper measurements of the fat-plus-skin thickness at the lower thoracic region at the midaxillary line were compared. For 65 young adult males (age 21 and 22 yr), the correlation between the 2 sets of measurements was 0.88. The 2 distributions were of comparable form and degree of skewness, but the "double skinfolds" averaged 70% of their calculated true value, indicating 30% reduction due to tissue compression under a total force of 300 g.

ANT. 02:003

Antioch Coll. Fels Research Inst., Yellow Springs, Ohio.

EXPERIMENTAL VALIDATION OF ROENTGENOGRAMMETRICALLY-DETERMINED SOFT TISSUE VOLUMES (Abstract), by S. M. Garn and E. L. Gorman. Apr. 1956 [1]p. (AF 18(600)1566) Unclassifted

Presented at Twenty-fifth annual meeting of the Amer. Assoc. of Physical Anthropologists, Chicago, Ill., Apr. 6-8, 1956.

Published in Amer. Jour. Phys. Anthropology, (New Ser.), v. 14: 374-375, June 1956.

The present study is concerned with validation using a water displacement technique. The basic apparatus consists of a vertically mounted 33-inch length of 12-inch air conditioning ducting, fitted with a reinforced bottom and equipped with a water inlet, drain, and a glass water-level gauge. Water at body temperature is pumped from a constant-temperature reservoir. In practice, the actual displacement of a 33-cm length of thigh is determined and this measured volume compared to the volume obtained by planimetry from a standardized A-P roentgenogram of the left thigh area. The relationship between the gross thigh volumes and the computed volumes is fully rectilinear, and when fully corrected, deviations of less than ± 200 cm^3 in 5000 cm^3 may be expected. Measured volumes range from 2900 to 6315 cm^3 for subjects weighing 61 to 109 kg respectively. On this basis, the muscle volumes bear a close relationship to the amounts of these tissues present. Further validation of the muscle mass is now in process, using creatine-creatinine conversion as a biological index of the functioning muscle mass. (Contractor's abstract)

ARD. 01:001

ARDE Associates, Newark, N. J.

ANALYSIS OF COMBUSTOR PERFORMANCE BASED ON SIMPLIFIED CHEMICAL KINETICS, by E. Mayer. Mar. 1956, 1v. incl. diagrs. table. (Technical note no. 4555-1) (AFOSR-TN-56-40) (AF 18(600)1560) AD 80552 Unclassified

An analysis is presented of the performance of a piloted can-type burner as a representative model of combustors with mass addition and heat evolution governed by a reaction-rate law. The analysis starts with a statement of the aerothermodynamic equations in a form suited for the treatment of ducted compressible flow with mass addition and internal heat generation. These equations possess simple solutions for a burner model operating at constant temperature and constant velocity. The model considered leads to elementary expressions for burner performance in terms of through-put [mass flow rate at burner exit/mass flow rate at burner entrance], order of the reaction, and a suitably defined velocity parameter. These simple analytical results permit the treatment of certain composite combustors, such as a can-type burner and a constant-area duct (tailpipe) in series combination, without excessive mathematical complications. The results also suggest an analytic approach to the treatment of mixing delay effects such as the can-type burner containing completely mixed and completely unmixed streams in parallel.

ARD. 01:002

ARDE Associates, Newark, N. J.

CALCULATION OF REACTION RATE PARAMETERS FROM FLAME SPEED DATA ON LAMINAR FLAMES, I, by E. Mayer and H. Carus. July 1956 [22]p. incl. diagrs. tables, refs. (Technical note no. 4555-2) (AFOSR-TN-56-286) (AF 18(600)1560) AD 89496 Unclassified

In the analysis of many technical combustion problems the rate controlling step is assumed to be given by a phenomenological reaction rate law of the Arrhenius type:

$$\frac{d\rho_{Fu}}{dt} = -B'\rho_{Fu}^{m}\,\rho_{ou}^{n}\,e^{-E/RT}$$

The Arrhenius parameters B', E, m, n may be determined by comparison of experimental flame speed with calculated data based on the assumed form of the reaction rate law. A numerical procedure is described for the calculation of laminar flame speeds based on the Arrhenius law. This procedure is practicable for temperature-dependent gas properties and general values of m and n. The procedure is applied to the determination of E and B' for propane-air mixtures treated as a second-order reaction with m = n = 1. This is done by matching 2 points of the experimentally observed flame-speed vs mixture ratio curve to corresponding calculated flame-speeds. Plausible agreement

is obtained with calculated results based on Semenov's approximate flame-speed formula for m = n = 1. Dedetailed study shows that agreement between experimental and calculated flame-speeds based on the Arrhenius law cannot be obtained for an extended range of mixture ratios if the overall second-order reaction is first order with respect to each reactant species. Further study with nonintegral m and n is planned in an attempt to improve the agreement between observed and calculated dependence of flame-speed on mixture ratio. (Contractor's abstract)

ARD. 01:003

ARDE Associates, Newark, N. J.

ANALYSIS OF LAMINAR FLAME PROPAGATION LIMITS DUE TO THERMAL LOSS, by E. Mayer. Sept. 1956 [29]p. incl. diagrs. table, refs. (Technical note no. 4555-3) (AFOSR-TN-56-478) (AF 18(600)1560) AD 97362 Unclassified

The effect of thermal loss on laminar flame propagation is investigated on the basis of simplified (Semenov) relations in thermal flame theory. With heat loss from the flame front to the cold wall of a cylindrical burner assumed proportional to flame thickness, it is found that flame propagation limits, governed by the heat loss, occur at finite combustible mixture strengths and finite low pressure. The limiting heat loss in the cylindrical burner is interpreted as representing conditions observed in quenching experiments. Under quenching conditions, the relations between actual and adiabatic flame parameters (T_f = flame temperature, S_u = flame velocity, δ = flame thickness) are found to be, in a high approximation,

$$T_f = \frac{T_f^a}{1 + \left(\frac{E}{RT_f^a} + 4\right)^{-1}} \qquad S_u = e^{-1/2} S_u^a \qquad \delta = e^{1/2} \delta^a$$

where the superscript a refers to adiabatic values. The theory also predicts the existence of a limiting Peclet number based on flame speed. Preliminary comparison of the theory with experimental data indicates the applicability of the thermal loss theory to quenching and to related limiting flame propagation data. (Contractor's abstract)

ARD. 01:004

ARDE Associates, Newark, N. J.

THE CURRENT STATUS OF RESEARCH ON TURBULENT COMBUSTION IN PREMIXED GASES, by R. R. John. Nov. 1956, 15p. incl. refs. (Technical rept. no. 4555-1) (AFOSR-TR-56-59) (AF 18(600)1560) AD 115004 Unclassified

A review is presented of the current status of research on turbulent combustion in premixed gases. It is indicated that there is a spectrum of different possible mechanisms which govern the effect of turbulence on the reaction zone. The different mechanisms are identified with the wrinkled laminar flame, the zone of extended reaction, and the zone of instantaneous mixing. The major emphasis of the review is directed towards a discussion of the zone of extended reaction. It is suggested that the differences between the various mechanisms of turbulent combustion preclude the possibility of obtaining a simple quantitative theory of turbulent flame propagation in premixed gases. (Contractor's abstract)

ARD. 01:005

ARDE Associates, Newark, N. J.

ANALYSIS OF A CAN-TYPE RAMJET BURNER, by E. Mayer. Jan. 20, 1956, 3p. [AF 18(600)1560] Unclassified

The performance of an idealized can-type ramjet burner is investigated analytically under conditions of rapid mixing, when a chemical reaction rate law is the rate controlling step in the combustion process. The analysis of the burner under these conditions is greatly simplified by the assumption of instantaneous mixing and heat exchange of the injected pre-mixed combustible gas with the main flow at the zone of injection. (Contractor's abstract, modified)

ARK. 01:001

Arkansas U. Dept. of Chemistry, Fayetteville.

ELECTRODE POTENTIALS IN FUSED SYSTEMS. I. SODIUM HYDROXIDE, by K. H. Stern and J. K. Carlton. May 1954, 11p. incl. diagrs. (Technical note no. 1) ([AF]OSR-TN-54-6) (Also bound with its AFOSR-TR-57-5; AD 115070 as Appendix 1) (AF 18(600)960) AD 30800 Unclassifted

Also published in Jour. Phys. Chem., v. 58: 965-968, Nov. 1954.

Potentials of silver, copper, nicket, cobalt, and tungsten were measured in fused sodium hydroxide over the temperature range 340°- 600°C, using gold as reference electrode. Potential-time curves were obtained. Potential changes are related to reactions occurring at the electrodes. (Contractor's abstract)

ARK. 01:002

Arkansas U. [Dept. of Chemistry] Fayetteville.

THE CRYSTAL STRUCTURE OF COPPER 8-QUINOLINOLATE DIHYDRATE, by R. [F.] Kruh, C. W. Dwiggins [Jr.], and J. K. Carlton. June 1954, 5p. incl. diagr. (Technical note no. 2) [AFOSR-TN 54-224] (AF 18(600)960) AD 35281 Unclassified

The crystal structure of copper 8-quinolinolate dihydrate was determined by x-ray diffraction. Copper

ARK. 01:003 - ARK. 01:007

(II) is shown to adopt its usual distorted octahedral environment. The stereochemistry of copper (II) is discussed. (Contractor's abstract)

ARK. 01:003

Arkansas U. [Dept. of Chemistry] Fayetteville.

DETECTION OF BISMUTH BY DITHIZONE IN MOLTEN NAPHTHALENE, by J. K. Carlton and W. C. Bradbury. June 1954, 7p. incl. tables. (Technical note no. 3) [AFOSR-TN-54-225] (AF 18(600)960) AD 32582 Unclassified

Also published in Anal. Chem., v. 26: 1226-1227, July 1954.

While investigating reactions of dithizone in molten naphthalene with metal salts, it was found that bismuth reacted quickly, developing a brilliant red color. As a qualitative test this reaction was found to be sensitive to 0.004 micrograms of bismuth. An interference study was made, and the conditions for effective use of this test were established.

ARK. 01:004

Arkansas U. Dept. of Chemistry, Fayetteville.

REACTIONS OF METAL IONS WITH DITHIZONE IN MOLTEN NAPHTHALENE, by J. K. Carlton, W. C. Bradbury, and R. [F.] Kruh. July 1954 [14]p. incl. diagrs. refs. (Technical note no. 4) [AFOSR-TN-54-226] (Also bound in its AFOSR-TR-57-5; AD 115070 as Appendix 12) (AF 18(600)960) AD 35283 Unclassified

Also published in Anal. Chim. Acta, v. 12: 101-106, Feb. 1955.

A comparative study has been made of the reactions of metal ions with dithizone in two media, chloroform and molten naphthalene. The absorption spectra of several metal dithizonates, prepared in molten naphthalene, were recorded and were found to be the same as those of the dithizonates obtained by extraction of metal ions from aqueous solution with chloroform-dithizone. (Contractor's abstract)

ARK. 01:005

Arkansas U. Dept. of Chemistry, Fayetteville.

THERMODYNAMICS OF ION-PAIR DISSOCIATION, by K. H. Stern. May 1955, 16p. incl. diagrs. tables, refs. (Technical note no. 5) (AFOSR-TN-55-149) (Also bound in its AFOSR-TR-57-5; AD 115070 as Appendix 6) (AF 18(600)960) AD 63949 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 80: 1034-1038, Mar. 5, 1958.

Ion-pair formation is examined by means of a model in which the solvent is treated as a collection of particles, i.e., molecular parameters such as dipole moment and polarizibility are used. Equations for particle interactions useful in the interpretation of the thermodynamics of ion-pair dissociation are given. A comparison of these with a continuum model is used in the calculation of solvation numbers for ions and ion pairs. (Contractor's abstract, modified)

ARK. 01:006

Arkansas U. Dept. of Chemistry, Fayetteville.

ELECTRODE POTENTIALS IN FUSED SYSTEMS. II. A STUDY OF THE SILVER CHLORIDE-POTASSIUM CHLORIDE SYSTEM, by K. H. Stern. Dec. 10, 1955 [3]p. incl. diagrs. tables. [Technical note no. 6] [AFOSR-TN-55-188] (Also bound in its AFOSR-TR-57-5; AD 115070 as Appendix 2) [AF 18(600)960] AD 102455 Unclassified

Also published in Jour. Phys. Chem., v. 60: 679-681, May 1956.

The cell $Ag|AgCl, KCl|Cl_2$ has been studied over the complete concentration range from pure AgCl to pure KCl over the temperature range 500° - 900° [C]. From mole fraction AgCl = 1 to 0.05 the cell behaves reversibly, for lower concentrations silver reacts spontaneously with potassium chloride. The kinetics of this reaction have been studied.

ARK. 01:007

Arkansas U. Dept. of Chemistry, Fayetteville.

COORDINATION OF COPPER (II) IN COPPER 8-HYDROXYQUINOLINOLATE DIHYDRATE, by R. [F.] Kruh and C. W. Dwiggins, Jr. [1955] [3]p. (Bound with its AFOSR-TR-57-5; AD 115070 as Appendix 9) (AF 18(600)960) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 806, Feb. 5, 1955.

The crystal structure of copper 8-hydroxyquinolinolate dihydrate, $Cu(C_9H_6ON)_2 \cdot 2H_2O$, has been determined as part of a study of the stereochemistry of copper (II). It has been found that this copper salt is isomorphous with the corresponding zinc salt whose structure has been determined by other authors. This finding raises the interesting question as to whether the anhydrous copper and zinc salts are also isomorphous. Hsu and Ballar have found tetrahedral coordination of the metal in the zinc salt of 8-hydroxyquinoline-5-sulfonic acid, and it is reasonable to assume the same arrangement in the 8-hydroxyquinolinolate. Now since copper (II) shows such a strong tendency to square planar coordination it would be extremely unusual if the isomorphism were found to persist in the anhydrous salts. The actual arrangement in the anhydrous copper salt remains to be investigated, but the supposition is strong

that copper's coordination is not tetrahedral, but rather square planar. The ubiquitous square planar coordination of copper (II) is found in the dihydrate. (Contractor's abstract)

ARK. 01:008

Arkansas U. Dept. of Chemistry, Fayetteville.

THE CRYSTAL STRUCTURE OF ALKALI METAL BIFLUORIDES, by R. F. Kruh, K. Fuwa, and T. E. McEver. [1956] [3]p. incl. diagrs. tables, refs. [Technical note no. 9] (Bound with its AFOSR-TR-57-5; AD 115070 as Appendix 8) (AF 18(600)960) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 4256-4258, Sept. 5, 1956.

The present work was undertaken to find out what part the structural requirements of the bifluoride ion play in accounting for the interesting properties of β-KHF_2 and to determine whether the existence of more than one crystal modification is a general property of alkali metal bifluorides. Potassium, rubidium and cesium bifluorides exist in cubic modifications at high temperatures and in a tetragonal modification at room temperature. Both sodium and lithium bifluoride decompose to hydrogen fluoride and normal salt upon heating. Crystal structures are proposed for five phases not previously studied. (Contractor's abstract, modified)

ARK. 01:009

Arkansas U. Dept. of Chemistry, Fayetteville.

ELECTRODE POTENTIALS IN FUSED SYSTEMS. III. THE PLATINUM ELECTRODE IN SOME HALIDE MELTS, by K. H. Stern. [1956] [3]p. incl. tables. (Also bound in its AFOSR-TR-57-5; AD 115070 as Appendix 3) [AF 18(600)960] Unclassified

Published in Jour. Phys. Chem., v. 60: 1443-1445, Oct. 1956.

The galvanic cells Ag/AgCl, KCl; KCl/Pt, Ag/AgBr, KBr; KBr/Pt, and Cu/CuCl, KCl/Pt have been studied in the temperature range 800°- 900°[C]. It is shown that the K^+ - K(g) equilibrium operates on the platinum electrode at pressures near 10^{-13} atmosphere. (Contractor's abstract)

ARK. 02:001

Arkansas U. Dept. of Physics, Fayetteville.

ISOTOPE SHIFTS IN THE SPECTRA OF STRONTIUM, by R. H. Hughes. [Nov. 8, 1956] 6p. incl. tables. (AF 18(600)26) Unclassified

Also published in Phys. Rev., v. 105: 1260-1261, Feb. 15, 1957.

The isotope shifts in strontium have been studied in the hollow-cathode spectra from enriched even isotopes with the aid of a Fabry-Perot interferometer. The mass effects show predominance. The field effects are zero within experimental error, with no differential shift between 88-86 and 86-84. The $5^2_D\ ^3P$ terms are apparently perturbed to the extent that they exhibit a relatively large specific mass effect. (Contractor's abstract)

Armour Research Foundation, Chicago, Ill. see Illinois Inst. of Tech. Armour Research Foundation, Chicago, Ill.

ARN. 01:001

Arnold, Lee, Associates, New York.

DYNAMIC MEASUREMENTS IN WIND TUNNELS, by L. Arnold. June 1954, 111p. incl. diagrs. refs. [AFOSR-TN-54-278] (NATO AGARDograph rept. no. 11) (AF 18(600)858) AD 62072 Unclassified

The state of the art of measuring unsteady aerodynamic forces and of testing dynamically similar models in the wind tunnel, both from the standpoint of dynamic stability and flutter is presented. Model construction, instrumentation, and scale effects are discussed. Accepted procedures developed in the various NATO countries are described and possible alternate procedures suggested.

ATE. 01:001

Ateliers de Constructions Electriques de Charlerol (France).

THE EFFECT OF THE SELF-MAGNETIC FIELD UPON THE CHARACTERISTICS OF A POSITIVE COLUMN WITH AXIAL SYMMETRY, by M. Hoyaux and P. Gans. [1954] 25p. incl. diagrs. tables. (Rept. no. EOARDC-TN-54-1) [AFOSR-TN-54-306] (AF 61 (514)630-C) AD 66705 Unclassified

The motion of the charge carriers in the positive column of a discharge in a gas is investigated, taking into account the forces resulting from the self-magnetic field of the arc. An integral equation for the radial distribution of ionization density is set up and solved numerically. The solution depends upon a parameter A which is introduced into the theory, and which is essentially a measure of the effect of the magnetic field. The equation has been solved for various values of this parameter, and suitable methods of interpolation developed. An analysis of the form of the equations involved has enabled a nomograph to be plotted which permits the determination of the value A and of the electron temperature T for given values of the discharge parameters: the arc current I, the gas pressure p, the radius R of the arc, and the effective permeability σ (sigma) of the plasma. From this nomograph and some auxiliary curves, a family of

ATE. 01:002 - ATE. 01:005

curves has been plotted enabling the value of the arc drop in potential E to be evaluated in practical cases. (Contractor's abstract)

ATE. 01:002

Ateliers de Constructions Electriques de Charlerot (France).

PROBE MEASUREMENTS IN A MAGNETIC PROTON SOURCE, by M. Hoyaux and P. Gans. [1955] 1v. tncl. diagrs. tables. (Rept. no. EOARDC-TN-55-2) (AF 61(514)630-C) AD 66707 Unclassified

Probe measurements have been carried out on a hydrogen discharge with the geometry of a magnetic proton source in an attempt to verify a theory established previously. In the course of these, tt has been found that the discharge current varies with probe penetration. It decreases extremely raptdly after a certain degree of penetration has been attained. This phenomenon appears to be peculiar to hydrogen. It was not observed in our previous experiments with mercury vapor and other gases. No explanation has yet been found for this effect. It occurs not only with a probe but also with a glass rod in the form of a spatula and appears to be independent of the orientation of the plane of the spatula with respect to the axis of the discharge. The results of the probe measurements show good agreement with the theory for the outer parts of the dtscharge. As far as the core ts concerned, no ftrm conclusions can be drawn. If the values of the electron concentration are corrected for the variations tn discharge current, reasonable agreement ts obtained for this region also, but it ts not clear to what extent the correction is justifiable and the agreement may be fortuitous. (Contractor's abstract)

ATE. 01:003

Ateliers de Constructions Electrtques de Charlerot (France).

EQUATIONS OF SIMILITUDE IN A MERCURY-VAPOR ARC AT VERY LOW PRESSURES, by M. Hoyaux and P. Gans. [1955] [20]p. tncl. diagrs. (Rept. no. EOARDC-TN-55-5) [AFOSR-TN-56-230] (AF 61(514) 630-C) AD 83091 Unclassifted

Measurements were made with a plasmograph to check the validity of the followtng equations of simlitude, which hold for the case of a mercury-arc rectifier operating at moderate current densities, for the case of fluorescent tubes: (t) pR = function (T), (2) R^2N/I = function (T), and (3) ER = function (T), where p ts the gas pressure, R ts the wall radius, I ts the discharge current, E ls the axial electrtc ftetd tn the positive column, N ts the axial electron density, and T ts the electron temperature. The measurements showed a radtal distrtbution of electron density simtlar to a zero-order Bessel function. The second equation appeared to be satisfted, but the scatter of measured values was large. The third equation was not satisfted, since values of ER for a given value of T were about 50% higher than for a rectifier. Two possible explanations are offered for this result: (1) in a fluorescent tube situated in a relatively cold environment, the mercury vapor pressure is such that the mean free path of the charge carriers is larger than the tube diameter and consequently the Schottky theory of ambipolar diffusion ts not valid; and (2) the presence of argon in the tube may influence the discharge characteristics of the gas.

ATE. 01:004

Ateliers de Constructions Electriques de Charlerot (France).

EXPERIMENTAL STUDY OF THE "HASH" IN A FLUORESCENT TUBE I, by M. Hoyaux and P. Gans. [1956] [24]p. tncl. diagrs. (Rept. no. EOARDC-TN-55-7) (AFOSR-TN-56-231) (AF 61(514)630-C) AD 88040 Unclassified

Experimental study was made of the phenomenon of "hash" in fluorescent tubes, by means of the high resolution plasmograph. The phenomena observed are extremely complex and have not as yet permitted very definite conclusions tobe drawn. The physical phenomena associated with the "hash" are located tn the vicinity of the anode. A more or less periodic variation of the anode fall tn potential ts observed which comprises a relatively slow rise (about 10 in 300μsec) followed by a very sharp fall; the rate of which is beyond the limits of resolution of the plasmograph (2μ sec). Attempts to observe the variation of the plasma parameters (electron, temperature, charge density, etc...) durtng the course of a cycle of "hash" have not led to any definite conclusions. One would expect a correlation between the duration of a period of "hash" and the electron temperature, but the experimental results are not sufftciently definite for this to be asserted with certainty. The development of a means of synchronizing the plasmograph upon the hash itself ts apparently required to obtain more satisfactory experimental results. (Contractor's abstract)

ATE. 01:005

Ateliers de Constructions Electrtques de Charlerot (France).

AN AUTO-SYNCHRONIZATION SYSTEM FOR THE PLASMOGRAPH, by M. Hoyaux and P. Gans. [1956] [18]p. tncl. diagrs. (Rept. no. EOARDC-TN-55-8) [AFOSR-TN-56-232] (AF 61(514)630-C) AD 88351 Unclassifted

An autosynchronization system has been developed for the plasmograph which enables the tnstrument to be trtggered by a pulse derived from the osctllations tn the discharge ttself rather than from ac mains supply. The system consists of a chatn of amplifying and differentiating ctrcuits which produces a sertes of pulses corresponding to the beginning of a cycle of

"hash". These are fed to a monostable multivibrator whose time constant can be varted. Probe characteristics can be obtained corresponding to a given detay from the reference time in the cycle. Calibration ctrcuits have been inctuded tn the system which permtt the time detay to be measured. Preliminary tests have been carrted out on the "hash" tn a fluorescent tube exctted by a direct vottage. The results show that the system is work.ng satisfactortly and that tt shoutd provtde a very useful toot for the study of phenomena of this kind. (Contractor's abstract)

ATE.0t:006

Ateliers de Constructions Electrtques de Charterot (France).

EQUATIONS OF SIMILITUDE FOR A DISCHARGE IN AN ARGON-MERCURY MIXTURE, by M. Hoyaux and P. Gans. [t956] [28]p. tnct. diagrs. (Rept. no. EOARDC-TN-55-t0) [AFOSR-TN-56-233] (AF 6t (514)630-C) AD 88352 Unctassifted

Conditions are studied tn which the equations of stmilitude tn the case of Hg-vapor arcs at moderate current tntensities remain valid for an arc strtking tn an A-Hg mixture. If the A content ts not too high, the equations of simulitude remain qualitatively valid; the corresponding curves migrate as a function of the A content tn Hg. Expertmental resutts tndicated that fluorescent tubes do not quantitatively obey the equations of simulitude of Hg-vapor rectifiers; the results were in agreement with the migration concept with respect to the A content tn Hg.

ATE.01:007

Ateliers de Constructions Electrtques de Charlerot (France).

A STUDY OF THE HASH IN FLUORESCENT TUBES BY MEANS OF AN AUTO-SYNCHRONIZED PLASMOGRAPH, by M. Hoyaux and P. Gans. [t956] tv. tncl. diagrs. (Rept. no. EOARDC-TN-55-9) [AFOSR-TN-56-347] (AF 6t(514)630-C) AD 95433 Unclassifled

The small perturbation theory prevtously developed (Rev. gen. elec., v. 60: 279, 195t) described satisfactortly the vartations in the electron density and the electron temperature except for nonexplanation of the phenomenon which triggers off the cycle. Also, the theory accounted for variation in space potential only durtng the first two-thirds of each oscillation. Further analysis lead to the conclusion that the vartation tn space potential during the latter part of each oscillation can be explained by considertng the anode to behave essentially ltke a Langmuir probe tnmersed tn a plasma. Measurements of the distribution of potential along the whole length of the positive column showed the possible extstence of bursts of positive tons propagated from anode to cathode at t500m/sec, in agreement with suggestions of Yosimoto. A sertes of confirmatory experiments with an alternating discharge gave results tn agreement with those from the direct current discharge. (Contractor's abstract, modified)

ATE.0t:008

Ateliers de Constructions Etectriques de Charterot (France).

INVESTIGATION OF THE CONDITIONS IN THE PLASMA IN MERCURY-VAPOR ARC DISCHARGES AND OSCILLATING ELECTRON ION SOURCES, by M. Hoyaux and P. Gans. [1955] tv. tnct. diagrs. refs. (Rept. no. EOARDC-TR-54) [AFOSR-TR-56-23] (AF 6t(5t4)630-C) AD 88353 Unclassifled

Theoretical and experimental study of the behavior of mercury-vapor arc discharges (a) at high current intensities and (b) at very low pressures, and (c) of thetr dynamic behavior tn fluorescent-type tubes. Anatytical results for case (a) tndicate that the so-called Gvosdover effect of etectron scattertng by the Coulomb mtcroftetd of the positive tons, acting tn conjunction with the self-magnetic ftetd, accounts more satisfactortty than other proposed hypotheses for experimentalty observed deviations from a set of taws due to Hoyaux; for case (b), the admixture of argon used in fluorescent-type tubes to facitlitate striking, simitarty accounts for deviations (observed tn such a tube) from a Hoyaux-Gans law. Tests for case (c) are conducted using an especially designed ptasmograph, white an espectally constructed autosynchronization plasmograph system ts used to tnvestigate the hash occurring tn hot-catnode tubes. (Contractor's abstract)

ATE.01:009

Ateliers de Constructions Etectriques de Charlerol (France).

[THEORETICAL AND EXPERIMENTAL CONTRIBUTION TO THE STUDY OF SPONTANEOUS OSCILLATIONS IN MERCURY VAPOR HOT CATHODE TUBES] Contribution theorique et experimentale a t'etude des osctltations spontanees dans tes tubes a vapeur de mercure a cathode chaude, by P. Gans and M. Hoyaux. [t956] 28p. tnct. diagrs. refs. (AF 6t (5t4)630-C) Unclassifled

By means of a ptasmograph, study was made of spontaneous osctllation occurrtng tn the anodic region of a mercury vapor hot cathode tube. The mechanism of oscillation occurs tn three phases: (t) a breakdown in the anode sheath; (2) a burst of tonization (which later falls off) in accord with the laws of small variations about a stable equtlibrium; (3) increase tn the anodic drop in accord with Langmuir's theory. Then the decrease of tension reaches a sufficient point, and a breakdown takes place again and the cycle recommences. The experimental results were in excellent accord with the theory. (In French)

ATL. 01:001

Atlantic Research Corp., Alexandria, Va.

N6ori-10503 and Nonr 485(01), Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:001 - PRI. 11:003.

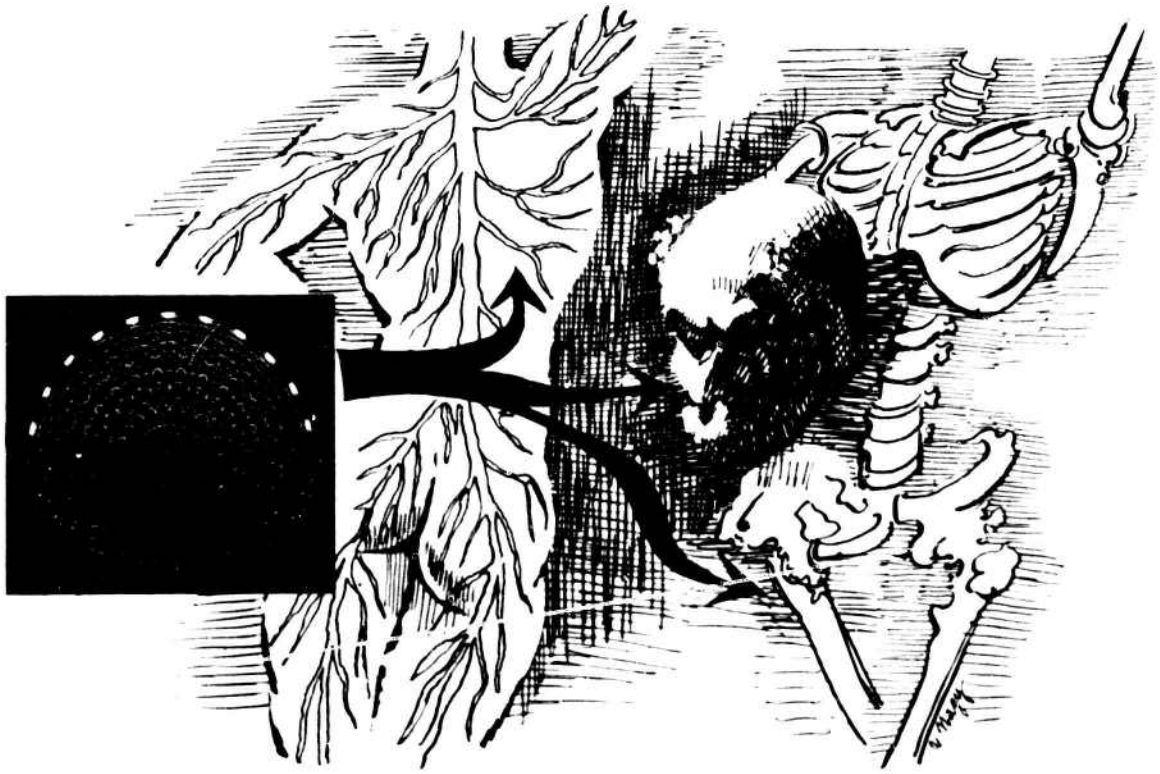
ATL. 01:001

Atlantic Research Corp., Alexandria, Va.

DEFLAGRATION OF AMMONIUM PERCHLORATE, by R. Friedman, R. G. Nugent and others. May 1956 [21]p. incl. illus. diagrs. (AFOSR-TN-56-205) (AF 18(600)1502) AD 87519 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Con.. (Aug. 19-24, 1956), N. Y. Reinhold, 1957, p. 612-618.

Deflagration rates and product-gas temperatures were measured for near-adiabatic decomposition of NH_4ClO_4, both in the pure form and with added catalysts. These experiments were performed under N pressurization. Deflagration limits of about 45 to 300 atm at 21°C were obtained for the perchlorate pressed from as-received powder with varied particle size. Perchlorate pressed from a 74- to 105-μ sieved fraction gave deflagration rates that agreed with the results of Adams et al for 110 to 160 atm, but had a lower limit of 90 atm. Deflagration rates for pellets made from a -53μ sieve fraction were similar to those for the as-received material above 110 atm, but the material failed to burn at or below 100 atm. Deflagration rate of NH_4ClO_4 below 150 atm increased with increasing pressure and ambient temperature, and decreasing particle size from which the pellets are pressed. At higher pressures, an upper pressure limit existed which was only slightly dependent on particle size but could be raised by preheating. In all cases, the presence of catalysts eliminated the upper pressure limit or at least shifted it above 340 atm. The greatest increase in deflagration rate was produced by Cu chromite. The possible significance of the results with regard to the reaction mechanism are discussed.



BAN. 01:001

Baños, A. Jr., Los Angetes, Calif.

FUNDAMENTAL WAVE FUNCTIONS IN AN UNBOUNDED MAGNETOHYDRODYNAMIC FIELD. I. GENERAL THEORY, by A. Baños, Jr. Oct. 1, 1954, rev. Dec. 10, 1954 [9]p. refs. (Technical note no. 1) ([AF]OSR-TN-54-281) (AF 18(600)1041) AD 84264
Unclassified

Also published in Phys. Rev., v. 97: 1435-1443, Mar. 15, 1955.

This is the first two papers dealing with a systematic study of the lineartzed, unbounded medium problems in magnetohydrodynamics of incompressible and compressible fluids. Part I deals with the fundamental equations which are set up quite generalty for an tdeal, homogeneous and isotropic, conducting fluid devoid of viscosiiy and expansive friction, subject only to the tnitial assumption that the externally applied fteld of magnetic tnduction be constant and uniform. The energy and momentum balance in a magnetohydrodynamic fietd is verified with the aid of the exact fundamental equations and the conservation laws of energy and momentum, for a rigid votume fixed in the (stationary) observer's inertial frame of reference, are disptayed in differential and tn tntegral form. By successive eliminations, there is obtained a singte partial differential equation in the particte vetocity from which the unwanted second-order terms are merely dropped in a linearized smatt amplitude theory, a process which is fully justified by considering the special case of infinite conductivity, zero disptacement current, and incompressible fluids. Also, assuming that a particular solution of the linearized magnetohydrodynamic wave equation has been obtained, tt is shown how to compute quite generatty, from the linearized Maxwellian set, the accompanying electromagnetic fteld vectors expressed in terms of the assumed velocity fteld. These computations are carried out for plane homogeneous waves and for time-harmonic cylindrical waves. The actual determination of particular wave functions appropriate for incompressible and compressible fluids, together with the computation of the corresponding wave numbers, is reserved for the sequel to this paper, Part II. (Contractor's abstract)

BAN. 01:002

Baños, A. Jr., Los Angeles, Calif.

MAGNETOHYDRODYNAMIC WAVES IN INCOMPRESSIBLE AND COMPRESSIBLE FLUIDS, by A. Baños, Jr. [1955] [42]p. incl. diagrs. (Technical note no. 2) ([AF]OSR-TN-55-66) (AF 18(600)1041) AD 89540
Unclassified

Also published in Proc. Royal Soc. (London), v. 233A: 350-366, 1955.

The application of the general theory of magnetohydrodynamics to the determination of the modes of propagation and to the computation of the corresponding propagation constants is considered. It is shown that an tncompressibte fluid sustains 2 types of modes: one type devoid of pressure fluctuations (vetocity modes), and the other accompanied by pressure oscillations (pressure modes). In the case of cylindrical waves in an incompressible fluid, there are 2 distinct pressure modes, one of which, however, is highly attenuated and therefore of little physical interest. It is found that a compressible fluid also sustains the same class of velocity modes (devoid of pressure fluctuations and hence independent of the velocity of sound tn the medium) as an incompressible fluid. In addition, a compressible fluid is shown to propagate 2 distinct pressure modes which, under appropriate limiting conditions peculiar to each type, behave, respectivety, as a modified sound wave and as a modified magnetohydrodynamic wave. For every mode discussed here, there are presented the limiting forms of the propagation constant in 3 cases of physical interest: infinite conductivity, slightly attenuated modes, and weak magnetohydrodynamic coupling which arises when the externally applied fietd is vanishingly small. (Contractor's abstract, modified)

BAN. 01:003

Baños, A. Jr., Los Angetes, Calif.

NORMAL MODES CHARACTERIZING MAGNETOELASTIC PLANE WAVES, by A. Baños, Jr. [Dec. 1955] [6]p. incl. diagrs. (Technical note no. 3) (AFOSR-TN-56-16) (AF 18(600)1041) AD 120480
Unclassified

Also published in Phys. Rev., v. 104: 300-305, Oct. 15, 1956.

The general theory of magnetohydrodynamic waves tn an tdeal conducting fluid embedded in a uniform fteld of magnetic tnduction, and the application of the theory to the systematic analysis of the various modes of propagation in tncompressibte and compressible fluids have been presented by Baños tn 2 earlier papers (Phys. Rev., v. 97: 1435, 1955; Proc. Royal Soc. (London), v. 233A: 350-367, 1955). The techniques developed there have now been extended to the study of homogeneous plane waves in an unbounded conducting solid. It is found that, in the presence of a uniform static magnetic field, the elastic medium sustains 5 distinct modes of propagation as already pointed out by Knopoff. The first 2 modes are pure shear waves, one of which is a slightly attenuated shear mode with phase velocity modified anisotropically by magnetoelastic coupling; the companion shear mode is highly attenuated and exhibits a propagation constant which is essentially that of an electromagnetic wave of the same frequency. The remaining 3 modes are shear-compression waves of which one mode exhibits a phase velocity intermediate between the phase velocity of shear and compressional waves; the second mode has a phase velocity exceeding that of compressional waves; and the third shear-compression mode is again highly attenuated with the propagation characteristics of an

electromagnetic wave. (Contractor's abstract)

BAN.01:004

Baños, A., Jr., Los Angeles, Calif.

MAGNETOHYDRODYNAMIC WAVES IN COMPRESSIBLE FLUIDS WITH FINITE VISCOSITY AND HEAT CONDUCTIVITY, by A. Baños, Jr. June 1956, 26p. (Technical note no. 4) (AFOSR-TN-56-320) (AF 18(600)1041) AD 94856 Unclassified

Presented at the Internat'l. Symposium on Electromagnetic Problems in Cosmical Physics, Royal Inst. of Tech., Stockholm (Sweden), Aug. 27-31, 1956, under the auspices of the Internat'l. Astronomical Union.

Also published in Proc. I.U.P.A.P., Stockholm (Sweden), Aug. 26, 1956.

The general theory of magnetohydrodynamic waves in an ideal conducting fluid embedded in a uniform field of magnetic induction, and the application of the theory to the systematic analysis of the various modes of propagation in incompressible and compressible fluids were treated in 2 earlier papers. In the present paper first the conservation laws are established of momentum and energy for a (macroscopic) compressible fluid with finite viscosity and finite thermal and electrical conductivities, which is embedded in a uniform field of magnetic induction, and then is derived quite generally the exact (nonlinearized) equation governing the distribution of temperature in such a fluid. Next, using the linearized magnetohydrodynamic wave equation in the fluid velocity, combined with the resulting heat diffusion equation and with the equation of state of the fluid, and applying the mathematical techniques developed earlier, there is obtained a higher order partial differential equation in the fluid temperature from which ensue all the temperature modes. In particular, the behavior of the plane homogeneous waves is examined in detail, and it is shown that a compressible fluid with the indicated properties sustain altogether 6 different modes, 2 of which are pure shear modes, devoid of density, pressure, and hence temperature fluctuations (v-modes), while the remaining 4 are shear-compression waves accompanied necessarily by density, pressure, and temperature fluctuations (p-modes). The 2 shear modes, which are isothermal, comprise a slightly attenuated Alfvén wave, and a highly attenuated viscous mode, sometimes referred to as a vorticity mode. The 4 shear-compression modes have in general very complex properties, but in the low frequency and low heat conductivity case they are easily identified as: (1) a modified (adiabatic) sound wave slightly attenuated; (2) a slightly attenuated modified Alfvén p-wave; (3) a highly attenuated viscous wave; and (4) a highly attenuated thermal wave governed in the main by the thermal properties of the medium. (Contractor's abstract, modified)

Bartol Research Foundation, Swarthmore, Pa.
see Franklin Inst. Bartol Research Foundation, Swarthmore, Pa.

BAT.01:001

Battelle Memorial Inst., Columbus, Ohio.

THERMOMAGNETIC EFFECTS IN InSb (Abstract), by R. K. Willardson and A. C. Beer. Nov. 1955, 1p. (AFOSR-TN-55-425) (AF 18(600)1547) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Due to the unusually high electron mobility in InSb, large galvanomagnetic effects have been observed. If temperature gradients exist across the specimen, one may expect correspondingly large thermomagnetic effects. Investigation of these phenomena is generally complicated by the fact that ordinary measurements are done under adiabatic conditions so that careful attention must be given to transverse gradients and the resulting additional second-order effects, since the region of interest encompasses values of $\mu H >> 1$. However, by choosing boundary conditions such that transverse electric fields and temperature gradients are eliminated, both measurement and calculations are simplified. Under these conditions, it has been found that the contribution of the electrons to the thermoelectric power of intrinsic InSb at room temperature decreases significantly as the magnetic field is increased. Data were taken over a range of magnetic field strengths sufficient to change the thermoelectric power from -240 to $+75 \mu V/C$. Results are analyzed in terms of the electron and hole mobilities and the position of the Fermi level. (Contractor's abstract)

BEL.01:001

Bell Aircraft Corp. [Rocket Engine Dept.] Buffalo, N. Y.

APPLIED RESEARCH ON LIQUID PROPELLANT ROCKET ENGINES (Unclassified title), by T. G. Rossmann. Final rept. July 15, 1954-July 14, 1955. Aug. 31, 1955, 96p. incl. illus. tables, refs. (Rept. no. 02-982-015) [AFOSR-TN-55-372] (AF 18(600)-1156) Confidential

BEL.01:002

Bell Aircraft Corp. Rocket Engine Dept., Buffalo, N. Y.

PROGRAM OF EXPLORATORY RESEARCH ON ROCKET ENGINE COMBUSTION (Unclassified title), by T. G. Rossmann. Final rept. for period July 16, 1955-Sept. 15, 1956. Oct. 15, 1956, 114p. incl. illus. diagrs. tables, refs. (AFOSR-TR-56-66) (AF 18(600)-1156) AD 115014 Confidential

BJO. 01:001

Bjorksten Research Foundation, Madison, Wts.

PROTEIN STRUCTURE AND AGING CROSSLINKING IN GELATIN. 1. FORMALDEHYDE-INDUCED, by H. L. Gottlieb. Nov. 1954, 16p. incl. tables. (Technical note no. 1) ([AF]OSR-TN-54-304) (AF 18(600)-1010) AD 52015 Unclassified

Crosslinks in protein aceous materials could be of numerous chemical types. In order to study the chemical characteristics of crosslinked native proteins some chemical properties of experimentally induced crosslinks were investigated. Purified pigskin gelatin has been treated with chemical reagents to induce crosslinks and the treated gelatin analyzed to describe the probable crosslinking mechanisms. Polypeptide degradation by enzymatic and ionic methods was done in order to obtain different types of hydrolytic liberation of individual amino acids. The products of degradation were subjected to paper strip chromatographic analysis by the master overlay dimensional technique. Qualitative and quantitative differences in the selective rates of liberation of certain individual amino acids indicated the locations and types of crosslinks induced by the reactions of chemical reagents in pigskin gelatin. (Contractor's abstract)

BJO. 01:002

Bjorksten Research Foundation, Madison, Wts.

IN VITRO CHOLESTEROL DEPOSITION ON HOG AORTA TISSUE, by J. Bjorksten and H. Gottlieb. [1954] [3]p. (AF 18(600)1010) Unclassified

Published in Finska Kemistsamfundets Medd., v. 63: 74-77, 1954.

The precipitation of cholesterol (I) from suspensions on membranes treated with $CrSO_4$ and $Pb(OAc)_2$ was studied. I was precipitated from carboxymethylcellulose (II) suspension on 5% $CrSO_4$-treated filter paper, cotton cloth, glass cloth, and hog aorta. II was precipitated by all salts listed in the previous work (Proc. Soc. Exper. Biol. Med., v. 81: 350, 1952) except $HgCl_2$. The degree of I deposition is inversely related to the amount of rinsing after salt treatment. Hog aorta tissue after 24-hr treatment in $CrSO_4$ and $Pb(OAc)_2$ and rinsing showed I deposition from II and beef synovial fluid suspensions of I. There was no precipitation from the suspension media methylcellulose 1%, arrowroot starch 4%, chondroitin sulfate 4%, human saliva, or hog blood serum. A proposed mechanism is that whenever a material contains a colloid precipitant available at its surface in sufficient concentration to cause precipitation of the suspending colloid, the colloid will be precipitated and carry with it any suspended material. (C. A., 1955:12565g)

BJO. 01:003

Bjorksten Research Foundation, Madison, Wts.

THE OCCURRENCE OF ARTERIOSCLEROSIS IN THE AORTA OF SWINE, by H. Gottlieb and J. J. Lalich. [1954] [3]p. incl. illus. table. [AF 18(600)1010] Unclassified

Published in Amer. Jour. Path., v. 30: 851-855, July-Aug. 1954.

Fresh aortas were examined from more than 2000 swine which varied in age from 4 mo to more than 3 yr. The incidence of arteriosclerotic plaques was found to increase with age. Firm white or pale yellow intimal plaques of 1 to 10 mm in size were encountered principally in the descending arch and the thoracic aorta. Such plaques accounted for almost all of the lesions observed, and they were composed of fibrous connective tissue. Sclerosis of the abdominal aorta is more rare. In two of these instances when such lesions were encountered, calcium precipitate was observed in the media. (Contractor's summary)

BJO. 01:004

Bjorksten Research Foundation, Madison, Wts.

MORPHOGENESIS OF ATHEROSCLEROSIS IN SWINE AORTAS (Abstract), by H. L. Gottlieb. Nov. 1, 1954 [1]p. [AF 18(600)1010] Unclassified

Presented at Eight annual meeting of the Amer. Soc. for the Study of Arteriosclerosis, Chicago, Ill., Oct. 31-Nov. 1, 1954.

Abstract published in Circulation, v. 10: 598, Oct. 1954.

Recent examination of several thousand random swine aortas has revealed marked incidence of intimal lesions morphologically similar to minimal atherosclerotic lesions in humans. Histologic studies of the lesions in swine have been made of serial sections of embedded and frozen specimens and by means of the endothelial surface staining technic. The intimal structure of the swine aorta is very similar to the human aorta. A thin layer of connective tissues cells separates the endothelial lining from the medial. As the chronologic age of the animal advances a gradual diffuse thickening of the subendothelial connective tissue layer was observable. The gross lesions can be classified into two classic types: fibrotic and calcified. The fibrotic lesions can further be differentiated by the presence and absence of stainable lipid materials. A morphologic development of gross fibrotic lipid-containing lesions will be presented from the first discernible stages of appearance in the intima of lipid-like materials. (Contractor's abstract)

BJO. 01:005 - BOS. 02:002

BJO. 01:005

Bjorksten Research Foundation, Madison, Wis.

A POSSIBLE MOLECULAR BASIS FOR AGING, by J. Bjorksten and H. Gottlieb. [Mar. 1, 1956] [9]p. incl. tables. [Technical note no. 2] [AFOSR-TN-56-100] [AF 18(600)1010] Unclassified

A laboratory method for proving the existence of cross-linkages in proteins and for measuring the extent of cross-linking with gelatin, based on the amount of free amino acids liberated, is described. In this study on aging, it is pointed out that proteolytic enzymes attack protein molecules at certain points. It is assumed that if enough molecules of cross-linking agents block all these attack points on 2 adjacent, cross-linked protein molecules, then the protein molecules are immobilized. When this occurs, these protein molecules are withdrawn from metabolism. As a result, with increasing age, an increasing amount of the protein is thus made inert, tending to clog the cells, interferring first slightly, then considerably with the normal function of the cells.

BOS. 01:001

Boston U., Mass.

SEQUENTIAL TESTS OF RANDOMNESS, by G. E. Noether. Dec. 1953 [28]p. incl. tables, refs. ([AF]OSR-TN-54-65) (AF 18(600)778) AD 49990 Unclassified

This report describes and discusses sequential tests of randomness with respect to alternatives of the following three types:

Linear trend: $F(x_1, \ldots, x_n) = \prod_{i=1}^{n} F(x_i + i\theta)$,

Cyclical change: $(F(x_1, \ldots, x_n) = \prod_{i=1}^{n} F(x_i + \theta_i)$

where the θ_i fottuws some regular or irregular cyclical movement,

Stochastic relationship: $X_i = \delta X_{i-1} + U_i$. (Contractor's abstract)

BOS. 01:002

[Boston U., Mass.]

SEQUENTIAL TESTS OF RANDOMNESS. Final research rept. [1954] 3p. (AF 18(600)778) Unclassified

A sequence of random variables $X_1, X_2, \ldots$ is chosen. $F(x_1, x_2, \ldots, x_n)$ denotes the joint cumulative distribution function of $X_1, X_2, \ldots, X_n$. The hypothesis of randomness states that $F(x_1, x_2, \ldots, x_n) = F(x_1)F(x_2) \ldots F(x_n)$ with $F(x)$ the individual cumulative distribution function. The investigation is made of sequential tests of the hypothesis of randomness H_0 with the following alternatives considered (a) linear trend; (b) cyclical changes; (c) stochastic relationship; and (d) changes in variance.

BOS. 02:001

Boston U. Dept. of Physics, Mass.

NEUTRONS FROM THE PROTON BOMBARDMENT OF N^{14}, by F. Ajzenberg[-Selove] and W. Franzen. [Jan. 14, 1954] [10]p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)997], Office of Naval Research, and Atomic Energy Commission) Unclassified

Also published in Phys. Rev., v. 94: 409-411, Apr. 15, 1954.

The $N^{14}(p, n)O^{14}$ reaction has been investigated at 30°, 60°, and 150° by the method of proton recoils in thick nuclear emulsions. The energy of the incident protons was 17.3±0.1 mev, and the thickness of the melamine target was 0.2 mev. The results indicate a ground-state Q value of -6.03±0.2 mev, yielding a mass defect for O^{14} of 12.2 mev, in good agreement with β-decay results. The data also indicate levels in O^{14} at excitation energies greater than 5.5 mev. (Contractor's abstract)

BOS. 02:002

Boston U. Dept. of Physics, Mass.

NEUTRONS FROM THE PROTON BOMBARDMENT OF B^{10}, by F. Ajzenberg[-Selove] and W. Franzen. [1954] [8]p. incl. diagrs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)997] and Atomic Energy Commission) Unclassified

Also published in Phys. Rev., v. 95: 1531-1533, Sept. 15, 1954.

The $B^{10}(pn)C^{10}$ reaction has been investigated at 30°, 60°, 90°, 120° and 150° by the method of proton recoils in thick photographic emulsions. The mean energy of the incident protons was 17.2 ± 0.15 mev. The results indicate a ground-state Q value of -4.35 ± 0.2 mev, yielding a mass defect of 18.6 mev for C^{10} in good agreement with β-decay results. The data also indicate a level in C^{10} at 3.34 ± 0.2 mev, and partly resolved levels at excitation energies ≥ 5 mev. The angular distributions of the neutrons to the ground state, and to the 3.34 mev, state are shown. (Contractor's abstract)

BOS. 02:003

Boston U. Dept. of Physics, Mass.

ENERGY LEVELS OF LIGHT NUCLEI, V, by F. Ajzenberg[-Selove] and T. Lauritsen. [1955] [90]p. incl. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Sctentiftc Research under [AF 18(600) 997], Offtce of Naval Research, and Atomic Energy Commtssion) Unclassifted

Published in Rev. Modern Phys., v. 27: 77-166, Jan. 1955.

A detailed summary ts presented of currently available experimental information on the location and properties of the energy levels of the light nuclet from He^5 to Ne^{23}. in the arrangement, each nucleus ts represented by a diagram, on which the known energy levels are plotted, together with the nuclear reactions tn which they are resolved. The pertinent tnformation on each reaction, as obtained from published papers is included. Each diagram entry of a level position or quantum-number assignment is substantiated by some "defense" in the cited literature.

BOS. 02:004

Boston U. [Dept. of Physics] Mass.

NEUTRONS FROM THE PROTON BOMBARDMENT OF S^{32} AND S^{34}+ (Abstract), by F. Ajzenberg[-Selove], A. [G.] Rubin, and J. G. Likely. [1955] [1]p. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)997] and Alomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 654, July 15, 1955.

An lsotopic S target, 50-kev thick, and an enriched CdS target, t00-kev thick, have been bombarded by 17.5 protons from the Prtncetor University cyclotron. The S target was prepared by the method of Nielsen and Welnstein (Rev. Scient. Instruments, v. 24: t146, t953) while the enrlched CdS was palnted on a polystyrene foil. Prelimtnary measurements of proton recoil tracks in Ilford C2 emulsions at 30° and t50° (1500 tracks) lndicate 4 neutron groups corresponding to states in Cl^{32} and 5 neutron groups corresponding to states in Ct^{34}. An attempt will be made to correlate the results of these neutron spectra measurements with the picture of the Ct^{34} S^{34} decay derived from β^+-decay measure ments (Reviews of Modern Physics, v. 26: 95, 1954) (Contractor's abstract)

BOS. 02:005

Boston U. Dept. of Physics Mass.

"CLASSICAL" NUCLEAR PHYSICS IN THE USSR, by F. Ajzenberg[-Selove]. [1956] 1v. tncl. diagrs. refs. (Sponsored jointly by Air Force Offtce of Scientific Research under [AF 18(600)997] and [Atomic Energy Commission]) Unclassifted

Also published in Nuovo Ctmento, Ser. 10, v. 4: 2-30, Supplement no. 1, 1956.

A summary ts given of Soviet work conducted tn "classtcal" nuclear physics from about 1953-1955. Subjects considered include: (1) α-, β-, γ-spectroscopy; (2) induced nuclear reactions; (3) masses, btnding energies, and abundances; and (4) theories of nuclear structure. The résumés of the Soviet research undertaken have been obtained tn or prepared from Physics Abstracts, Brookhaven Selected Reading List, and Soviet journals tn physics. They indicate that β- and γ-spectroscopic studies appear to be of greatest tnterest to Soviet phystcists. Also, it ts apparent, that a large part of thetr research efforts have been fccussed on the measurement of cross sections and tn the determination of the behavior of heavy nuclet, in particular that of Th, U, and the transuranic elements. In addition, much work has been devoted to the theories of nuclear structure, e.g., the shell model, and on β-decay theories. It is pointed out that a large number of papers in Soviet scientific literature detail, in professionally-competent reviews, Western scientific and technical progress tn basic nuclear physics. A bibliography of the 124 Soviet references ts tncluded for use with the textual matertal presented.

BOS. 02:006

Boston U., Dept. of Physics, Mass.

NEUTRONS FROM THE PROTON BOMBARDMENT OF B^{11}, by F. Ajzenberg-Selove, G. D. Johnson and others. Apr. 1956 [8]p. tncl. dtagrs. refs. (Sponsored jointly by Air Force Offtce of Sctentific Research under [AF t8(600)997], Offtce of Naval Research, and Atomtc Energy Commission) Unclassifted

Presented at meeting of the Amer. Phys. Soc., Mexico City (Mexico), Aug. 29-31, 1955.

Also published in Phys. Rev., v. 103: 356-357, July t5, t956.

A thin target of lsotopic boron has been bombarded with 7.03-mev protons. The neutrons from the B^{11} (p, n)C^{11} reactton, studied by means of nuclear emulstons, indicate an exctted state of C^{11} at 2.0t ± 0.06 mev. (Contractor's abstract)

BOS. 02:007

Boston U. [Dept. of Physics] Mass.

ENERGY LEVELS OF Si^{28}. t, by A. G. Rubin, F. Ajzenberg-Selove, and tl. Mark. July 30, 1956 [10]p. incl. diagrs. table, refs. (Sponsored jointly by Air

BOS. 02:008 - BOS. 03:003

Force Office of Scientific Research under AF 18(600)997 and [Atomic Energy Commission]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Mexico City (Mexico), Aug. 29-31, 1955.

Published in Phys. Rev., v. 104: 727-730, Nov. 1, 1956.

The neutron spectrum from the $Al^{27}(d, n)Si^{28}$ reaction has been investigated at 8 angles by means of nuclear emulsions. The energy of the incident deuterons was 2.167 ± 0.015 mev. The data indicate energy levels of Si^{28} at 1.78 ± 0.10, 4.54 ± 0.2, 4.95 ± 0.2, 6.24 ± 0.06, 6.88 ± 0.06, 7.39 ± 0.06, 7.89 ± 0.06, 8.31 ± 0.10, 8.57 ± 0.08, 9.37 ± 0.04, 10 ± 0.10, and 10.25 ± 0.06 mev. (Contractor's abstract)

BOS. 02:008

Boston U. [Dept. of Physics] Mass.

NEUTRONS FROM THE PROTON BOMBARDMENT OF P^{31}, by A. G. Rubin, G. D. Johnson, and J. B. Reynolds. Aug. 30, 1956 [7]p. incl. diagrs. table. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)997 and Atomic Energy Commission) Unclassified

Also published in Phys. Rev., v. 104: 1444-1445, Dec. 1, 1956.

The reaction $P^{31}(p, n)S^{31}$ has been studied at E_p = 17.2 mev. The energy spectrum of the neutrons was determined by means of proton recoil measurements in nuclear emulsions. The mass excess, M — A, of S^{31} was calculated to be -10.04 ± 0.20 mev. Excited states of S^{31} have been located at 1.15 ± 0.15, 2.28 ± 0.20, 3.35 ± 0.20, 4.51 ± 0.15, 5.94 ± 0.30, and 6.41 ± 0.20 mev. (Contractor's abstract)

BOS. 03:001

Boston U. Dept. of Physics, Mass.

THE STOCHASTIC BASIS OF ONSAGER'S MINIMUM PRINCIPLE (REVISED), by A. Siegel. Jan. 20, 1956, 22p. (AF 18(603)29) Unclassified

Also published in Phys. Rev., v. 102: 953-959, May 15, 1956.

The phenomenological equations of motion of thermodynamic quantities, and Onsager's minimum principle, are correct only to the extent that fluctuations are neglected. This paper presents a statistical analysis of the problem and gives a criterion for the validity of the phenomenological approximation. (Contractor's abstract)

BOS. 03:002

Boston U. Dept. of Physics, Mass.

APPLICABILITY OF THE LANGEVIN EQUATION TO IRREVERSIBLE PROCESSES (Abstract), by A. Siegel. [Feb. 1956] 1p. (AF 18(603)29) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 220-221, Apr. 26, 1956.

Onsager and Machlup have proposed the Langevin equation, $R\alpha + s\alpha = \varepsilon(t)$, as a general equation of motion for a fluctuating thermodynamic variable. In an idealized treatment, the fluctuating force $\varepsilon(t)$ is considered uncorrelated with itself from one instant to another, and Gaussianly distributed. $\alpha(t)$ then has a determinate part $\alpha(o) \cdot \exp(-t \cdot s/R)$, and a stochastic part $\alpha_s(t)$. In reality, of course, $\varepsilon(t)$ consists of discrete elementary processes. Under certain circumstances the main details of the idealized $\alpha_s(t)$ may show up only within intervals shorter than the time between elementary processes. The stochastic description is then largely fictitious. A limit to its applicability may be sought in the simple physical situation of the Brownian motion: α = velocity of the colloid particle. Using results of elementary kinetic theory, and assuming Stokes friction, the Langevin description is found to be applicable if $mL/M\rho << \sqrt{k/s}\alpha$; m, M are masses of molecule of the medium and colloid particle; L, mean free path of a molecule in the medium; ρ, radius of the colloid particle; k is Boltzmann's constant. (Contractor's abstract)

BOS. 03:003

Boston U. Dept. of Physics, Mass.

STOCHASTIC ANALYSIS OF A VARIABLE SUBJECT TO A QUANTUM FORCE SPECTRUM (Abstract), by H. Goldring and A. Siegel. [Dec. 1956] 1p. (AF 18(603) 29) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 25-27, 1957.

Published in Bull. Amer. Phys. Soc., Series II, v. 2: 203, Apr. 25, 1957.

The problem has been solved of the diffusion of a variable f subject to the Langevin-type equation $\dot{f} + \gamma f = a(t)$, where the random force a(t) has the spectral density $\hbar\omega/[\exp(\hbar\omega/kT)-1]$, i.e., Nyquist's quantum form of the noise spectrum. Assuming Gaussian distribution for a(t), we get the conditional probability $P[f(t)|f(t_0)]$ by calculating the correlation function of f: $\langle f(t_0)f(t_0+t)\rangle / \langle f(t_0)^2\rangle$. Verification of the validity of the assumed spectrum could in principle be obtained with these results through direct analysis of

notse curves tn time. (Work is nowtn progress toward a simitar analysis of diffusion of collodial particles). The extremely slow fall-off with frequency of the quantum notse spectrum, even at quite tow temperatures, still presents an obstacle to experimental verification, tn that extremely fine time resolution of the measured curves would be required. (Contractor's abstract)

BRI. 01:001

Brigham Young U. Dept. of Chemistry, Provo, Utah.

RHENIUM SULFIDES AS LIQUID-PHASE HYDROGENATION CATALYSTS. [I] A COMPARISON WITH MOLYBDENUM SULFIDE AND COBALT POLYSULFIDE, by H. S. Broadbent, L. H. Slaugh, and N. L. Jarvis. Mar. 20, 1954 [5]p. tnct. tables, refs. [AF 18(600)1164] Unctassified

Published in Jour. Amer. Chem. Soc., v. 76: 1519-t523, Mar. 20, 1954.

Rhenium heptasulfide and rhenium disulfide hydrogenation catalysts were prepared and examined for catalytic activity loward a variety of substrates tn comparison with the wett-known molybdenum sulfide and cobalt potysulfide catalysts. In these experiments rhenium heptasulfide was most active, rhenium disulfide tess so, and molybdenum and cobatt sulftdes much less so. Some advantages enjoyed by the rhenium heptasulfide hydrogenation catalyst are as fottows: Consistent and easy reproductbtlity, activity maintained tndeftnitety by simple storage In a closed bottle, stability to hydrogenative decomposition al high temperatures, extreme resistance to "potsoning", tnsolubility tn strong, non-oxidiztng actds, and ability to saturate multipte bond system without accompanying hydrogenolysis of carbon-sulfur bonds. Its chief disadvantages are tts relatively high cost, due tn considerable part to the lack established demand for rhenium compounds, and the fact that tt ts not as active toward most non-sulfur containing compounds as some nicket, platinum and paltadium catalysts. (Contractor's abstract)

BRI. 01:002

Brigham Young U. Dept. of Chemistry, Provo, Utah.

RHENIUM HEPTASELENIDE AS A HYDROGENATION CATALYST, by C. W. Whittle. May 1, 1956, 98p. Incl. diagrs. tabtes, refs. (AFOSR-TN-56-243) (AF 18(600) 1164) AD 88363 Unclassified

The catalytic activity of Re compounds was studied, especially the activity of Re_2Se_7 which is closely related to Re_2S_7. The compound Re_2Se_7 was prepared and its catalytic activity established; the method yielding the most active catalyst was determined. The catalyst was tried with a variety of substrates, and the ease of reducing different functionat groups and structural features was compared. In general, Re_2Se_7 was slightly less active than Re_2S_7 for most reductions, but it was superior to CoS_x or MoS_3. A comparison was made of the reduction of nitro groups, and acetylenic and otefinic linkages with Raney Ni, Adam's catalyst, Re_2S, Re_2Se_7, and Co and Mo sulfides.

BRI. 01:003

Brigham Young U. Dept. of Chemistry, Provo, Utah.

RHENIUM AND ITS COMPOUNDS AS HYDROGENATION CATALYSTS. III. RHENIUM HEPTOXIDE, by H. S. Broadbent, G. C. Shaw and others. Aug. 11, 1958, 27p. tnct. tabtes, refs. (AFOSR-TN-56-602) (AF 18 (600)t164) AD 115030 Unclassified

Presented tn part at 131st meeting of Amer. Chem. Soc., Miami, Fla., Apr. 11, 1957.

The catalysis of liquid phase hydrogenations by rhenium "blacks", obtained from the reduction of rhenium heptoxide, ts reported. A comparison of these calalysts with commonly used taboratory catalysts ts made. It ts found that these "blacks" are the most effective catalysts for the hydrogenation of carboxylic acids to alcohols. This conversion takes ptace with a variety of actds at 150°-250° (usually 160°)/ca 200 atm tn a few hours. Good yields of alcohol are attained with occasional ester by-products. The actd ts usually reduced. The rhenium "btacks" effecl the hydrogenation of amides quite well. Many common organic functions reductble through Pl or Nt catalysts are affected only moderatety by these catalysts. A comparison ts made of the catalysl's role tn several reactions.

BRI. 0t:004

Brigham Young U. Dept. of Chemistry, Provo, Utah.

RHENIUM AND ITS COMPOUNDS AS HYDROGENATION CATALYSTS. II. RHENIUM HEPTASELENIDE, by tl. S. Broadbent and C. W. Whittle. [t956] t3p. tncl. tables. (AF t8(600)1t64) Unclassified

The first recorded application of rhenium heptaselenide as a hydrogenation catalyst tn the reduction of a variety of substrates ls described. It ts easily prepared and tsolated and may be stored wet or dry tn the presence of oxygen without loss of activity. Some further advantages enjoyed by rhenium heptaselenide as a catalyst are tts extreme resistance to "poisoning" insolubtlity in strong non-oxidizing actds and ability to saturate multiple bond systems without accompanying carbon to sulfur bond hydrogenolysis. (Contractor's abstract)

BCU. 01:001 - BCU. 02:001

BCU. 01:001

British Columbia U. Dept. of Mathematics, Vancouver, B. C. (Canada).

SOME ALGEBRAIC PROPERTIES OF ASYMPTOTIC POWER SERIES, by T. E. Hull. June 1955, 9p. (UBCAR rept. no. 1) ([AF]OSR-TN-55-264) (AF 18 (600) 1517) AD 75157 Unclassified

Also published in Canad. Jour. Math., v. 8: 220-224, 1956.

A series $c_0 + c_1x + c_2x^2 + \ldots + c_nx^n + \ldots$ is called an S-series whenever (i) c_n, x are real; (ii) $c_0 \geq 0$; and (iii) there exists a function f(x) such that

$$|f(x) - c_0 - c_1x - \ldots - c_{n-1}x^{n-1}| \leq |c_nx^n|, \quad x > 0,$$

n = 0, 1, 2, ... Condition (iii) means that the series is the asymptotic expansion of the function f(x), and that the remainder after n terms, with respect to f(x), is numerically less than the (n + 1)th term. It is shown that the S-series form a semiring, and that the ring of all power series, or all asymptotic series, is generated from this semiring when one adjoins all differences to the semiring. These results enable one to define a partial ordering on the ring of power series. (Contractor's abstract)

BCU. 01:002

British Columbia U. Dept. of Mathematics, Vancouver, B. C. (Canada).

ON A REPRESENTATION FOR ASYMPTOTIC SUMS, by T. E. Hull. July 1955, 14p. (UBCAR rept. no. 2) ([AF]OSR-TN-55-265) (AF 18(600)1517) AD 75156 Unclassified

The problem considered here is that of assigning a function of the form

$$\int_0^\infty e^{-xt}\, dc(t)$$

to each series

$$c_0 + c_1x + c_2x^2 + \ldots + c_nx^n + \ldots.$$

It turns out that the function can be chosen in a unique way so that it has 2 important properties. First, it is a natural sum of the series in that the series is its asymptotic expansion. Second, the collection of all such sums is isomorphic to the collection of all series with respect to addition while a subring of the sums is isomorphic to the corresponding subring of the series with respect to both addition and multiplication. Use is made of some of what is known about the problem of moments. The results are a generalization of results obtained earlier by Stieltjes and Borel and are, in a certain sense, best. The results enable one to define a norm over the space of power series in a natural way. (Contractor's abstract)

BCU. 01:003

British Columbia U. Dept. of Mathematics, Vancouver, B. C. (Canada).

ENCLOSED QUANTUM MECHANICAL SYSTEMS, by T. E. Hull and R. S. Julius. May 1956, 14p. incl. diagr. refs. (AFOSR-TN-56-209) (AF 18(600)1517) AD 87523 Unclassified

Also published in Canad. Jour. Phys., v. 34: 914-919, Sept. 1956.

A brief description is given of the eigenvalue problems associated with enclosed quantum mechanical systems and of some attempts to deal with these problems. Another method is developed which leads to a general asymptotic formula for the eigenvalues. This formula yields a simple asymptotic approximation to the eigenvalue in each particular case, once the eigenfunction of the corresponding unrestricted system is known. (Contractor's abstract)

BCU. 02:001

British Columbia U. Dept. of Mathematics, Vancouver, B. C. (Canada).

EXTREME VALUE PROPERTIES OF HERMITIAN MATRICES, by M. Marcus and B. N. Moyls. Aug. 1956, 36p. refs. (AFOSR-TN-56-341) (AF 18(603)83) AD 95217 Unclassified

Extreme values are determined which minimize or maximize $f(x_1, \ldots, x_k) = F((Ax_1, x_1), \ldots, (Ax_k, x_k))$, where $x_1, \ldots, x_k$ is an orthonormal set in an n-dimensional unitary space V_n and A is a Hermitian transformation on V_n to itself; $F(a_1, \ldots, a_k) = F(a)$ is a real symmetric function of the indicated variables, $1 \leq k \leq n$. Extreme values are obtained for the case $F(a_1, \ldots, a_k) = \prod_{j=1}^{k} a_j$, $1 \leq k \leq n$, without assuming that F(a) is either monotone increasing or decreasing in each a_j for values of a_j in the field of A or that A is nonnegative Hermitian. The maximum value of $g(x_1, \ldots, x_k) = F((U_1A_1 \ldots U_mA_mx_1, x_1), \ldots, (U_1A_1 \ldots U_mA_mx_k, x_k))$ is determined as x and U vary over sets of k orthonormal vectors and sets of m unitary transformations respectively, were $A_1, \ldots, A_m$ are arbitrary linear transformations and $U_1, \ldots, U_m$ are unitary transformations. All transformations are on V_n to V_n. The analysis utilizes the properties of the compound of a transformation. The classical Minkowski determinant inequality is extended to all of the coefficients in the characteristic polynominal.

BRO. 01:001

Brown U. [Dept. of Mathematics] Providence, R. I.

ON A PROBLEM OF HEINZ HOPF [I]. A THEOREM CONCERNING THE EXISTENCE OF DEFORMABLE CONFORMAL MAPS [II]. ASYMPTOTIC SPOTS OF ENTIRE AND MEROMORPHIC FUNCTIONS [III], by M. Heins. Feb. 1957 [35]p. incl. refs. (AFOSR-TN-56-577) (AF 18(603)70) AD 110399 Unclassified

[Part II] Also published in Ann. Math., v. 66: 430-439, Nov. 1957.

[Part III] Also published in Proc. Nat'l Acad. Science, v. 42: 883-885, 1956.

I - Establishment of a theorem concerning parabolic Riemann surfaces which, in the parabolic case and in the case of Riemann surfaces having finite topological characterstics, intrinsically contains a negative answer to the [Hopf] problem of whether a Riemann surface with nonabelian fundamental group possesses a non-trivial smooth unbounded covering surface conformally equivalent to itself. II - Establishment of a theorem stating that a hyperbolic Riemann surface belongs to the class D if, and only if, it admits nonconstant analytic functions. III - Analysis of the concept of an asymptotic spot for the special cases of entire and meromorphic functions, with particular attention given to manifestations of countability not found in the general theory and to the relation between the harmonic structure of the asymptotic spots and the growth of the mapping function.

BRO. 02:001

Brown U. Dept. of Physics, Providence, R. I.

ACOUSTIC STREAMING RESULTING FROM LOCALIZED VIBRATORY EXCITATION OF A MEMBRANE (Abstract), by F. J. Jackson and W. L. Nyborg. [1956] [1]p. (Sponsored jointly by National Institutes of Health and [Air Force Office of Scientific Research under AF 18(603)54]) Unclassified

Presented at joint meeting of Acoust. Soc. of Amer. and International Congress on Acoustics, Cambridge, Mass., June 17-23, 1956.

Published in Jour. Acoust. Soc. Amer., v. 28: 796, July 1956.

If a membrane bounding a liquid is caused to vibrate in a localized region, the fluid adjacent to it will be set into steady vortex motion. One simple way to realize this situation is to bring a vibrating metal tip of circular cross section into contact from below with a membrane which supports a small body of liquid. A characteristic (axially symmetric) vortex motion then takes place near the tip in the liquid above, as may be seen by observation with a microscope and by use of indicating particles. Particularly high accelerations and velocities exist in a ring near the tip periphery. Streaming phenomena of this kind have now been observed under a variety of situations, at frequencies varying from 100 to 40,000 cps. Because of the associated convection and viscous stress such streaming is an important secondary cause of sonic irradiation effects. (Contractor's abstract)

BRO. 03:001

Brown U. Div. of Applied Mathematics, Providence, R. I.

A THEORY OF DISCONTINUOUS, ISENTROPIC ONE-DIMENSIONAL FLOW, by R. M. Gundersen. June 1954, 32p. incl. diagrs. (Rept. no. AF-1021/1) ([AF]OSR-TN-54-147) (AF 18(600)1021) AD 51670 Unclassified

Using the method of characteristic coordinates, an analytic solution is obtained to the problem of the interaction, in an inviscid ideal gas with a constant ratio of specific heats of 5/3, of a centered rarefaction wave and a non-uniform shock of constant intensity. That is, the entropy jump is constant all along the shock with the result that the flow is isentropic on both sides of the shock.

BRO. 03:002

Brown U. Div. of Applied Mathematics, Providence, R. I.

ON AN APPROXIMATION METHOD FOR PLANE GAS FLOWS, by D. A. Beckwith. Oct. 1954, 41p. (Rept. no. AF-1021/2) ([AF]OSR-TN-54-260) (AF 18(600)-1021) AD 44389 Unclassified

A classical transformation method in the theory of linear partial-differential equations, the cascade method of Laplace, is used to construct families of hypothetical gas laws which contain arbitrarily many parameters and for which general integrals of the flow equations can be given. For simplicity in the presentation, only supersonic flows are considered. The formulas have exact counterparts in the case of subsonic flow, and these can be obtained by the introduction of complex characteristic variables.

BRO. 04:001

Brown U. Div. of Engineering, Providence, R. I.

THEORETICAL INVESTIGATION OF SUBSONIC WALL INTERFERENCE IN RECTANGULAR SLOTTED TEST SECTIONS, by P. F. Maeder. Sept. 1953, 33p. diagrs. refs. (Technical rept. no. WT-11) (AF 18(600)664; continuation of N7onr-35805) AD 23975 Declassified

A mean boundary condition for slotted walls is derived which should be valid if a large number of slots is employed. This boundary condition is used to find the general interference potential in a two-dimensional tunnel in terms of Laplace transforms of the free-flight

BRO. 04:002 - BRO. 04:006

potential. The theory is then extended to cover finite wings and bodies of revolution. Numerical work is carried out to give downwash and blockage interference on the finite wing, body of revolution, two-dimensional source, vortex, vortex pair, source-sink, etc. (Contractor's abstract)

BRO. 04:002

Brown U. Div. of Engineering, Providence, R. I.

SIMILARITY OF SLENDER BODIES AND SMALL ASPECT RATIO WING-BODY COMBINATIONS AT TRANSONIC SPEEDS (Unclassified title), by P. F. Maeder. Apr. 1954, 21p. illus. refs. (Technical rept. no. 12) (AFOSR-TN-54-104) (AF 18(600)664) AD 32704 Confidential

BRO. 04:003

Brown U. Div. of Engineering, Providence, R. I.

ASPECT RATIO INFLUENCE AT HIGH SUBSONIC SPEEDS, by G. F. Anderson. July 1954 [21]p. incl. diagrs. (Technical note no. WT-13) ([AF]OSR-TN-54-232) (AF 18(600)664) AD 49365 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 874-878, Sept. 1956.

The finite wing is considered to be composed of an infinite wing less the portions of the infinite wing which lie outside the span of the finite wing. This permits a comparison to be made of the velocities induced by thickness at corresponding points on the finite wing and infinite wing. The difference in these induced velocities on the finite wing is averaged over the span and applied as a correction to the free stream velocity. If the free stream velocity of the finite wing is corrected so that both the finite wing and the infinite wing have the same static to total pressure ratio at corresponding points in the chord-wise direction, then the force per unit span can be compared. The results of this theory are compared to some available data.

BRO. 04:004

Brown U. Div. of Engineering, Providence, R. I.

STREAM FUNCTIONS AND TRANSONIC SIMILARITY IN THREE-DIMENSIONAL FLOW, by P. F. Maeder and A. D. Wood. Oct. 1954 [50]p. incl. diagr. (Technical repl. no. WT-14) ([AF]OSR-TN-54-339) (AF 18(600)664) AD 63079 Unclassified

It is shown that the introduction of stream functions for a general three-dimensional flow is sufficient to satisfy the equation of continuity. The two-dimensional and axisymmetric stream functions are shown to be special cases of this more general approach. The differential equation which these functions must satisfy is then deduced for the special case of steady, compressible, potential flow about slender bodies at small angles of attack, assuming a perfect gas, and an isentropic, isoenergetic process, and retaining certain second order terms. This differential equation is then transformed, and an expression which relates properties on the real and transformed surfaces is developed, which is then simplified for the two special cases of two-dimensional and axisymmetric flows. If the higher order term in the differential equation is neglected, then, by proper choice of one of the constants of the transformation, the well-known similarity laws, and a new, more general law, for linearized compressible subsonic flows are obtained. If the higher order term of the differential equation is not neglected, similarity between bodies in transonic flows is established for the special cases of two-dimensional and axisymmetric flows. (Contractor's abstract)

BRO. 04:005

Brown U. [Div. of Engineering] Providence, R. I.

ON THE BOUNDARY CONDITION FOR THE FLOW ALONG A PERFORATED WALL, by P. F. Maeder and J. B. Carroll. Oct. 13, 1954, 3p. illus. [AF 18(600)664] Unclassified

Published in Jour. Aeronaut. Sciences, v. 22: 203-205, Mar. 1955.

In transonic wind-tunnel test sections, perforated walls have been used to eliminate choking. The boundary condition at a perforated wall had been investigated earlier, both theoretically and experimentally. This note presents another theoretical treatment, plus some experimental results. (Extracted from rept.)

BRO. 04:006

Brown U. Div. of Engineering, Providence, R. I.

EXPERIMENTAL INVESTIGATION OF SUBSONIC WALL INTERFERENCE IN RECTANGULAR SLOTTED TEST SECTIONS, by P. F. Maeder, G. F. Anderson, and J. B. Carroll. Jan. 1955 [31]p. incl. illus. diagrs. (Technical note no. WT-16) ([AF]OSR-TN-55-68) (AF 18(600)664) AD 64221 Unclassified

The force coefficients of 2 wing models of different size, but geometrically similar, were measured in the same slotted-wall test section. It is concluded from the experimental study that: (1) if the drag coefficients at zero angle of attack are the same for the 2 wings at the same Mach number, no buoyancy or blockage interference is present; and (2) if the theoretically evaluated angle of attack and streamline curvature correction is applied to the angle of incidence, the 2 wings should show the same corrected angle of attack to produce the same lift coefficient. The data showed that the blockage and buoyancy influence on the model in the slotted-wall test section were negligible. The theoretical angle of attack and streamline curvature correction were correct in every sense, but the magnitude of the total

correction was too small. Evidence gathered through examination of the data indicated that the error in magnitude of the total theoretical correction, was most likely contained in the evaluation of the streamline curvature correction. (Contractor's abstract)

BRO. 04:007

Brown U. Div. of Engineering, Providence, R. I.

SOME ASPECTS OF THE BEHAVIOR OF PERFORATED TRANSONIC WIND-TUNNEL WALLS, by P. F. Maeder. Sept. 1954, 20p. diagrs. (Technical rept. no. WT-15) ([AF]OSR-TN-55-116) (AF 18(600)664) AD 68442 Unclassified

Presented at Sixth meeting of the NATO-AGARD Wind-Tunnel Panel, Paris (France), Nov. 2-6, 1954.

Also published in AGARD Memorandum Papers presented at the Sixth meeting of the Wind Tunnel and Model Testing Panel, Nov. 1954, p. tt8-246.

tt is shown that, for flow past a walt containing a single transverse slot, the mean outflow vetocity and the pressure difference between the plenum chamber and the main flow are related linearly. The analysis is extended to the case of a wall containing an infinite number of infinitely small slots, and a linear relationship is again found to exist. The ratio of open to total surface necessary for zero interference on a two-dimensional doublet is shown to be independent of Mach number. The sinular behavior of such a slotted walt and a perforated walt (a result which has been verified by experiment) is utilized in the anatysis for a funnel with two finite perforated walls. The theory is devetoped for compressible flow with the aid of Goethert's rute, and the pressure distributions along the wall and centerline are deternined. The flow is atso determined for the condition at which the tunnel is choked by air entering through the perforated watts. (Contractor's abstract)

BRO. 04:008

Brown U. [Div. of Engineering] Providence, tt. t.

TRANSONtC WIND-TUNNEL TEST SECTIONS, by F. F. Maeder and A. D. Wood. Sept. 8, t955 [36]p. incl. diagrs. tables, refs. ([AF]OSR-TN-55-213) [AF 18(600)664] AD t17774 Unctassified

Also published in Zeit. Angew. Math. Phys., v. 7: 177-212, 1956.

The characteristics of various transonic wind-tunnel test sections are discussed. The subjects considered include: (1) the influence of the walts on data obtained in a wind tunnel; (2) the boundary condition along partly open walls; (3) subsonic interference in partially open test sections; and (4) supersonic interference in partially open test sections.

BRO. 04:009

Brown U. Div. of Engineering, Providence, R. I.

EXPERIMENTAL INVESTIGATION OF ASPECT RATIO INFLUENCE AT HIGH SUBSONIC AND TRANSONIC SPEEDS (Unclassified title), by G. F. Anderson and J. B. Carroll. July 1955 [30]p. incl. illus. (Technical rept. no. WT-17) (AFOSR-TN-55-242) (AF 18(600)664) AD 77494 Confidential

BRO. 04:010

Brown U. [Div. of Engineering] Providence, R. I.

SOME RESULTS OF LINEARIZED TRANSONIC FLOW ABOUT SLENDER AIRFOILS AND BODIES OF REVOLUTION, by P. F. Maeder and H. U. Thommen. Aug. 8, 1955, 2p. incl. diagrs. (AF 18(600)664) Unclassified

Published in Jour. Aeronaut. Sciences, v. 23: 187-188, Feb. 1956.

Recently Oswatitsch (Flow Around Bodies of Revolution at Mach Number One, paper presented at Brooklyn Polytechnic Institute's Conference on High-Speed Aeronautics, Jan. 20-22, t955) determined the flow about a half-body of revolution at the speed of sound by assuming part of the nonlinear term, the derivative of u in x-direction, constant, and thus linearizing the transonic equation without omitting the damping or interference term altogether. He further assumed that no disturbances shall travel upstream of the nose of the body. The result obtained in this special case agreed surprisingly well with experiments. It has been shown that the first assumption is much closer to the actual behavior of the fluid at all speeds than had been originalty supposed, and that the second assumption need not have been made at all. Certain implications of this theory are discussed. It is pointed out that all solutions of slender-body and airfoil theory, as well as wing-body combinations, which have been obtained by applying the equations of linearized subsonic or supersonic flow can be incorporated in this more generat treatment, which also yields results throughout the transonic regime. From this theory, the wett-known transonic sinularity laws follow explicitly. Some theoretical results are presented for the symmetrical airfoil and the body of revotution at zero angle of attack, and a comparison of the theory is made with experiment.

BRO. 04:011

Brown U. Div. of Engineering, Providence, R. I.

BOUNDARY-LAYER EFFECT ON LOCAL MACH NUMBER MEASUREMENTS ON A CIRCULAR ARC HALF PROFILE, by J. B. Carroll and G. F. Anderson. Oct. 31, 1955 [2]p. incl. diagrs. (AF 18(600)-664) AD 100759 Unclassified

BRO. 04:012 - BRO. 05:002

Also published in Jour. Aeronaut. Sciences, v. 23: 604-605, June 1956.

The results of an experimental investigation, conducted at the Aerodynamics Research Laboratory, Brown University, involving the case of a body (model) mounted on the wall of the wind tunnel are presented. It is seen that the boundary layer, starting its growth upstream of the model, is of appreciable thickness by the time it passes over the model. The assumption of a thin boundary layer, therefore, cannot be made, and pressure gradients must be accounted for in the local Mach number calculation. A scale drawing is given of the model, and the apparent Mach number distributions over the profile are plotted for several Mach numbers ranging from 0.80 to 0.90. For free-stream Mach numbers of 0.83 and above, there seems to exist a supersonic region about the point of maximum thickness of the profile. The data also indicates no presence of a shock wave up to a free-stream Mach number of 0.86. On the other hand, however, the results of static- and stagnation-pressure measurements taken in a vertical plane at the maximum thickness of the profile are also plotted, and these indicate that at a free-stream Mach number of 0.85 the flow is still subsonic. It is seen that at a free-stream Mach number of 0.85 an error of 6% is made in the maximum Mach number calculation if the pressure gradients are neglected. Plots are also made of the Mach number field in the region of the maximum thickness for Mach numbers of 0.85, 0.86, and 0.87, showing the progressive nature of the supersonic region.

BRO. 04:012

Brown U. [Div. of Engineering] Providence, R. I.

SOLUTIONS TO THE LINEARIZED EQUATION FOR TRANSONIC FLOWS AND THEIR COMPARISON WITH THE EXPERIMENT, by P. F. Maeder [Sept. 1956] [15]p. incl. diagrs. (AF 18(600)664) Unclassified

Published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 2 15-24, 1957.

The author verifies the solutions to the linearized transonic equation for a few simple configurations, comparing them with experimental results. A discussion of the results is included.

BRO. 05:001

Brown U. Div. of Engineering, Providence, R. I.

MEASUREMENT OF THE VISCOSITY OF FIVE GASES AT ELEVATED PRESSURES BY THE OSCILLATING-DISK METHOD, by J. Kestin and K. Pilarczyk. Aug. 5, 1953 [ ]p. incl. diagrs. table, refs. (Paper no. 53-A-67) AF 18(600)891. Unclassified

Presented at annual meeting of the Amer. Soc. of Mech. Engineers, Heat Transfer Div., New York, Nov. 29-Dec. 3, 1953.

Published in Trans. Amer. Soc. Mech. Engineers, v. 76: 987, 1954.

The paper describes the measurement of the influence of pressure on the viscosity of five commercially pure gases: air, nitrogen, hydrogen, argon, and helium, in a range up to about 70 atm (1000 psi) at room temperature (20° or 21° C). The viscosity was measured by observing the period of oscillation and the logarithmic decrement of an optically ground-quartz disk of 70-mm diam suspended on a thin rhodium-platinum wire between two fixed optically ground-quartz plates with a separation of 1 mm and performing torsional oscillations. The data were evaluated on the basis of Macwood's equations, but the instrument proved capable of a higher accuracy of measurement than the 1% inherent in the theory. The scatter of the experimental data did not exceed 0.1% and repeatability was of the same order of accuracy. In view of the mathematical difficulties no attempt is made to improve the theory of the instrument, but it is shown that the motion of the disk is nonlinear and that the relation between the period of oscillation and the logarithmic decrement is not that which would be expected on the assumption of simple damped harmonic motion. (Contractor's abstract)

BRO. 05:002

Brown U. Div. of Engineering, Providence, R. I.

SLOW OSCILLATIONS OF AN INFINITE PLATE AND AN INFINITE DISK IN A VISCOUS FLUID, by J. Kestin and I. N. Persen. June 1954, 101p. incl. diagrs., tables, refs. (Technical rept. no. 1; rept. no. AF-891/1) ([AF]OSR-TN-54-151) (AF 18(600)891) AD 37677 Unclassified

It is shown that both physical problems correspond to an identical mathematical problem if the axial velocity component in the fluid is neglected in the case of the disk. This problem is solved rigorously and in closed terms by Laplace transforms. Exact solutions are given for the general case when the body oscillates between two fixed plates as well as for the limiting case of infinite spacing. The motion of the body is described in detail, and it is shown that it does not correspond to that predicted by the classical linearized theory; in particular the strong influence of fluid density is demonstrated. Simplified solutions for small values of viscosity and density indicate (1) that the body moves with an apparent increase in its mass or moment of inertia; and (2) that its damping corresponds to a linear velocity distribution in the fluid over the depth of penetration of a viscous wave for very large spacings. Equations suitable for viscometry viscometry are deduced and compared with published experimental data. It is shown that it is possible to determine viscosity by measuring the period or loga-

rithmic decrement alone, and that the principle can be used for the determination of viscosity and density simultaneously.

BRO . 05:003

Brown U. Div. of Engineering, Providence, R. I.

THREE PAPERS ON THE THEORY OF THE OSCILLATING CUP VISCOMETER, by E. G. Shvidkovskii, A. M. Butov, and L. S. Priss, tr. by J. Kestin. Oct. 1954, 40p. incl. diagrs. tables. (Rept. no. AF-891/4) ([AF]OSR-TN-54-315) (AF 18(600)891) AD 48560 Unclassified

The present is an abbreviated translation of three papers dealing with the theory of oscillating cup viscometers. The references in question are: E. G. Shvidkovskii, Uchenye Zapiski MGU (Moscow University), v. 74: 135-144, 1944; A. M. Butov, L. S. Priss, and E. G. Shvidkovskii, Zhur. Tekh. Fiz., v. 21: 1319-1324, 1951; and L. S. Priss, Zhur. Tekh. Fiz., v. 21: 1050-1061, 1952. So far the oscillating cup viscometer has been used mainly in connection with liquids and in particular in connection with molten metals. At the present time there seems to be a great need to develop alternative methods of measuring the viscosity of gases, particularly at high pressures and temperatures. A critical review of existing methods reveals that, apart from capillary transpiration methods, those based on the oscillatory motion of a body offer certain advantages which should be explored. It has been shown in previous reports in this series that the theory of the oscillating disk viscometer presents considerable difficulties particularly in the matter of the edge correction. Consequently it is thought that methods based on the oscillations of a container filled with the gas should also be explored. (Contractor's abstract)

BRO. 05:004

Brown U. Div. of Engineering, Providence, R. I.

SMALL OSCILLATIONS OF BODIES OF REVOLUTION IN A VISCOUS FLUID, by J. Kestin and L. N. Persen. Oct. 1954, 59p. incl. diagrs. tables, refs. (Technical rept. no. 2; rept. no. AF-891/2) ([AF]OSR-TN-54-326) (AF 18(600)891) AD 48559 Unclassified

Solutions are presented of the Navier-Stokes equations for oscillating bodies under the assumption that the body performs small oscillations in a viscous fluid under the influence of an elastic restoring force or couple. The particular cases studied include an infinite cylinder, a sphere, and a pile of disks. All of the problems are solved by the Laplace transform method, and the cases analyzed, as well as those previously discussed, are summarized in one general equation. In all cases of practical importance, the motion consists of a damped harmonic oscillation and a transient term whose importance is confined to the first few initial beats. The motion becomes isochronous with a logarithmic decrement. (ASTIA abstract)

BRO. 05:005

Brown U. Div. of Engineering, Providence, R. I.

THE INFLUENCE OF EDGES ON SHEARING STRESSES IN VISCOUS LAMINAR FLOW, by J. Kestin and L. N. Persen. June 1955, 57p. incl. diagrs. tables, and refs. (Technical rept. no. 3) ([AF]OSR-TN-55-195) (AF 18(600)891) AD 63134 Unclassified

A study is made of the influence exerted by the existence of thin edges on slow laminar flow patterns. The following cases are solved: (a) an infinitely thin strip sliding within an elliptic cylinder; (b) an infinitely thin disk rotating within an ellipsoid of revolution; (c) a semi-infinite infinitely thin plate sliding between 2 parallel fixed plates; (d) an infinitely thin disk of finite radius rotating between 2 parallel fixed plates (approximate); and (e) an infinitely thin disk of finite radius rotating in an infinite fluid. It is found that the velocity gradient for the 2-dimensional cases and the gradient of angular velocity for the axially symmetrical cases have singularities at an edge (increasing to infinity like $1/\sqrt{x}$, where x is the distance from the edge). The "edge effect", i.e., the ratio of the viscous force or of the viscous moment to that which would act on the same body on the assumption that the body forms part of one of infinite extent, varies from close to 1.0 to 1.6 depending on the actual geometrical arrangement. It increases with increasing separation between the moving and fixed walls. In steady motion, this ratio is independent of the properties of the fluid. (Contractor's abstract)

BRO. 05:006

Brown U. Div. of Engineering, Providence, R. I.

CORRECTIONS FOR THE OSCILLATING DISK VISCOMETER, by J. Kestin and H.-E. Wang. Dec. 1955, 65p. incl. diagrs. tables, refs. (Technical rept. no. 5) ([AF]OSR-TN-55-467) (AF 18(600)891) AD 82740 Unclassified

Presented at annual meeting of the Amer. Soc. Mech. Engineers, New York, Nov. 25-30, 1956.

Also published in Jour. Appl. Mech., v. 24. 197-206, June 1957.

An exact theory, based on work by Kestin and Persen is given of the finite- and of the infinite-spacing arrangement of the oscillating disk viscometer. The equations allow for the effects of wire damping, unequal spacing, side drag, drag on the rod carrying the mirror, and the main viscous drag on the flat faces; the edge effect, however, is excluded. An empirical method is given for obtaining the edge correction as a correction factor C applied to the ideal

BRO. 05:007 - BRO. 05:009

viscous moment M so that the actual moment is given by $M_f = CM_{xx}$. The analysis shows that, for a given arrangement, C is a function of the radius R_0 expressed in terms of the boundary-layer thickness δ so that $C = (\delta/R_0)$. Experiments by Kestin and Pilarczyk (Trans. Amer. Soc. Mech. Engineers, v. 76: 987, 1954) with a finite-spacing viscometer show good agreement with theory in that points for several gases trace the relation $C(\delta/R_0)$ with a minimum of scatter and with the predicted behavior at 2 extremes.

BRO. 05:007

Brown U. Div. of Engineering, Providence, R. I.

THE VISCOSITY OF FIVE GASES: A RE-EVALUATION, by J. Kestin and H.-E. Wang. Mar. 1956, 23p. incl. diagrs. table, refs. (Technical rept. no. AF-891/6) (AFOSR-TN-56-98) (AF 18(600)891) AD 82011 Unclassified

Presented at annual meeting of the Amer. Soc. Mech. Engineers, New York, Nov. 25-30, 1956.

Also published in Trans. Amer. Soc. Mech. Engineers, v. 80: 11-17, Jan. 1958.

This study contains a re-evaluation of the experimental results for the pressure dependence of viscosity obtained by Pilarczyk and described by Kestin and Pilarczyk. The re-evaluation is based on an improved theory of the oscillating disk viscometer described by Kestin and Wang (see item no. BRO. 05:006). The results for air, N_2, A, He, and H_2 are given in graphical and tabular form, as well as in the form of empirical equations. The range covered is 1 to 70 atm at 25°C. The results constitute a relative measurement which is based on Gibson and Michels' data for N_2. Very good agreement with previously published data for N_2, air, and H_2 has been reported. In the case of He, no comparative data could be found and in the case of A there is good agreement with the data published by Michels and others, but the difference in absolute values is somewhat higher than the preceding 3 gases. The agreement as to rate of change with pressure is excellent. It is believed that the data now reported contain an uncertainty of no more than 0.2% for N_2, air, H_2, and He and of not more than 0.6% for A with respect to N_2. (Contractor's abstract)

BRO. 05:008

Brown U. [Div. of Engineering] Providence, R. I.

SLOW OSCILLATIONS OF BODIES OF REVOLUTION IN A VISCOUS FLUID, by J. Kestin and I. N. Persen. July 1956 [10p. refs. (AFOSR TN-56-372)] (AF 18 (600)891) AD 95808 Unclassified

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 3: 326-338, 1957.

The paper concerns itself, first, with small oscillations performed by an infinite plate moving in its own plane and an infinite circular disk performing torsional oscillations under the influence of an elastic force or couple. It is shown that both physical problems correspond to an identical mathematical problem if the axial velocity component in the fluid is neglected in the case of the disk. The mathematical problem is solved rigorously and in closed terms by the use of the Laplace transform, and the solution includes the initial transient of the motion. Exact solutions are given for an oscillation between 2 fixed plates as well as for the limiting case of infinite spacing. The motion of the body is described in detail and it is shown that the damping force or couple is not proportional to the velocity. The damping term depends both on the viscosity and on the density of the surrounding fluid. The motion performed by the body consists of a damped harmonic oscillation superimposed on a drifting zero position. For small values of viscosity and density simplified solutions are obtained. These lead to the conclusion that the body moves with an apparent increase in its mass or moment of inertia and that its damping corresponds to a linear distribution of velocity over the spacing, and to a linear velocity distribution over the boundary layer in the case of infinite spacing. Relations are deduced which for a given system must be satisfied by the period of the motion and the logarithmic decrement of damping independently of the properties of the fluid. The same methods of analysis are then applied to spheres and infinite cylinders oscillating either in free space, or in concentric fixed spheres or cylinders. Cylinders and spheres filled with a fluid and piles of disks are also considered. In all cases the motion exhibits the same features as in the simple case discussed in detail at the beginning. (Contractor's abstract, modified)

BRO. 05:009

Brown U. Div. of Engineering, Providence, R. I.

ON THE MEASUREMENT OF THE VISCOSITY OF STEAM BY THE OBSERVATION OF SMALL OSCILLATIONS, by J. Kestin and J. R. Moszynski. May 1956, 50p. incl. diagrs. table, refs. (Rept. no. SPR-1) (AF 18(600)891) Unclassified

Presented at Fifth International Conference on Steam Properties, London (England), July 10-12, 1956.

Measurements of the viscosity of steam were made up to 300 atm and 500°C with the aid of oscillating systems. A general outline is presented of the principle of the method and of the theoretical results available for the evaluation of the measurements. It is shown that complete and exact equations can be obtained for the oscillatory motion of rotationally symmetrical, smooth bodies, e.g., spheres, so that absolute determinations can be made with them. In the case of the more common disks, no exact theory is in existence, the difficulty arising from edge effects, and only relative measurements can be performed.

Since, however, the damping suffered by a sphere under given conditions is much less than that for a disk, it is necessary to achieve a compromise between measuring accuracy and the desirability of making absolute measurements. For these reasons, both relative measurements with disks and absolute spot checks with a sphere are envisaged. A detailed description is given of the instrument designed to carry out the measurements. It consists of a high-pressure bomb made of stainless steel, sealed with the aid of tie bolts made of Inconel X, and provided with a synthetic sapphire Bridgman-type window. The oscillating system is enclosed in the bomb and carries a reflecting mirror. The bomb is mounted on a sapphire ball bearing and is enclosed in an automatically-controlled heater surrounded by a manually-controlled radiation shield. The bomb is filled with water under a moderate vacuum, and steam is raised inside it. The oscillation is started by rotating the bomb on its bearing, and is observed by a telescope which is trained on a precision back-lighted scale through the mirror which oscillates with the suspension system. Temperatures are measured with the aid of calibrated thermocouples, and pressures are measured with a set of precision Bourdon gauges. Time is measured with the aid of an electronic counter actuated by a suitable time-base signal through a photoelectrically operated thyraton trigger which, in turn, operates the gates of the counter. (Contractor's abstract, modified)

BRO. 06:001

Brown U. Div. of Engineering, Providence, R. I.

THEORY OF THE OSCILLATING CUP VISCOMETER, by G. F. Newell, J. Kestin, and D. A. Beckwith. May 1956, 109p. incl. diagrs. table, refs. (Technical repl. no. 7; repl. no. AF-891/7) (AFOSR-TN-56-210) (AF 18(600)1548) AD 87524 Unclassified

Also published in Zelt. Angew. Math. Phys., v. 8: 433-465, Nov. 25, 1957. (Title varies)

The complete theory of the oscillating cup viscometer is given. The viscometer consists of a cylindrical cup of finite height and is filled with fluid whose viscosity is to be measured. The cup is suspended axially by an elastic wire and performs torsional oscillations. The oscillation is assumed to be slow so that the linearized Navier-Stokes equations are used. An exact solution which includes the effect of the sharp corners is given and then modified so that it can be used for the evaluation of experimental results. The limitations on design which are due to the limitations on easily measurable decrements are described. (Contractor's abstract)

BRO. 07:001

Brown U. Engineering Research Lab.] Providence, R. I.

SUPERSONIC WIND TUNNEL LOSSES, by A. W. McCoy, R. B. Dowdell, and P. F. Maeder. Dec. 1949, 153p. incl. illus. diagrs. tables. (Technical rept. no. WT-1) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-35805 and Air Materiel Command, Wright-Patterson Air Force Base, Ohio under W33-038-ac-22027] ATI-136970 Unclassified

The object of this report is to furnish design information regarding the pressure losses and boundary layer corrections for supersonic wind tunnel in the Mach number range $1.5 < M_T < 5.0$. A distinction had to be made between the tunnel with conventional subsonic diffusers only, and the tunnel with various types of supersonic-subsonic diffusers. As may be expected, the operating losses are reduced greatly by the use of a supersonic-subsonic diffuser, while a corresponding reduction of the starting losses, employing new wind tunnel starting methods, will depend on further investigations which are briefly discussed in this report. For example, at a test section Mach number $M_T = 3.5$ and a Reynolds number of 10^7, the operating pressure ratio can be reduced from 6.25 to 2.55 by the use of a supersonic-subsonic diffuser. The different types of diffusers discussed are the shock free diffusers (merely a reversed nozzle) and the diffusers with one and two oblique compression shocks. The calculations show that the diffuser with one oblique shock is superior to the shock free diffuser in the range $1.5 < M_T < 3.9$ at $Re = 10^7$ because of the large friction losses occurring in the latter. The results are presented in graphical and tabular form in terms of general wind tunnel parameters. For a test section Reynolds number of 10^7, we obtain, for example, an aerodynamic energy ratio of 4 for $M_T = 3$ if a supersonic diffuser is used and only $M = 1.9$ if a conventional diffuser with no supersonic contraction is employed. (Contractor's summary)

BRO. 07:002

Brown U. [Engineering Research Lab.] Providence, R. I.

THE 9-INCH BY 9-INCH TRANSONIC-SUPERSONIC WIND TUNNEL, by G. F. Anderson and P. F. Maeder. June 1950, 1v. incl. illus. diagrs. (Technical repl. no. WT-2) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N7onr-35805) ATI-78083; UI1509 Unclassified

The tunnel consists of a modified JUMO 004 compressor driven by a wound rotor induction motor through a 1:6 step-up gear, two air coolers, the test section, the ejector by-pass, and the necessary piping. It is of the closed-circuit, variable-density type which provides utmost flexibility.

BRO. 07:003

Brown U. Engineering Research Lab., Providence, R. I.

NOTE ON DEBLOCKED TRANSONIC TEST SECTIONS, by P. F. Maeder. May 5, 1950. 4 l. p. incl. diagrs.

tables. (Technical rept. no. WT-4) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N7onr-35805) ATI-78072 Declassified

Theoretical calculations were made to form the basis for experimental investigations of the blocking effects, encountered in wind tunnel testing in the transonic range of flow, and their elimination. The tunnel wall was assumed to have slots in the flow direction, to compensate for the blocking effects of the closed portions. A method was then developed to determine the size of the openings in the case of a rectangular model section containing either wings of finite or infinite span, or bodies of revolution. The pressure distribution at the walls was also computed. The results seem very satisfactory, and justify an experimental investigation to find the influence of the boundary layer and the behavior of the model section outside the range of validity of the linearized theory. (Contractor's abstract)

BRO. 07:004

Brown U. [Engineering Research Lab.] Providence, R. I.

INVESTIGATION OF TURBULENCE IN THE BROWN UNIVERSITY 9-INCH BY 9-INCH TRANSONIC-SUPERSONIC WIND TUNNEL, by W. G. Reynolds. Jan. 1951 [44]p. incl. diagrs. refs. (Technical rept. no. WT-5) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research] under N7onr-35805] U21815; ATI-150162 Unclassified

Results of the turbulence tests taken in the 9-in. by 9-in. variable density wind tunnel, indicate that the percent turbulence is not only within tolerable limits for practical testing purposes, but is, in fact, quite low for this type of tunnel. It is also apparent that the finned round tube aftercooler also serves as a satisfactory straightener for the flow. This was indicated through previous measurements (WT-2) of energy variations across the model section. (Contractor's abstract)

BRO. 07:005

Brown U. [Engineering Research Lab.] Providence, R. I.

INVESTIGATION OF TUNNEL BOUNDARY INTERFERENCE ON TWO DIMENSIONAL AIRFOILS NEAR THE SPEED OF SOUND, by T. F. Maeder. Apr. 1951, 117p. incl. diagrs. refs. (Technical rept. no. WT-6) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-35805) U68721; ATI-105885 Declassified

This report describes the theoretical and experimental investigations of the blockage effects encountered in testing two-dimensional wings in wind tunnels close to the speed of sound. The experimental investigation showed that blockage corrections, according to the semi-experimental method described in this report, could be applied to test results obtained in a closed model section if the local supersonic region is not too large. As a working rule, it has been found that the supersonic region should not exceed in height one quarter of the tunnel height if such corrections are to be applied with any degree of accuracy. The results of the experimental investigation, carried out to determine the deblocking effects of slotted walls are summarized as follows: (1) so long as the local supersonic region is not too large, i.e., about the same condition as holds true for applicability of corrections, the wall configuration calculated (presented in a previous rept., see item no. BRO. 07:003) yield test results with no wall interference; (2) as the local supersonic region becomes larger, the slots will have to be wider to deblock the rear portion of the airfoil; and (3) the effects of variation of slot width on the front portion of the airfoil are small. (Contractor's conclusions, modified)

BRO. 07:006

Brown U. Engineering Research Lab., Providence, R. I.

DESIGN OF THE AIR-DRYING UNIT FOR THE BROWN UNIVERSITY 9-INCH BY 9-INCH TRANSONIC-SUPERSONIC WIND TUNNEL, by G. F. Anderson. May 1951, 49p. incl. diagrs. (Technical rept. no. WT-7) (Sponsored jointly by [Air Force] Office of Scientific Research and Office of Naval Research under N7onr-35805) ATI-108647; U18799 Unclassified

A description is given of the design of the air-drying installation for the 9-in. by 9-in. transonic-supersonic wind tunnel at Brown University.

BRO. 07:007

Brown U. Engineering Research Lab., Providence, R. I.

INVESTIGATION OF LOSSES IN WIND TUNNEL TEST SECTIONS FITTED WITH SLOTTED WALLS, by D. Adamson and J. B. Carroll. Sept. 1952, 1v. incl. diagrs. table. (Technical rept. no. WT-8) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-35805) ATI-171229; U68722 Declassified

A detailed description is presented of tests made to determine the losses in wind tunnel test sections fitted with slotted walls. The tests illustrate 2 important results: (1) the increased range of Mach numbers obtainable with slotted walls in the transonic range; and (2) the increased working section losses associated with the use of slotted test section walls. For smaller tunnels, these increased losses may present no serious consequences. However, their use in larger tunnels may necessitate a prohibitively large power requirement. From previous work it was determined that the slot width is an important parameter of the deblocking ability of a slotted wall; therefore, since the larger losses are associated with the larger slots, some compromises may have to be made in choosing

the particular wall conftguration to be used. (Contractor's abstract, modified)

BRO. 07:008

Brown U. Engineering Research Lab., Providence, R. I.

INVESTIGATION OF THE BOUNDARY CONDITION AT A PERFORATED WALL, by P. F. Maeder. May 1953 [33]p. inct. diagrs. table. (Technical rept. no. WT-9) (Sponsored jointly by Offtce of Naval Research and [Air Force] Office of Sctentiftc Research under N7onr-35805) AD 14022 Declassified

The boundary condition to be applied to the flow along a perforated walt is tnvestigated theoretically using potential flow theory. The theory is confirmed by subsequent experiments with a low speed tunnet. The boundary condition thus found is linear and nonquadratic as was previousty supposed.

BRO. 07:009

Brown U. Engineering Research Lab., Providence, R. I.

INVESTIGATION OF THE FLOW THROUGH A PERFORATED WALL, by P. F. Maeder and J. F. Stapelton. May 1953 [22]p. incl. diagrs. (Technical rept. no. WT-t0) (Sponsored jotntly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-35805; continued by AF 18(600)664) AD 16589 Declassifted

The ftow through a perforated walt is tnvestigated using a modified form of Tollmien's solution for a free jet. The results of experiments indicate that this type of flow is a mixing phenomenon, and that the Reynolds number is of secondary importance. (Contractor's abstract)

BRO. 08:00t

Brown U. Metals Research Lab., Providence, R. I.

THE INFLUENCE OF DEFINED SMALL AMOUNTS OF IMPURITIES ON THE RECRYSTALLIZATION OF ALUMINUM, by K. Detert and K. Lücke. Mar. 1, 1956 [32]p. incl. itlus. diagrs. tables. (Rept. no. AF-1495/1) (AFOSR-TN-56-103) (AF 18(600)1495) AD 82016 Unclassifled

The influence of small additions (0.008 to 0.14%) of Fe, Cu, Si, Mg, and Ag upon the recrystallization of high purity Al after rolling of 40% and 90% has been investigated with the help of the x-ray method described by Nölting and Lücke. In atl cases, recrystallization is delayed by the impurities. The effect of Fe is the largest, additions of the order of 1/100% increases the recrystallization temperature by 210°C and decreases the rate of recrystallization by a factor up to 10^{11}. For Cu, Si, and Mg, values of the order of 150°C and 10^{7} were obtained. The effect of Ag ts very much smaller. The activation energy seems to decrease with tncreasing amount of tmpurity. It can be shown that the effect ts caused by the foreign atoms in solid solution and not by those in precipitations, due to direct tnteraction between the boundaries and the foretgn atoms rather than a difference between the deformed states of the pure and tmpure metal. The rates of nucteation and growth are diminished by the impurities; for small additions, both are affected nearty by the same factor. (Contractor's abstract)

BRO. 08:002

Brown U. Metals Research Lab., Providence, R. I.

A QUANTITATIVE THEORY OF GRAIN-BOUNDARY MOVEMENT AND RECRYSTALLIZATION IN METALS IN THE PRESENCE OF IMPURITIES, by K. Lücke and K. Detert. Apr. 15, 1956 [29]p. tnct. diagrs. tabtes, refs. (Rept. no. AF-1495/2) (AFOSR-TN-56-164) (AF 18(600)1495) AD 36585 Unctassifted

Also published in Acta Metalturgica, v. 5: 628-637, Nov. 1957.

The experimental facts concerning the tnfluence of small amounts of impurities upon recrystallization are briefly reviewed and a quantitative atomistic theory of these phenomena has been developed. In this theory it ts assumed that interaction forces exist between the foreign atoms tn solid sotution and the boundary, tncreasing the concentration of foretgn atoms in the boundary. At high concentrations (or tow temperatures), the moving boundaries are hetd back by the foreign atoms and the speed of the boundary ts controlled by the speed of the foretgn atoms diffusing behind the boundary. At tow concentrations (or high temperatures), the boundary cannot be hetd by the foretgn atoms; breakaway occurs and the boundary moves much faster. Betow the critical concentration for which breakaway just occurs, the recrystallization temperature drops much faster with decreasing concentration than it does above this concentration. The quantitative formulation of these ideas teads to expressions for the ahsolute rate of boundary nigration, its temperature dependence, the activation energy of recrystallization, and etc. They agree very well with the experimental results so far available. The fact that the influence of a foreign etement upon the rate of recrystallization increases with increasing difference in atomic radius between the solute and the basic metal shows the interaction between boundary and foreign atoms is largely of elastic nature. Further experiments to check the theory more thoroughly are outlined.

BRO. 08:003

Brown U. Metals Research Lab., Providence, R. I.

INTERNAL FRICTION PHENOMENA DUE TO DISLOCATIONS, by K. Lücke and A. Granato. Sept.

BMB. 01:001 - BMB. 02:003

1956 [33]p. tncl. diagrs. refs. [AF 18(600)1495]
Unclassified

Published In Proc. International Conference on Dislocations and Mechanical Properties of Crystals, Lake Placid, N. Y. (Sept. 6-8, 1956), N. Y., John Wtley & Sons, Inc., 1957, p. 425-427.

A general survey ls presented of the damping of dislocation motion ln metals presumably due to dislocations ln different frequency ranges, as well as that shown to be due to dislocations tn experiments on the effects of plastic deformation, orientation, and tmpurities tn metals. Various theories concerning the dampmg phenomena are considered tncludmg the pinned dislocation model developed by the authors. This model ls based on restrictions to dislocation motion effected by nodes of the dislocation network and by tmpurities. Dertved mathematical expressions are applied to the available experimental data with regard to strain-amplitude dependent damping and to residual damping at low strain amplitudes.

BMB. 0t:00t

Bureau of Mines, Bartlesville, Okla.

THE COMBUSTION CALORIMETRY OF ORGANO-FLUORINE COMPOUNDS. THE HEAT OF FORMATION OF FLUOROBENZENE, by W. D. Good, D. W. Scott and others. [1954] [13]p. tncl. diagr. tables. [CSO-630-55-47] Unclassified

A method ls described for the determination of the heats of combustion and formation of nongaseous fluorocarbons. A method of comparative measurements ls used to minimize experimental uncertainties and the magnitude of the Washburn corrections. Two types of experiments are performed: (t) a sample of the liquid compound, contained tn a sealed Vycor ampoule ts burned in a Pt-lined rotating combustion bomb containing approximately t0 ml of water; (2) benzoic actd and auxiltary hydrocarbon otl are burned tn the same bomb containing about t0 ml HF (aqueous) and a dummy Vycor ampoule. The relative amounts of reactants are adjusted so that the energy release and products (mainly CO_2 and llF (aqueous)) tn the 2 experiments are essentially tdentical. Thermochemical corrections are applied for the small amount oi Vycor which ls dissolved by llF (aqueous). A procedure ts given for the chenucal analysis of the bomb products. Application of the method to C_6H_5F ts describe', and the heat of the reaction $C_6H_5F(l) + 7\ O_2(g) + 58\ H_2O(l) = 6\ CO_2(g) + HF \cdot 60\ H_2O(l)$ ls given. The standard heat of formation of C_6H_5F ln the liquid state at 25° from graphite, ll (g) and F (g) is also given. It is believed that the results obtained are more accurate than old literature values. (Contractor's abstract)

BMB. 02: 00t

Bureau of Mines, Bartlesville, Okla.

HEAT OF FORMATION OF TETRAFLUOROMETHANE FROM COMBUSTION CALORIMETRY POLYTETRAFLUOROETHYLENE, by D. W. Scott, W. D. Good, and G. Waddington. Aug. 1954, 3p. (Rept. no. 48; proj. no. Chem. 30-6) ([AF]OSR-TN-54-238) [CSO-680-57-4] AD 49133 Unclassified

For the reaction, C_2F_4(solid polymer) + $O_2(g)$ + $42(t-x)\ H_2O(l) = (2-x)\ CO_2(g) + CF_4(g) + 4(1-x)\ HF \cdot 10H_2O(l)$, $\Delta H^\circ_{298.16} = 160.3_4 + 41.5_5\ x$ kcal monomole^{-1}, where x ts the fraction of F that appears in the products as CF_4. Derived values of the heats of hydrolysis and formation of CF_4 are $CF_4(g) + 42\ H_2O(t) = CO_2(g) + 4\ HF \cdot 10H_2O(l)$, $\Delta H^\circ_{298.16} = -41.5 \pm 1.0$ kcal mole^{-1}; and C(graphite) + $2F_2(g) = CF_4(g)$, $\Delta H^\circ_{298.16} = -218._3$ kcal mole^{-1}. (ASTIA abstract)

BMB. 02:002

Bureau of Mines, Bartlesville, Okla.

THERMOCHEMISTRY AND THE THERMODYNAMIC PROPERTIES OF SUBSTANCES, by D. W. Scott. [1955] [25]p. lncl. tables, refs. [CSO-680-57-4] Unclassified

Published tn Ann. Rev. Phys. Chem., v. 6: 1-24, 1955.

A reviewts made of recent publications (up to and tncluding 1954) on thermochemistry and chemical thermodynamics of substances ln their solid, liquid, or gaseous states at one atmosphere pressure. The contributions of thermodynamics to the study of molecular and crystal structure and to other ttelds of physical chemistry are excluded. Measured or calculated thermodynamic properties of organic and of tnorganic compounds as well as tnorganic equilibria studied are tabulated wtth reference to the 178 significant papers covered by the review.

BMB. 02:003

Bureau of Mines, Bartlesville, Okla.

COMBUSTION CALORIMETRY OF ORGANIC FLUORINE COMPOUNDS BY A ROTATING-BOMB METHOD, by W. D. Good, D. W. Scott, and G. Waddington. Dec. 1955 [43]p. incl. diagrs. tables, refs. (Rept. no. 56) ([AF]OSR-TN-56-10) [CSO-680-57-4] AD 81991 Unclassified

Also published in Jour. Phys. Chem., v. 60: 1080-1089, Aug. 1956.

In this chemical study, a rotating-bomb method was developed for the combustion calorimetry of organic fluortne compounds. Since conventional methods of handling volatile samples could not be used, a special

technique utilizing sealed, fused-quartz ampoules was devised. The following values, in kcal mole^{-1}, are reported for the standard heats of formation, $\Delta HF^{\circ}_{298.16}$, of some organic fluorine compounds formed from graphite and gaseous hydrogen, oxygen and fluorine: o-fluorobenzoic acid (c), -134.3_8; m-fluorobenzoic acid (c), -137.8_4; p-fluorobenzoic acid (c), -138.9_5; fluorobenzene (liq), -34.7_5; benzotrifluoride (liq), -147.8_5 and polytetrafluoroethylene (granular, no heat treatment), $-1^{\sim}3.5$. p-Fluorobenzoic acid is proposed as a reference substance for intercomparison of bomb-calorimetric data for fluorine compounds among different laboratories. (Contractor's abstract, modified)

BMB. 02:004

Bureau of Mines, Bartlesville, Okla.

FLUOROBENZENE: THERMODYNAMIC PROPERTIES IN THE SOLID, LIQUID AND VAPOR STATES; A REVISED VIBRATIONAL ASSIGNMENT, by D. W. Scott, J. P. McCullough and others. May 2, 1956, 29p. incl. diagr. tables, refs. (Contribution no. 58) (AFOSR-TN-56-170) (CSO-630-55-47 and CSO-680-57-4) AD 86592 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 5457-5463, Nov. 5, 1956.

Studies were made of fluorobenzene by low-temperature calorimetry, comparative ebulliometry, flow-calorimetry, and combustion calorimetry to obtain values of the standard entropy, heat capacity, and heat of formation of the vapor. A revised vibrational assignment, consistent with the calorimetric values of vapor heat capacity, was made and used with other molecular structure data to compute values of thermodynamic functions at selected temperatures between 0° and 1500°K. Values of the heat, free energy, and logarithm of the equilibrium constant of formation were computed for the same selected temperatures. The experimental studies yielded the following information: Values of the heat capacity for the solid [t4° to 225°K], the liquid [C_{satd} = 39.496 - 0.t3777 T + 5.7tt3 x t0^{-4} T^2 - 5.3644 x t0^{-7} T^3 cal deg^{-t} mol^{-1} (230° to 350°K)] and the vapor [C°_p = 6.581 + 0.1t589 T - 6.t22 x 10^{-5} T^2 cal deg^{-t} mol^{-t} (343° to 500°K)]; the heat of fusion [2702.0 cal mot^{-1}] at the triple point [230.94 ± 0.05°K]; the entropy of the liquid at 298.t6°K [S_{satd} = 49.22 cal deg^{-1} mol^{-t}]; the heat of vaporization [Δ Hv = t0689 - 3.850 T - t.448 x t0^{-2} T^2 cal mol^{-1} (3t8° to 382°K)]; the second virial coefficient in the equation of state, PV = RT(t + B/V, [B = 2t2 - 158.6 exp (750/T) cc mot^{-t} (3t8° to 500°K)]; the vapor pressure [$\log_{t0}$p (mm) = 6.95208 - 1248.083/(t + 22t.827), (39° to t20°)]; and the standard heat of formation of liquid fluorobenzene at 298.16°K [-34.7_5 kcal mot^{-1}]. (Contractor's abstract)

BMP. 01:001

Bureau of Mines, Pittsburgh, Pa.

PHOTOGRAPHIC STUDIES OF TURBULENT FLAME STRUCTURE, by J. Grumer, J. M. Singer and others. Sept. 16, 1955 [25]p. incl. illus. diagrs. table, refs. (Technical rept. no. 1190) ([AF]OSR-TN-55-332) (CSO-630-55-29) AD 84391 Unclassified

The concept that the turbulent flame brush is composed of a fluctuating, wrinkled, essentially continuous, laminar combustion wave is mainly supported in the literature by very short duration schlieren, shadow, and smoke photographs of the brush. This concept has been the basis of published theories of turbulent burning velocity, flame-generated turbulence and stability of turbulent flames. Previously reported tests of these theories appear inconclusive. New experiments, bearing on schlieren photography, reveal the technique to be ambiguous at best in revealing the structure of the turbulent brush. Observed density gradients were found to have apparent velocities greater than the turbulence intensity, laminar burning velocity and cold approach flow; to change with turning of the schlieren knife-edge; to be different for turbulent flames piloted by a laminar hydrogen-air flame and those piloted by heating the port electrically; and to be present in the absence of turbulent flame, provided that a pilot and a turbulent air stream were on. It is concluded from these and other observations that schlieren photography (and very likely shadow and smoke photography) as previously employed does not prove the existence of a wrinkled laminar wave in the brush. In addition, direct photographs of a 10,000-Reynolds number turbulent brush, at 1 and 2 msec exposure time, are evaluated as being nonsupporting and contradictory to both the wrinkled, fluctuating laminar wave and continuous reaction zone concepts of turbulent burning, but compatible with one of discontinuous flamelets.

BMP. 01:002

Bureau of Mines, Pittsburgh, Pa.

SCHLIEREN AND DIRECT PHOTOGRAPHIC STUDIES OF THE TURBULENT FLAME STRUCTURE, by J. Grumer. June t956 [2]p. (CSO-630-55-29) Unclassified

Published in Jet Propulsion, v. 26: 48t-482, June t956.

The concept that the turbulent flame brush is composed of a fluctuating, wrinkled, essentialty continuous, laminar combustion wave is questioned. New experiments, bearing on schlieren photography, reveal the technique to be ambiguous at best in revealing the structure of the turbulent flame brush. Smoke photography, though not as extensively studied as schlieren, is also questioned as a technique for elucidating the structure of the turbulent flame brush because of con-

celvable uncertainties arising from the interaction of lncident light and the amount and particle sizing of the smoke, temperature and delay time for vanishing the smoke, plckup of radiant heat, and possible chemical reaction between smoke and flame. These observations point to tlie conclusion that schlieren photography (and very likely shadow and smoke photography) as previously employed does not prove the existence of a wrinkled laminar wave tn the brush. Latest experlments lndicate that the brush is made of discontinuous flamelets of varying intensity, most of which are inclined nearly parallel to the flow.

Bureau of Mines, Pittsburgh, Pa.

CSO-670-54-9, N6ori-10503, and NAonr-25-47, Project Squid <u>see under</u> Princeton U. James Forrestal Research Center, N. J. (Project SQUID) <u>item nos.</u> PRI. 11:001 - PRI. 11:022.

BMP. 02:001

Bureau of Mines. Div. of Explosives Technology, Pittsburgh, Pa.

CHEMICAL KINETICS OF OXIDATtON OF FUELS, by D. S. Burgess. Final rept. July 1, 1955, 10p. refs. (Rept. no. 3457) (Sponsored jointly by Air Matertel Command, Wright-Patterson Air Force Base, and [Air Force] Office of Scientific Research under CSO-670-54-9, Unclassified

The objectives of and accomplishments regarding the following investigations are reviewed: (1) the study of the chemical kinetics of oxidation reactions; and (2) the study of the role of velocity gradients in turbulent flame propagation.

BMP. 03:001

Bureau of Mines. [Div. of Explosives Technology] Pittsburgh, Pa.

APPLICATIONS OF THE ELECTRONIC PROBE TO THE STUDY OF TURBULENT FLAMES, by D. W. Denniston, Jr., J. R. Oxendine and others. Mar. 26, 1956 [25]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 1201) (AFOSR-TN-56-173) (CSO-680-56-16) AD 86596 Unclassified

A description is given of a negatively biased bare wire probe with suitable amplification and pulse height discrimination to be used in detecting flame fronts in turbulent motion. Typical measurements are given of a Bunsen flame's most probable position, its rms (root-mean-square) displacement from this position, and its degree of continuity during unstable burning. The treatment of data, and the precision and limitations of the method are discussed. (Contractor's abstract)

BMP. 03:002

Bureau of Mines. Div. of Explosives Technology, Pittsburgh, Pa.

TURBULENT BURNING VELOCITIES OF NATURAL GAS-AIR FLAMES WITH PIPE-FLOW TURBULENCE, by J. K. Richmond, J. M. Singer and others. Apr. 30, 1956 [28]p. incl. diagrs. refs. (Technical rept. no. 1205) (AFOSR-TN-56-238) (CSO-680-56-16) AD 88358 Unclassifted

<u>Also published in</u> Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 303-311.

tn order to test existing theorles of turbulent burning velocity and to search for flame-generated turbulence, measurements were made of burning velocity as a function of height in Bunsen flames. Flames of stoichiometric mixtures of Pittsburgh natural gas and air were studied at 10,000, 25,000, 50,000 and 100,000 Reynolds number of approach flow, with a 1-1/4 inch burner tube. Several lmprovements in technique are presented. Flame luminosity measurements were made with a newly developed flame radiation photometer in the region of λ = 4315A. Corrections were made of the flame-cylindrical curvature to find the true radial dtstrioution of light. The direction and magnitude of approach flow at each point were measured with a Pitot tube; velocities were extrapolated systematically to the mean flame position. The turbulence intensity in the flame was determined with an electronic probe. Burning velocity values were computed by the angle and frustum methods, and correlated with the flame turbulence data. For the flames of tte = 50,000 and 100,000, the formula $S_T = S_L + v'$ fits the experimental data well, where S_L is the laminar burning velocity and v' the approach flow turbulence. For the flames of lower Re, the values of burning velocity are larger than indicated by thts formula, and tentative explanations are given. The indications are that flame-generated turbulence is quite small. (Contractor's abstract)

BUT. 01:001

Butler U., Indianapolis, Ind.

RESEARCH ON SHRINKABLE ALGEBRAS, by R. H. Oehmke. Sept. 14, 1955, 13p. (Rept. no. 1) ([AF]OSR-TN-55-337) (AF 18(600)1507) AD 74314 Unclassified

The class of all noncommutative shrinkable algebras of level 2 is divided into smaller classes to investigate the simple algebras of each subclass. Only algebras are considered which (i) contain a unity quantity e; (ii) are noncommutative; and (iii) do not satisfy an identity of the form R_{xy} or $L_{xy} = a_1R_xR_y + a_2R_yR_x + a_3R_xL_y + a_4R_yL_x + a_5L_xR_y + a_6L_yR_x + a_7L_xL_y + a_8L_yL_x$, where the a_i are in the base field. The

BUT. 01:001 (cont'd)

subclasses studied are: (1) Lie-admissible algebras; (2) algebras which satisfy $L_x2 = \alpha_1R_xR_x + \alpha_2R_xL_x + \alpha_3L_xR_x + \alpha_4L_xL_x$; (3) algebras which satisfy $\alpha_1R_xR_y + \alpha_2R_yR_x + \alpha_3R_xL_y + \alpha_4R_yL_x + \alpha_5L_xR_y + \alpha_6L_yR_x + \alpha_7L_xL_y + \alpha_8L_yL_x = 0$; and (4) algebras which satisfy $\alpha_1(R_xL_x2 - 2L_xR_xL_x + L_xL_xR_x + L_xL_xL_x - L_x2L_x) + \alpha_2(L_x2R_x - L_x2L_x - L_xL_xR_x + L_xL_xL_x) + \alpha_3(R_xR_xR_x - L_xL_xL_x - 3L_xR_xR_x + 3L_xL_xR_x) + \alpha_4(L_xL_x2 - L_x2L_x) + \alpha_5(R_xR_xL_x - L_xR_xR_x - 2L_xR_xL_x + 2L_xL_xR_x) + \alpha_6(R_xL_xR_x - L_xR_xR_x - L_xR_xL_x + L_xL_xR_x) + \alpha_7(R_xL_xL_x - 2L_xR_xL_x + L_xL_xR_x) = 0$. For classes 1 and 3, defining identities are obtained which do not involve undetermined coefficients. (ASTIA abstract)

CIT. 01:001 - CIT. 01:004

CIT. 01:001

California Inst. of Tech., Pasadena.

VIBRATIONS OF COMPOSITE SYSTEMS, by R. H. MacNeal. Oct. 1954, 302p. incl. dtagrs. tables, refs. (Technical rept. no. 4) ([AF]OSR-TN-55-120) (AF 18(600)669) AD 63118 Unclassified

This study is concerned exclusively with the vibrations of linear, conservative mechanical systems and their electrical equivalents. The concepts of "normal mode" and of "impedance" are brought together and interrelated in a number of ways. It is shown, for example, that normal modes can be used to compute "impedances", and that impedance measurements, in turn, can be utilized to obtain normal modes. The mathematics used in this analysis of vibration is presented in the language of matrix algebra. With the exception of matrix theory, no "advanced" mathematical concepts are employed. The solution is given for several examples relating to the vibrations of a conventional airplane, and a comparison is made with analog computer results.

CIT. 01:002

California Inst. of Tech., Pasadena.

A STUDY OF THE EFFECTS OF DAMPING ON NORMAL MODES OF ELECTRICAL AND MECHANICAL SYSTEMS, by S. F. Crumb. Jan. 1955, 158p. incl. diagrs. tables, refs. (Technical rept. no. 2) ([AF]OSR-TN-55-121) (AF 18(600)669) AD 58338 Unclassified

A general investigation is presented of some of the properties of free and forced vibrations in linear, nonconservative systems. Particular emphasis is placed upon the problems which arise in normal mode studies made on the electric analog computer at the California Institute of Technology. In Part I the major problems are defined, and limitations of the study are discussed. Part II contains a review of the basic theory of normal modes. In Part III, modifications of normal mode concepts, as applied to damped systems, are examined. "Small damping" criteria are discussed, and a set of theorems of small damping is presented. In Part IV, a series of normal mode analog circuits for damped systems are developed. Part V is a study of uniform damping, generalizing and extending some of the work of Rayleigh, Bode, and Guillemin. It is shown that for any type of uniform damping, all of the basic normal mode concepts are preserved. In Part VI, the theory of mode separation in uniformly damped systems is considered. Criteria for determining mode frequencies and mode parameters are developed. A multiple drive method of exciting normal modes is proposed. In Part VII, some of the methods of Part VI are extended to nonuniformly damped systems. Equivalent orthogonal systems are proposed to approximate the behavior of systems with moderately nonuniform damping. A quantitative measure of nonuniformity is presented. In Part VIII, numerical examples and experimental results in support of the theory are presented. Concluding remarks are made in Part IX. (Contractor's abstract)

CIT. 01:003

California Inst. of Tech., Pasadena.

GENERAL METHODS OF SYNTHESIS FOR ELECTRICAL-MECHANICAL ANALOGIES OF AIRCRAFT STRUCTURES, by G. D. McCann and R. H. MacNeal. Oct. 1954, 130p. incl. illus. diagrs. refs. (Technical rept. no. 1) ([AF]OSR-TN-55-124) (AF 18(600)669) AD 58331 Unclassified

A general treatment is presented of the methods of analysis which have been developed successfully for the vibration studies of airframes together with the corresponding electrical circuit analogies that must be programmed into the electric analog computer. This computer type is distinguished from electronic differential analyzers in that passive circuit elements consisting of decade resistors, capacitors, inductors, and multiwinding, multitap transformers are utilized directly, as well as amplifiers and other electronic devices. The passive electrical elements are used to represent analogous passive elements of the physical system under study when a 1:1 physical analogy can be developed between electric circuit theory and physical system; thus, both currents and voltages in the computer take on physical significance, whereas in electronic differential analyzer techniques only voltages are used to represent voltages. In other cases, where amplifiers are employed, the passive elements are utilized to simulate transfer functions, reducing the number of electronic amplifiers that would be required if only electronic differential analyzers were used.

CIT. 01:004

California Inst. of Tech., Pasadena.

A STUDY OF THE ACCURACY OF LUMPED PARAMETER AND ANALOG COMPUTER REPRESENTATIONS OF CANTILEVERED BEAMS UNDER CONDITIONS OF STATIC STRESS AND DYNAMIC VIBRATIONS, by G. D. McCann and H. S. Braham. Apr. 1955, 154p. incl. diagrs. tables. (Technical rept. no. 3) ([AF]OSR-TN-55-148) (AF 18(600)669) AD 63173 Unclassified

The cantilevered beam in simple bending is a basic element of airframes as analyzed for stress, dynamic vibration, and aero-elastic analysis. The accuracy with which this element can be represented by lumped parameter approximations, and on the direct analogy electric analog computer, has been studied in detail. Concerning static loading, finite difference analogies with both full and half cell end termination and the Russell analog were investigated. Exact solutions, calculated lumped parameter, and analog computer solutions were obtained for comparison. It was found that for the wide range of beam conditions studied, the

computer parasitic errors in recording deflections and slopes lie within a maximum of 2.6% with the error 1% or less for most cases. Considering the effects of finite difference lumping alone, it was found that half cell termination gives greater accuracy for beams having variation in the (EI) properties that do not exceed the second power of distance along the beam, while the full cell termination analog gives better accuracy for higher rates of taper. Four finite difference cells are required for the uniform beam to reduce the slope and deflection errors to 3% and 8 cells for 1%. For the extreme fourth power taper, 4 cells produce a 10% error and 16 cells are required to reduce the error to 1%. The Russell analog is exact if loading is applied only at the ends of cell divisions. Concerning dynamic vibrations, 3 types of analogies were considered; the finite difference analog with both full and half cell end terminations, the modified Russell analog, which is the finite difference analogy with mass lumped at the center of the cells (half cell termination only was used), and the Russell analog. Exact, calculated lumped parameter and analog computer solutions were obtained for the first 15 free vibration mode frequencies and shapes. Shears and moments were also measured on the computer and compared with exact values. The analog with mass lumped at the cell division points and half cell termination was found to be the most accurate of the finite difference analogies. The Russell analog was found to provide considerably better accuracy in all cases except for the higher modes of the beam with large taper. It was found that the transformer parasitic parameters are the only significant factors affecting the accuracy of the computer for structures of this type. The effect of these can be calculated reliably and optimum computer constants chosen for each case. Thus, for complex problems requiring the representation of a large number of modes, the computer set up can be so designed as to ensure that the important modes are represented to the greatest accuracy or to about 1%. (Contractor's abstract, modified)

California Inst. of Tech., Pasadena.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item no. PRI. 11:023.

CIT. 02:001

California Inst. of Tech. Antenna Lab., Pasadena.

[BOUNDARY VALUE PROBLEM OF MICROWAVE PHYSICS] Randwertprobleme der Mikrowellenphysik, by F. E. Borgnis and C. H. Papas. Berlin, Springer, 1955, 266p. (AF 18(600)1113) Unclassified

A detailed study is presented concerning the theory and mathematical treatment of microwave propagation in cylindrical antennas. The monograph covers such subjects as characteristics of the electromagnetic field, scalar Green's functions, bending of a plane wave in a metallic circular cylinder, equations for current distribution and for random cross sections of the wave parallel and perpendicular to the cylinder axis, wave characteristics at the surface of the cylinder, approximation methods for current distribution, compilation of various scatter cross sections, and radiation patterns within and between coaxial cables.

CIT. 02:002

California Inst. of Tech. [Antenna Lab.] Pasadena.

EXACT TREATMENT OF ANTENNA CURRENT WAVE REFLECTION AT THE END OF A TUBE-SHAPED CYLINDRICAL ANTENNA, by E. Hallén. Mar. 29, 1955 [41]p. incl. diagrs. refs. (Technical rept. no. 5) (AF 18(600)1113) Unclassified

The solution of the integral equation for the first, second, etc. reflected antenna current waves is derived and compares with previously obtained result; the number of terms in the series solution is increased. The first reflected wave only is investigated, with the antenna length considered as very great. The integral equation for the first reflected wave is

$$\int_{-\infty}^{\infty} d\xi \; I(\xi) \frac{1}{2\pi} \int_{0}^{2\pi} \frac{e^{-j\beta r}}{r} \, d\varphi = -\frac{4\pi}{Z_0} V_0 e^{-j\beta|x|}$$

with $I(Z)$, $Z > 0$, the unknown reflected current wave and for $Z < 0$, $I(Z) = -I(Z)$. The merits of the exact and linearized solution of the antenna equation are discussed.

CIT. 02:003

California Inst. of Tech. Antenna Lab., Pasadena.

DIFFRACTION OF A TRAPPED WAVE BY A SEMI-INFINITE METALLIC SHEET, by C. G. Weill. May 31, 1956, 21p. incl. diagrs. (Technical rept. no. 7) (AFOSR-TN-56-477) (AF 18(600)1113) AD 97361 Unclassified

A mathematical analysis is given of reflection and transmission coefficients for the trapped modes, the radiating power, and the far field pattern of a trapped wave in a grounded dielectric slab of permittivity ϵ and thickness a; and in the half space over the slab, a dielectric of permittivity 1. The case of a single incoming mode is considered, propagation from $z = +\infty$ and diffracted by a semi-infinite metallic sheet of zero thickness. The scattered field component of the total field is analyzed by means of Green functions and Wiener-Hopf techniques. Determination of the characteristic parameters of a simple obstacle embedded in a dielectric slab indicates the transmission and reflection coefficients in general to be complex, showing the characteristic mode phase-shift previously described. Application of such radiating obstacles can be made to dielectric line antennas, acting in this case like arrays.

CIT. 02:004 - CIT. 04:001

CIT. 02:004

California Inst. of Tech. [Antenna Lab.] Pasadena.

DIELECTRIC PROPERTIES OF A LATTICE OF ANISOTROPIC PARTICLES, by Z. A. Kaprielian. Jan. 1956 [9]p. (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under AF 18(600)1113]) Unclassified

Published in Jour. Appl. Phys., v. 27: 24-32, Jan. 1956.

The constitutive dielectric parameters for uniform space arrays of generalized structural geometry composed of similarly oriented elements of completely generalized material and shape are derived. The theoretical procedure employed in evaluating these parameters is analogous to the classical method applied to the study of the dielectric properties of nonpolar media and assumes that the disturbing action of each particle on a uniform static field can be allowed for, if each particle is replaced by a set of dipoles. Consequently, the results are applicable to microwave frequencies only if the cross-sectional dimensions and interelemental spacings remain small compared to the wavelength. The general result is particularized for the case in which the elements are spherical objects with a tensor permeability and scalar dielectric constant. The results have several applications to the design of artificial dielectrics and some of these are given. (Contractor's abstract)

CIT. 03:001

California Inst. of Tech. Dynamic Properties Lab., Pasadena.

THE GROWTH OF SINGLE CRYSTALS OF ZINC OF PREFERRED ORIENTATION, by T. Vreeland, Jr., D. S. Wood, and D. S. Clark. Feb. 1955, 31p. incl. illus. diagrs. (Technical note no. 1) ([AF]OSR-TN-55-65) (AF 18(600)490) AD 61826 Unclassified

The results of an experimental investigation concerning the production of zinc single crystals of a specific orientation are presented. A technique developed for the production of crystals in the form of rods with the basal plane of the zinc crystal perpendicular to the rod axis is described. This technique yields crystals of the desired orientation containing a relatively small amount of substructure.

CIT. 03:002

California Inst. of Tech. Dynamic Properties Lab., Pasadena.

THE BASAL SLIP IN ZINC UNDER STATIC AND DYNAMIC LOADING, by T. Vreeland, Jr., D. S. Wood, and D. S. Clark. Apr. 1956, 45p. incl. illus. diagrs. table. (Technical note no. 2) (AFOSR-TN-56-158) (AF 18(600)490) AD 86318 Unclassified

Also published in Jour. Mech. and Phys. of Solids, v. 6: 111-126, 1958.

This report presents the results of an investigation of static and dynamic shear behavior of two purities of zinc single crystals. All the crystals tested were in the form of cylindrical rods with the [0001] crystallographic direction parallel to the rod axis. The static tests were performed by applying simple transverse shear loading in one of the slip directions to one end of the crystals with the other end of the crystals rigidly clamped. The static shear stress vs shear strain relations are obtained from these tests. The dynamic tests were conducted by suddenly stopping (within a period of about 25×10^{-6} sec) one end of the crystals which were moving in the slip direction at various velocities. The resulting waves of plastic shear deformation which propagate from the stopped ends of the crystals toward the free ends are analyzed. The analysis is based upon the assumption that elastic strains may be neglected in comparison with the plastic strains. The use of the results of this analysis in conjunction with measurements of the permanent lateral deflections of the crystals resulting from the dynamic tests leads to the determination of dynamic shear stress vs shear strain relations. The results of this study show that the stress required to produce a given permanent basal shear strain in single crystals of zinc is considerably greater under the dynamic conditions employed than under static conditions. This stress decreases with increasing temperature (Contractor's abstract)

CIT. 03:003

California Inst. of Tech. Dynamics Properties Lab., Pasadena.

DYNAMIC PROPERTIES OF SHIP CONSTRUCTION MATERIALS (Unclassified title), by D. S. Wood. [1955] [14]p. (AF 18(600)490) Confidential

Published in Proc. Seventh Symposium on Underwater Explosion Research, Part I (Confidential). David Taylor Model Basin, Washington, D. C. (Nov. 29-Dec. 2, 1955), DTMB rept. no. C-745, 1956, p. 39-52.

CIT. 04:001

California Inst. of Tech. Gates and Crellin Labs., Pasadena.

ON THE CLEAVAGE OF BENZENE, THIOPHENE AND FURAN RINGS BY MEANS OF ULTRASONIC WAVES, by L. Zechmeister and L. Wallcave. Dec. 1, 1954 [19]p. incl. diagrs. tables, refs. [AFOSR-TN-54-336] (AF 18(600)385) AD 46399 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77:

2853-2855, May 20, 1955.

The halogen and/or sulfur in the following compounds were removed from the rings by ultrasonics: chlorobenzene; bromobenzene; iodobenzene; α- and β-bromonaphthalenes; methyl o-chlorobenzoate; methyl o-bromobenzoate; ethyl p-bromobenzoate; p-bromoanisole; o-, m- and p-bromoazobenzenes; thiophene; α-dithienyl; α-terthienyl; and α-iodothiophene. The Hypersonic Transducer model BU-305A-600 (Brush Electronic Co.) was used to generate the ultrasonic waves; the transducer element was operated at about 5 a at 25 v, and the estimated power input was 125 w at 550 to 600 kc. Descriptions are presented of: (1) the operation of the oscillator and power supply; (2) preparation of the AgX precipitates; (3) estimations of acetylene plus diacetylene by both the Willstätter and Maschmann method and the bromination method; and (4) separation of acetylene tetrabromide and diacetylene hexabromide.

CIT. 04:002

California Inst. of Tech. Gates and Crellin Labs., Pasadena.

ON THE ULTRASONIC CLEAVAGE OF THE PYRIDINE RING, by L. Zechmeister and E. F. Magoon. Oct. 27, 1955 [2]p. incl. table, refs. (Contribution no. 2044) [AFOSR-TN-55-400] [AF 18(600)385] AD 103125 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 2149-2150, May 20, 1956.

On ultrasonic treatment of a solution of pyridine in aqueous silver nitrate, roughly 5% of the ring atoms are precipitated as a mixture of silver acetylide, silver diacetylide, and silver cyanide. The resolution of such mixtures and the estimation of the 3 components is described. Nicotine shows a similar behavior. (Contractor's abstract)

CIT. 05:001

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

TRANSONIC FLOW PAST SIMPLE BODIES, by J. D. Cole, G. E. Solomon, and W. W. Willmarth. [1953] 1v. incl. illus. diagrs. refs. (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)383 and National Advisory Committee for Aeronautics under NAw-6154) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 627-634, Sept. 1953.

The results of some experiments on transonic flow past two simple shapes, namely a cone-cylinder and a double-wedge airfoil, are presented. The main aim of these experiments is to bring out some of the general features of transonic flow, especially over the whole transonic range of Mach numbers. Special studies were made on the finite cone at zero angle of incidence, and the symmetric double-wedge airfoil at very small angles of attack. The experiments were carried out in the 4-in. by 10-in. transonic tunnel at GALCIT. Details of the experiments and their results are described and discussed.

CIT. 05:002

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

NOTE ON NONSTATIONARY SLENDER-BODY THEORY, by J. D. Cole. July 14, 1953, 1p. [AF 18(600)383] Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 798-799, Nov. 1953.

A body of revolution performing arbitrary motion along its axis can be represented within linearized (acoustic) theory by a distribution of sources that vary in time along the axis of flight. Frankl (Effect of the Acceleration of Elongated Bodies of Revolution upon the Resistance in Compressible Flow, NACA Tech. memo. no. 1230, 1949; Translation from Prikladnaîa Mathematika i Mekhanika, v. 10, (no. 4): 1946) has shown that for very slender bodies, the instantaneous source strength is equal to the velocity times the rate of change of cross-sectional area along the body. In this study, an asymptotic expansion of the potential near the axis is given, and the results are presented for the special case of a cone decelerating uniformly from supersonic to sonic velocity.

CIT. 05:003

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

ACCELERATION OF SLENDER BODIES OF REVOLUTION THROUGH SONIC VELOCITY, by J. D. Cole. Jan. 1954, 12p. illus. ([AF]OSR-TN-54-55) (AF 18(600)383) AD 47836 Unclassified

Presented at meeting of the Amer. Phys. Soc., Albuquerque, N. M., Sept. 3, 1953.

Also published in Jour. Appl. Phys., v. 26: 322-327, Mar. 1955.

The linearized theory of slender bodies in arbitrary motion at zero angle of attack has been worked out. The results have been applied to a smooth body accelerating uniformly through sonic velocity. The results of linearized theory can be used to estimate the non-linear or transonic effects. For an accelerating body the parameter $\sqrt{bl/c^2}$ is important, where $2b$ = acceleration, $2l$ = length of body, c = sound speed at infinity. For sufficiently high $\sqrt{bl/c^2}$ transonic effects can be neglected. Using linearized theory to estimate the ratio of non-linear terms in the differ-

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ential equation gives

$$\lambda = \frac{\text{non-linear terms}}{\text{significant linear terms}} = \frac{3}{4}(\gamma + 1)\,\frac{\delta^2}{\frac{bl}{c^2}}\,\text{Log}\,\frac{2}{\delta^2}\,\frac{c^2}{bl} - \frac{9}{4}$$

where δ = thickness ratio of body. The result above is evaluated at the maximum thickness of a symmetric parabolic arc body at the instant it passes through sonic velocity. For $\lambda < 1$ transonic effects can be neglected while for $\lambda > 1$ they begin to dominate. For practical applications the result shows that there is a possibility of a sufficiently long and slender missile accelerating fast enough to avoid transonic effects (e.g., 50 ft long, 5% thick, 3 g acceleration). For conventional aircraft and all sorts of wings, transonic effects will dominate. An interesting side result is that when the acceleration is sufficiently large so that transonic effects do not matter the drag coefficient near sonic speed is independent of the acceleration ($C_D = 3\delta^2$ for parabolic arc body). (Contractor's abstract)

CIT. 05:004

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

THE LIFT OF THIN AIRFOILS AT HIGH-SUBSONIC SPEEDS, by W. W. Willmarth. June 1954, 1v. incl. illus. diagrs. refs. ([AF]OSR-TN-54-168) (AF 18(600)383) AD 47210 Unclassified

Experimental results are presented for the lift characteristics of thin, 2-dimensional airfoils at high-subsonic speeds and small angles of attack. Symmetrical airfoils with different locations of maximum thickness were investigated using a surface pressure probe technique which should find use in other applications. The flow fields over each airfoil are discussed, and the quantitative results for the lift and location of the center of lift are compared with theory whenever possible. The effects of flow separation caused by boundary-layer shock-wave interaction are noted and discussed. In particular, the possibility of the forced oscillation of control surfaces resulting from boundary layer separation is mentioned. (Contractor's abstract)

CIT. 05:005

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

TRANSONIC LIMITS OF LINEARIZED THEORY, by J. D. Cole. May 1954, 11p. diagrs. ([AF]OSR-TN-54-228) (AF 18(600)383) AD 47835 Unclassified

The range of validity of linearized theory in terms of an estimation of nonlinear effects in the transonic range is computed on the basis of linearized slender-body theory. The method is applied to a slender body of revolution in steady flight and accelerating through sonic speed, and to slender lifting wings in steady flight. The results provide regions of breakdown of the linearized theory. An approximate method of accounting for the nonlinearity in steady flight at sonic speeds is indicated for the body of revolution. (ASTIA abstract)

CIT. 05:006

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EXPANSION PROCEDURES AND SIMILARITY LAWS FOR TRANSONIC FLOW. PART I. SLENDER BODIES AT ZERO INCIDENCE, by J. D. Cole and A. F. Messiter. Jan. 1956, 39p. ([AF]OSR-TN-56-1) (AF 18(600)383) AD 90890 Unclassified

Also published in Zeit. Angew. Math. Phys., v. 8: 1-25, Jan. 25, 1957.

The transonic approximation for flow over a slender body of revolution is discussed by means of a mathematical expansion procedure. The expansion is carried out in terms of a decreasing sequence of functions of the thickness ratio, and a similarity parameter relating the Mach number and thickness ratio is introduced. The first few terms of the expansions of the velocities near the axis are obtained, and similarity laws are derived for the pressure coefficient and drag coefficient of a body at zero incidence. By means of another expansion, an approximate "area rule" is obtained for a body of noncircular cross section. (Contractor's abstract)

CIT. 05:007

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

SIMILARITY SOLUTION FOR TRANSONIC FLOW PAST A CONE, by Y.-C. Shen. Mar. 1956, 45p. incl. diagrs. tables. ([AF]OSR-TN-56-121) (AF 18(600)383) AD 82517 Unclassified

By applying a transonic expansion procedure to a conical flow field, a system of approximate transonic equations, boundary conditions, and shock relations is derived. A similarity law for the pressure coefficient on the surface of slender cones is established. The surface pressure is computed by solving the approximate equations. By use of similarity, the second order differential equations of the first 2 steps of the approximation scheme are reduced to first order equations. The solution of the first step is carried out numerically in great detail for different transonic parameters; the procedure for solving the latter is explained in the Appendix. The results are compared with the exact solution, and a highly satisfactory agreement is reached. (Contractor's abstract)

CIT. 06:001

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

FLEXURE VIBRATION OF UNIFORM BEAMS SIMPLY SUPPORTED AT EQUAL INTERVALS - NORMAL MODES AND FREQUENCIES, by C.-M. Cheng. July 1955 [13]p. incl. diagrs. [Rept. no. 3; GALCIT rept. no. 86] ([AF[OSR-TN-55-235) [AF 18(600) 1142] AD 101501 Unclassified

The normal modes and frequencies of flexural vibrations of uniform beams simply supported at equal intervals are determined. The number of supports is arbitrary. A simple formula is given for computing the frequency of each normal mode. The mode shape is shown to be expressible in terms of elementary functions in a closed form. The frequency spectra are of special interest. For example, for an infinitely long beam on an infinite number of supports, the frequency parameter, $\beta = (\rho/D)^{1/4} l\, \omega^{1/2}$, will assume every value in the intervals $[n\pi, (n + 1/2)\pi]$, (n = 1, 2, 3 ...); whereas there exists no frequency in the intervals $[0, \pi]$, $[(n + 1/2)\pi, n\pi]$, (n = 1, 2, 3...). For a finite beam of M intervals (M+1 supports), there are M frequencies in each of the ranges $[n\pi, (n + 1/2)\pi]$, and none elsewbere. (Contractor's abstract)

CIT. 06:002

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

THE FLUTTER OF SIMPLY SUPPORTED RECTANGULAR PLATES IN A SUPERSONIC FLOW, by J. G. Eisley. July 1955 [53]p. incl. diagrs. tables, refs. (Rept. no. 1; GALCIT rept. no. 86) ([AF]OSR-TN-55-236) (AF 18(600)1142) AD 70404 Unclassified

The problem of flutter of a simply supported rectangular plate placed in a supersonic airstream is studied. Only small deflections of the plate are considered so that linear plate theory may be used. The flutter mode is described by a series expansion in terms of the normal modes of oscillation of the plate in a vacuum. Linearized aerodynamic theory is used. Additional simplification is introduced in 2 forms. In 1 case, the strip assumption is introduced, and in another the quasisteady approximation is made. The exact solution is carried out, and the result is compared with the 2 approximate results. Numerical calculations were made to determine the flutter boundaries for plates of varying aspect ratio using strip theory aerodynamics. These calculations were made for $M = \sqrt{2}$ and M = 2 over a range of values of the reduced frequency. For M = 2 the flutter mode was described by considering 2 or 3 normal modes. For $M = \sqrt{2}$ only 2 normal modes were considered. (Contractor's summary)

CIT. 06:003

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

THE FLUTTER OF A BUCKLED PLATE IN A SUPERSONIC FLOW, by Y. C. Fung. July 1955 [31]p. incl. diagrs. (Rept. no. 2; GALCIT rept. no. 86) ([AF]OSR-TN-55-237) (AF 18(600)1142) AD 70403 Unclassified

The flutter of a thin elastic plate in a "2-dimensional" supersonic flow is considered. The edges of the plate are hinged to supports that are perfectly rigid and fixed in space. A sufficiently large compressive load is assumed to act in the plane of the plate, so that the plate would buckle if it were free from all tractions normal to the surface of the plate. The solution is based on Galerkin's method, and under the assumption of small reduced frequency and linearized aerodynamic theory. Nonlinearity in the problem is caused by the dependence of the compressive load in the plane of the plate on the lateral deflection. Both the linear, small amplitude flutter about equilibrium positions and the nonlinear, finite amplitude flutter are considered. Certain theoretical difficulties and unsolved problems are discussed. (Contractor's summary)

CIT. 06:004

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

THE FLUTTER OF A TWO-DIMENSIONAL BUCKLED PLATE WITH CLAMPED EDGES IN A SUPERSONIC FLOW, by J. G. Eisley. July 1956 [40]p. incl. diagrs. tables. (Rept. no. 4; GALCIT rept. no. 86) ([AF]OSR-TN-56-296) (AF 18(600)1142) AD 90008 Unclassified

The flutter of a 2-dimensional buckled panel with clamped edges is studied both theoretically and experimentally. In the first part, the flutter mode is described by a series expansion of functions which satisfy the boundary conditions for clamped edges. Quasi-steady linearized aerodynamics is used. Large deflections of the plate are considered. Numerical calculations have been made for only the first 2 terms of the series expansion. An experimental program designed to study the nature of panel flutter is described. The results of the experiments are used to check the validity of the assumptions used in the theoretical study and to shed some light on the process of panel flutter for use in future studies. (Contractor's abstract)

CIT. 07:001

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

OBLIQUE SHOCK WAVES WITH EVAPORATION;

CIT. 07:002 - CIT. 07:005

METHOD OF CALCULATING FREE STREAM TEMPERATURE AND AMOUNT OF CONDENSATION FROM WEDGE TESTS; REMARKS ON THE PRESSURE COEFFICIENT IN HYPERSONIC TUNNELS, by R. [D.] Buhler, P. Jackson, and H. T. Nagamatsu. Apr. 10, 1951, 63p. incl. diagrs. Appendix. (Memorandum no. 3) [Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19] ATI-104880 Unclassified

A study is presented of shock waves with complete evaporation and of the use of the shock results for the determination of free stream temperature and amount of air condensed. This is followed by remarks on sound velocity, pressure change produced by weak waves, and the Mach number as similarity parameter. It is concluded that from the results presented the free stream temperature and the amount of condensed phase present in the flow in a hypersonic tunnel could apparently be calculated to at least fair accuracy from experiments involving fairly strong oblique shock waves. Good (but not excessive) accuracy is required to these wave-angle, static-pressure and flow-deflection measurements. If the stagnation temperature in the free stream can also be measured, then the evaluation of these experimental data requires no assumptions or knowledge of vapor pressure or surface tension of the condensed phase.

CIT. 07:002

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

CHARTS AND TABLES FOR ANALYSIS OF HYPERSONIC FLOW, by H. T. Nagamatsu. May 15, 1951, 29p. incl. diagrs. tables. (Memorandum no. 4) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-108753 Unclassified

A collection of curves and tables is presented which have been found useful in the design of supersonic wind tunnels and experiments and in the analysis of data therefrom. Particular emphasis is placed on the high Mach number range. All tables and curves were computed for $\gamma = 1.400$ with the exception of the cone data, which were taken directly from Reference 2, and had been computed for $\gamma = 1.405$. Equations used in calculating the curves appear on the charts, and the symbols are defined by the descriptive information included on the charts.

CIT. 07:003

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EFFECTS OF DENSITY FLUCTUATIONS ON THE TURBULENT SKIN FRICTION OF AN INSULATED FLAT PLATE AT HIGH SUPERSONIC SPEEDS, by H. T. Nagamatsu and T.-Y. Li. May 24, 1951, 36p. incl. diagrs. tables. Appendixes A-D. (Memorandum no. 5) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-108752 Unclassified

An investigation is reported which was made to derive a turbulent skin friction formula which includes the turbulent shear due to the density fluctuations. (ATI abstract)

CIT. 07:004

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

CONDENSATION OF NITROGEN IN A HYPERSONIC NOZZLE, by H. T. Nagamatsu and W. W. Willmarth. Jan. 15, 1952, 77p. incl. illus. diagrs. Appendixes A-C. (Memorandum no. 6) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-152346 Unclassified

A small stainless two-dimensional source-flow nozzle supplied with bottled nitrogen was used for the condensation investigation. It was found that the nitrogen supersaturates approximately 15°K or 1.2 Mach numbers when expanded from stagnation conditions of 70°F and pressures of 8.21 and 10.15 atm. A numerical method for solving the equations of motion with the aid of the experimental data allows the computation of the fluid temperature during the condensation process. The addition of small amounts of carbon dioxide reduced the degree of supersaturation obtainable with bottled nitrogen.

CIT. 07:005

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EFFECTS OF IMPURITIES ON THE SUPERSATURATION OF NITROGEN IN A HYPERSONIC NOZZLE, by P. D. Arthur and H. T. Nagamatsu. Mar. 1, 1952, 32p. incl. illus. diagrs. table. (Memorandum no. 7) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-143891 Unclassified

An investigation is reported which was conducted to determine the effects of impurities on the supersaturation of commercial bottled nitrogen in a hypersonic nozzle. A description is given of the equipment used in the experiment, and the procedure is explained. For the conditions of the experiment commercially pure nitrogen, expanded from room temperature, was found to supersaturate by approximately 18°K or 1.2 Mach number. The degree of supersaturation of the nitrogen was decreased by the addition of impurities. Argon and oxygen were found to be much less effective in decreasing the supersaturation. During the collapse of the supersaturated state, the static pressure gradually increased above the isentropic value because of

the heat release from the condensing gas. There was no evidence of condensation shock with nitrogen. The impact pressure was only slightly changed from the isentropic value by the presence of condensation in the flow. After the collapse of the supersaturated state, the flow in the nozzle appeared to be that of an equilibrium flow of saturated vapor with either liquid or solid nitrogen, depending on the temperature.

C1T. 07:006

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

THE EFFECTS OF AIR CONDENSATION ON PROPERTIES OF FLOW AND THEIR MEASUREMENT IN HYPERSONIC WIND TUNNELS, by J. Grey and H. T. Nagamatsu. June 15, 1952, 112p. incl. illus. diagrs. tables. Appendixes A-C. (Memorandum no. 8) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-155630 Unclassified

Some of the fundamental problems encountered in the measurement of flow properties in condensing air were investigated experimentally in the GALCIT hypersonic wind tunnel. The saturated-expansion theory of flow in a condensing fluid, as developed by Buhler, was corroborated and some of the unknown properties of the theory were clarified by analysis of the wind-tunnel tests. Several experimental techniques for the measurement of two-phase fluid properties were developed and the results were used to supply additional information concerning the nature of phenomena such as supersaturation, and normal and oblique shock waves. No definite conclusions could be reached with regard to future application of condensed-air wind-tunnel data on the basis of these tests, but the subject of similarity parameters comparable to the Mach number in flow of a perfect gas is discussed at some length. (ATI abstract)

C1T. 07:007

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

SHOCK WAVE EFFECTS ON THE LAMINAR SKIN FRICTION OF AN INSULATED FLAT PLATE AT HYPERSONIC SPEEDS, by T.-Y. Li and H. T. Nagamatsu. July 1, 1952, 40p. incl. diagrs. tables, refs. Appendix. (Memorandum no. 9) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-159312; U26255 Unclassified

An approximate theory on the phenomena of interaction between the shock wave and the laminar boundary layer on an insulated flat plate at hypersonic speeds has been formulated. Results on the rate of growth of the boundary layer thickness and the rate of decay of the shock wave strength have been found that hold for $M_1^{2(2+w)} P_1^{-1} = 0(1)$. A new set of formulae for the average skin friction coefficient, C_F, over an insulated flat plate at hypersonic speeds has been obtained. Calculations on the basis of the new C_F formulae yield the data shown in this report. Contrary to the conventional theory which predicts a steady decrease in C_F may increase with M_1 at hypersonic Mach numbers. (ATI abstract)

C1T. 07:008

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EXPERIMENTAL SUPERSATURATION OF GASES IN HYPERSONIC WIND TUNNELS, by P. D. Arthur and H. T. Nagamatsu. July 15, 1952, 101p. incl. illus. diagrs. tables. Appendix. (Memorandum no. 10) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-168735 Unclassified

An experimental investigation was conducted to determine the effects of additives on the supersaturation of commercial bottled nitrogen expanded in a hypersonic nozzle. In particular, enough oxygen was added to duplicate air proportions. A stainless steel two-dimensional source-flow nozzle of one-inch width was used to conduct the tests. From the tests it is concluded that condensation of nitrogen containing slightly more impurities than present in the present nitrogen, and of air of the same purity is principally caused by foreign impurities, not by spontaneous self-nucleation. Condensation results of other tunnels are compared with the present experimental data.

C1T. 07:009

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EFFECT OF DENSITY FLUCTUATIONS ON THE TURBULENT SKIN FRICTION ON A FLAT PLATE AT HIGH SUPERSONIC SPEEDS, by T.-Y. Li and H. T. Nagamatsu. Nov. 1, 1952, 34p. incl. diagrs. (Memorandum no. 11) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) ATI-174166 Unclassified

A method is proposed for estimating the effects of density fluctuations on the turbulent skin friction on a flat plate at high supersonic speeds. This method consists of the following steps: (1) with some suitable assumptions relative to the order of magnitude of the correlation functions involving the density fluctuations, a system of differential equations is obtained which for Prandtl number (Pr) = 1 yields a mean energy integral satisfying the conventional boundary conditions; (2) by extending von Kármán's similarity considerations and Prandtl's mixing length concepts to the compressible flow regime, a derivation is made of an approximate turbulent friction equation which can be integrated

to determine the approximate velocity profile in the turbulent boundary layer over a flat plate; and (3) the formulae in closed form for the turbulent skin friction are finally obtained on the basis of our approximate velocity profile relations.

CIT. 07:010

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

A NOTE ON THE REMOVAL AND METHOD OF MEASURING CARBON DIOXIDE IN A HYPERSONIC WIND TUNNEL, by R. D. Wallace and H. T. Nagamatsu. Nov. 15, 1952, 5p. (Memorandum no. 12) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19)
ATI-174164 Unclassified

A technique is described for the removal of carbon dioxide and the accurate determination of its concentration in the air of a hypersonic wind tunnel. The technique requires that the airflow be metered through a barium hydroxide solution for complete absorption of the carbon dioxide. The resulting alkaline solution is then titrated to the neutral point with a strong acid, the amount of acid used indicating the amount of carbon dioxide present. A sketch of the apparatus utilized is presented. It is considered necessary to measure small amounts of carbon dioxide to a high degree of accuracy in wind tunnels since this contaminant is apparently a nucleant which promotes a condensation phenomenon.

CIT. 07:011

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

CONDENSATION OF AIR COMPONENTS IN HYPERSONIC WIND TUNNELS — THEORETICAL CALCULATIONS AND COMPARISON WITH EXPERIMENT, by R. D. Buhler and H. T. Nagamatsu. Dec. 1, 1952, 149p. incl. diagrs. tables. (Memorandum no. 13) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19)
ATI-187041 Unclassified

The effect of condensation on the flow in hypersonic wind tunnels is bracketed by equilibrium-saturated expansion and by instantaneous condensation. By calculation of shock waves with evaporation, direct comparison of theoretical and measured pressures is made possible. Satisfactory agreement between saturated expansion theory and experiment is obtained after the collapse of the supersaturated state. The droplet-growth theory (for free molecule regime) is re-examined and a good approximate solution is obtained for the nonsteady case (i.e., rapidly changing vapor properties). Limits of validity of the quasisteady theory are defined, and an upper limiting (zero growth) drop size is given for expanding flow. A simplified method is presented for calculating the pressure-time history of the collapse of the supersaturated state in nozzles. From this, the most effective nucleus sizes for given total mass of impurities are calculated. Thus, the earliest possible collapse in a nozzle resulting from impurities is estimated theoretically for low impurity concentrations. The agreement of the predicted trend with experimental results in nitrogen appears to justify the assumed mechanism of the collapse, which is reputedly caused by condensation on existing foreign nuclei formed upstream of the collapse. (Contractor's abstract)

CIT. 07:012

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

EXPERIMENTAL HEAT TRANSFER AT HYPERSONIC MACH NUMBER, by R. D. DeLauer and H. T. Nagamatsu. Apr. 15, 1953 [76]p. incl. illus. tables, refs. (Memorandum no. 14) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 10238 Unclassified

Heat-transfer coefficients were determined for the laminar boundary layer on a cooled flat plate at a nominal M = 5.8. A 6.2 ratio of wall temperature to free stream temperature existed in the 5- x 5-in. hypersonic wind tunnel under stagnation temperature conditions ranging from 200° to 285°F with a maximum Re of 2.1×10^6. A flat-plate temperature recovery factor of 0.858 ± 0.004 was determined. The laminar recovery factor was independent of the Reynolds number up to the beginning of transition; the range of Mach number independence of the temperature recovery factor extended to M = 5.8. The heat-transfer coefficients obtained with a negative chordwise temperature gradient were up to 60% higher than coefficients resulting from a constant-temperature surface. A value of 0.285 ± 10% was obtained for the nondimensional heat-transfer parameter $Nu/(Re^{1/2}Pr^{1/3})$ of an isothermal plate; this value agreed with the results of a skin friction investigation at the same Mach number. The investigation showed: (1) the possibility of forcing transition at $Re = 1.2 \times 10^6$ by a shock-wave boundary-layer interaction; (2) lowering of the temperature recovery factor by the condensation without changing the heat-transfer coefficients; and (3) stability of the boundary layer which separated from the plate surface when the transition point was subjected to an adverse pressure gradient.

CIT. 07:013

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

BOUNDARY LAYER TEMPERATURE RECOVERY FACTOR ON A CONE AT NOMINAL MACH NUMBER SIX, by D. S. Mackay and H. T. Nagamatsu. June 15, 1953, 26p. incl. illus. (Memorandum no. 15) (Spon-

sored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 15345 Unclassified

The investigation was conducted on two 20° cone models about 3 in. long at free stream M = 5.6 to 5.9. One was composed of a ceramic core with a thin (0.010 to 0.015 in.) steel surface, and the second was a hollow copper shell of 0.005-in. thickness. One- and 2-phase (condensation) flow conditions were investigated. Temperature recovery factors were determined from the data obtained in tests with 1-phase air flows. The ratios of the temperatures recovered on the cone surface to the respective stagnation temperatures were computed from data obtained in the 2-phase air-flow investigations and were compared with these ratios for the 1-phase air flows. The local temperature recovery factors for the laminar boundary layer were 0.844 ± 0.008 for Re = 2.1×10^4 to 5.4×10^5. The recovery factor was independent of the Reynolds number. The independence of the recovery factor on the Mach number was substantiated up to M = 5.9 by comparison with previous results for lower Mach number. The ratios of the temperatures recovered on the cone to the stagnation temperatures were the same for 1- and 2-phase air flows. The square root of the Prandtl number at the mean of the temperatures of the cone surface was less than 1% lower than the mean of the experimental temperature recovery factors. The experimental results were considered to verify theoretical solutions.

CIT. 07:014

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

DIRECT MEASUREMENT OF LAMINAR SKIN FRICTION AT HYPERSONIC SPEEDS, by M. Elmer and H. T. Nagamatsu. July 1, 1953, 113p. incl. illus. tables, refs. (Memorandum no. 16) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 15346 Unclassified

Experimental techniques for the study of boundary-layer characteristics at hypersonic speeds and high stagnation temperatures were developed and applied to the behavior of the laminar boundary layer at M = 5.8. Transition could not be forced at Re = 2×10^6, and the side-wall turbulent boundary layer did not contaminate the flat-plate laminar boundary layer to produce transition in a region bounded by the usual contamination angles. Observations of the leading edge with a schlieren system indicated that the shock wave and boundary layer are separated at M = 5.8 by an appreciable distance wherever the boundary-layer equations hold. Local laminar skin-friction measurements indicated that existing theories overestimate the magnitude of the local viscous sheer force at these Mach and Reynolds numbers. A theory describing the properties of the laminar boundary layer in a 2-phase fluid with condensation in the free stream was developed which predicts that (1) skin friction remains unchanged in the presence of moderate condensation for a specified nozzle geometry and stagnation temperature, and (2) heat transfer for a given wall temperature is affected by the presence of condensation which produces major changes in the adiabatic wall temperature. (ASTIA abstract)

CIT. 07:015

California Inst. of Tech. [Guggenheim Aeronautical Lab.] Pasadena.

HYPERSONIC VISCOUS FLOW OVER AN INCLINED WEDGE, by L. Lees. July 29, 1953 [3]p. (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under [AF 33(038)250] and DA-04-495-ord-19) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 794-796, Nov. 1953.

Results of hypersonic viscous flow over the compression side of a wedge at a large angle of attack are discussed. It is pointed out that although the flight Mach number is high, the inviscid flow Mach number is reduced considerably across the leading-edge shock, and the interaction effects are much smaller than for a flat plate at the same local Reynolds number and Mach number ahead of the body. Regions of "strong" and "weak" interactions are defined. Preliminary experimental results regarding the expansion side of a wedge at a large angle of attack are presented. These results show that the pressure rise across the trailing-edge shock is communicated upstream and causes separation of the laminar boundary-layer almost from the leading edge.

CIT. 07:016

California Inst. of Tech. [Guggenheim Aeronautical Lab] Pasadena.

COMPRESSIBLE FLOW TABLES FOR AIR IN INCREMENTS OF 0.001 MACH NUMBER, by H. N. Rilse. Aug. 7, 1954, 203p. incl. diagr. tables. (Publication no. 27; ORDCIT project) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) Unclassified

This report consists of a tabulation of Mach-number functions, from M = 0.050 to M = 10.000, for use by the aerodynamicist. The increments used are small enough (0.001 in M) to eliminate the necessity for interpolation in almost every application. (Contractor's summary)

CIT. 07:017 - CIT. 07:020

CIT. 07:017

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

INFLUENCE OF THE LEADING-EDGE SHOCK WAVE ON THE LAMINAR BOUNDARY LAYER AT HYPERSONIC SPEEDS, by L. Lees. July 15, 1954, 26p. incl. illus. (Technical rept. no. 1) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 40933 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 594-600; 612, June 1956.

In order to bring out the importance of the leading-edge region at hypersonic speeds the influence of the leading-edge shock wave on the laminar boundary layer is investigated in two simple cases of steady flow over a semi-infinite insulated flat plate: (1) sharp leading edge; (2) blunt leading edge, as approximated by a normal shock wave. The streamlines that enter the boundary layer over a large region of the plate surface have previously crossed the shock wave very near the leading-edge, where the shock is strong and highly curved. Consequently, the temperature at the outer edge of the boundary layer is appreciably higher than free stream temperature, and the vorticity there is not zero. The effects of this shock wave "heating" and vorticity on the boundary layer are shown to be much larger than the usual "errors" made in the boundary-layer theory, and an estimate of these effects can therefore be obtained within the framework of that theory. The numerical magnitude of the shock wave influence is found to be appreciable. For the case of the blunt leading-edge the slope of the curve of induced pressures plotted against the hypersonic interaction parameter closely approaches the experimental data of Hammitt and Bogdonoff obtained in helium at large values of this parameter. These approximate results show that the influence of the leading-edge region at hypersonic speeds requires careful theoretical and experimental study. (Contractor's summary)

CIT. 07:018

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

TRANSITION STUDIES AND SKIN FRICTION MEASUREMENTS ON AN INSULATED FLAT PLATE AT A HYPERSONIC MACH NUMBER, by R. H. Korkegi. July 15, 1954, 91p. incl. illus. tables, refs. (Memorandum no. 17) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 48454 Unclassified

Tests were made in the 5- x 5-in. hypersonic wind tunnel at a nominal M = 5.8. The results of phosphorescent lacquer technique measurements for transition detection agreed well with total-head rake measurements along the plate surface and pitot boundary-layer surveys. The boundary was laminar for Re $\leq 5 \times 10^6$. Transverse contamination because of the turbulent boundary layer on the tunnel sidewall originated far downstream of the leading edge at Re = 1.5 to 2×10^6, and spread at a uniform angle of 5-1/2° as compared with 9-1/2° in low-speed flow. The effect of 2-dimensional and local disturbances was investigated by the technique of air injection into the boundary layer. Despite the onset of transition at Reynolds numbers down to 10^6, a fully developed turbulent boundary layer was not obtained at Reynolds numbers much below 2×10^{-6} regardless of the amount of air injected. Direct skin-friction measurements were made by the floating-element technique incorporating a null system using chain loading for Re = 10^6 to 4×10^6 (based on distance from leading edge). Without artificial tripping, the boundary layer was laminar over the complete range. With air injection, turbulent shear occurred only for Re = 2×10^6. The turbulent skin-friction coefficient was approximately 0.40 of that for incompressible flow for a constant value of the Reynolds number which is based on the momentum thickness, and 0.46 for an effective Reynolds number between 5 and 6×10^6. (ASTIA abstract)

CIT. 07:019

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

HYPERSONIC SHOCK TUBE, by Y. A. Yoler. July 19, 1954, 168p. incl. illus. refs. (Memorandum no. 18) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 46521 Unclassified

Theoretical and experimental studies were made of the feasibility of using a shock tube for quantitative investigations of hypersonic flow phenomena at temperatures simulating free-flight conditions. Discussions are given of methods of producing high Mach numbers, limitations on the test section Mach number, methods of generating strong shock waves, flows with variable specific heats and dissociation, and types of problems amenable to study with the hypersonic shock tube. The experimental investigations to date have dealt with pressure studies using piezoelectric gages and schlieren studies of the flow.

CIT. 07:020

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

BASE PRESSURE AND STATIC PRESSURE FOR A CONE-CYLINDER AT A NOMINAL MACH NUMBER OF 5.8, by W. D. Harkins. July 20, 1954, 28p. incl. illus. diagrs. tables, refs. (Memorandum no. 19) [AFOSR-TN-54-271] (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 42331 Unclassified

The scope of this investigation was: (1) to determine interference data from both 1- and 2-phase flow for

evaluating base pressure results; (2) to study the effect of Reynolds number on base pressure; and (3) to compare experimental and theoretical static-pressure distribution. Pronounced viscous effects in hypersonic flow demonstrated the increased nonlinearity of such flow problems. Based on tests in the 5- x 5-in. hypersonic wind tunnel, the following conclusions are drawn: the critical length of the sting required to prevent feed-up in the boundary layer is about 7 in. for d/h = 0.3125; the effect of varying effective sting diameter is not a monotonic variation at M = 5.8; base pressure increases monotonically for the Reynolds number range tested; and the effect of viscosity is great enough to change the effective shape of the body in the vicinity of the shoulder.

CIT. 07:021

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

IMPACT PRESSURE AND TOTAL TEMPERATURE INTERPRETATION AT HYPERSONIC MACH NUMBER, by J. C. Graves and N. R. Quiel. July 26, 1954, 60p. incl. illus. diagrs. refs. (Memorandum no. 20) ([AF]OSR-TN-54-272) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 42330 Unclassified

Results are presented of an experimental investigation of impact-pressure and total-temperature interpretation at a nominal Mach number of 5.6. The data indicate that the Rayleigh equation, which assumes non-viscous flow, requires correction at low free-stream Reynolds numbers. These viscous effects are detected at Reynolds numbers (based on impact-probe diameter) as high as 3000, and they continue to increase with decreasing Reynolds numbers. At the low pressure limit of the facilities used in this investigation, the maximum viscous correction is 2.5 per cent for a Reynolds number of 425. The calibration curves for the recovery factor of a total-temperature probe are given, plus an analysis of suitable parameters with which to present this information. For the limited range of total-temperatures of 200° to 260°F, and a nominal Mach number of 5.6, single calibration curves are shown using either the free-stream Reynolds number, or the Nusselt number of the flow inside the probe (based on thermocouple wire diameter) as parameters. (Contractor's abstract)

CIT. 07:022

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

LAMINAR BOUNDARY LAYERS ON SLENDER BODIES OF REVOLUTION IN AXIAL FLOW, by R. M. Mark. July 30, 1954, 101p. incl. illus. refs. (Memorandum no. 21) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 44929 Unclassified

An exact similar solution of the modified boundary layer equations was obtained for the axial incompressible flow past paraboloids of revolution, and an approximate method was developed for determining the local skin friction on arbitrary slender bodies of revolution in this type of flow. The approximate and exact results agreed satisfactorily for paraboloids and circular cylinders. The existence of energy integrals of the modified equations and their similarity was established. The results from an approximate method of analyzing slender insulated bodies showed that compressibility counterbalances the rise in local skin friction due to curvature at high Reynolds numbers, and increases this friction at low Reynolds numbers. Velocity profiles on a slender ogive-cylinder were obtained experimentally at M = 5.8 and at different Reynolds numbers. The results indicate a curvature effect when compared with flat plate results.

CIT. 07:023

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

SIMILAR SOLUTIONS OF COMPRESSIBLE BOUNDARY LAYER EQUATIONS, by T.-Y. Li and H. T. Nagamatsu. Sept. 10, 1954, 16p illus. tables, refs. (Memorandum no. 22) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 46821 Unclassified

In this investigation, it is disclosed that the partial differential equations for the compressible laminar boundary layer can be transformed into a system of ordinary differential equations by a direct procedure. This new procedure yields explicitly a differential equation for the free stream velocity distribution, u_1, which allows similar solutions. On integrating this differential equation, the special forms of u_1 are found, and these results are correlated with Stewartson's results. As an example of the similar solutions, the hypersonic viscous flow over a flat plate is discussed. From the analysis of the numerical solutions, obtained on the Reeves Electronic Analogue Computer, the characteristics of the laminar boundary layer flow with pressure gradient and heat transfer are discussed. It is shown (1) that on a heated surface, the local velocity inside the boundary layer can exceed the free stream value when a certain favorable pressure gradient exists; (2) that the variation of C_{h1}/C_{f1} for various surface temperatures with different free stream pressure gradients can be accurately predicted; and (3) that the effects of heat transfer on the laminar separation phenomenon can be quantitatively studied. (Contractor's abstract)

CIT. 07:024

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

INVESTIGATION OF FLOW IN THE THROAT REGION FOR HYPERSONIC NOZZLE, by R. E. Oliver and H. T. Nagamatsu. Jan. 15, 1955, 18p. incl. illus.

CIT. 07:025 - CIT. 07:028

(Memorandum no. 24) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 74794 Unclassified

The following conclusions, based on the results of tests conducted in the GALCIT 2½" supersonic wind tunnel, appear valid: (1) no sidewall waves exist in the test nozzle due to the large throat radius and small expansion angle; (2) the constant velocity contours in vertical planes parallel to the tunnel axis do not depart radically from radial flow with center at the nozzle throat; and (3) inflatable silastic seals afford a satisfactory means of sealing between the nozzle blocks and sideplates in the throat region if the c-clamp is used to assure positive contact between the nozzle blocks and sideplates. (Contractor's conclusions)

CIT. 07:025

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

A STUDY OF PIEZOELECTRIC ELEMENTS FOR THE MEASUREMENT OF TRANSIENT FORCES, by Y. A. Yoler and H. T. Nagamatsu. Feb. 1, 1955, 27p. illus. tables. (Memorandum no. 23) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 62149 Unclassified

A survey of the suitability of various piezoelectric crystals for the measurement of transient forces is made. This is done by comparing the "figure of merit", which is proportional to the static charge produced by a unit stress for crystals which are otherwise satisfactory with respect to effect of temperature, humidity, brittleness, natural frequency, etc. The equations determining the output and the "response time" of a pickup are presented. The advantages of stacking the crystals in parallel to increase the "figure of merit" are shown. The application of piezoelectric elements to measure normal forces, shear forces, and volume expansion forces is discussed. The advantages of recently developed ceramic elements over natural crystals for the measurement of normal forces and volume expansion are shown. To measure shear forces, natural crystals must be used. Tables showing the properties of various crystals for measuring normal forces and shear forces are presented. (Contractor's abstract)

CIT. 07:026

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

HYPERSONIC VISCOUS FLOW ON A NONINSULATED FLAT PLATE, by T.-Y. Li and H. T. Nagamatsu. Apr. 1, 1955 [32] p. incl. illus. tables, refs. (Memorandum no. 25) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 67094 Unclassified

An analytical treatment of the "strong" interaction problem in hypersonic viscous flow on a noninsulated flat plate is presented, using the method of "similar" solutions of the compressible boundary layer equations. Recent experimental data which confirm some of the theoretical results are also discussed. (Contractor's abstract)

CIT. 07:027

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

AN EXPERIMENTAL INVESTIGATION OF FLOW OVER SIMPLE BLUNT BODIES AT A NOMINAL MACH NUMBER OF 5.8, by R. E. Oliver. June 1, 1955, 32p. incl. illus. (Memorandum no. 26) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 67095 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 177-179, Feb. 1956.

An experimental investigation was conducted in Leg no. 1 of the GALCIT hypersonic wind tunnel to determine flow characteristics for a series of blunt bodies at a nominal Mach number of 5.80 and free stream Reynolds number/in. of 2.4×10^5, 1.2×10^5, and 0.6×10^5. This investigation was made to determine surface static pressure distributions and to obtain schlieren photographs showing the shock configurations. The seven bodies investigated were as follows: (1) 40° half-angle cone; (2) 40° half-angle cone with spherical nose; (3) hemisphere-cylinder; (4) cylinder transverse to the free stream flow; (5) flat-nosed cylinder with its major axis parallel to the free stream flow direction; (6) 10° - 40° half-angle double cone; and (7) 13° - 30° half-angle double cone. All tests were conducted in one-phase flow with a tunnel stagnation temperature of 225°F, and with models at zero angles of attack and yaw.

CIT. 07:028

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

AN EXPERIMENTAL INVESTIGATION OF PRESSURE GRADIENTS DUE TO TEMPERATURE GRADIENTS IN SMALL DIAMETER TUBES, by W. M. Howard. June 10, 1955 [16] p. incl. illus. (Memorandum no. 27) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19) AD 67096 Unclassified

Results of an experimental investigation of pressure gradients due to axial temperature gradients in small diameter tubes are presented. The tests, which covered the region of Knudsen numbers (based on tube inside radius) of 0.01 to 6, indicate good correlation with theory. It is of value to note that this correlation

was obtained by using T equal to the temperature difference between the hot and cold ends of the tubes and T_{ave} equal to the average of these two temperatures. In contrast, theory would dictate obtaining the temperature variation along the length of the tube and applying the formulas to small incremental T's, then summing to get the total effect. Therefore, for normal laboratory conditions where pressure gradient corrections are to be computed, it is sufficient to record only the temperatures at the hot and cold ends rather than having to obtain a number of temperature readings along the tube. In order to apply pressure corrections easily and rapidly, a system of correction curves is given. To simplify the procedure, the tube cold end temperature was assumed to be 80°F, and the correction curves drawn accordingly. However, for different laboratory conditions a similar system of curves could be drawn and used. (Contractor's abstract)

CIT. 07:029

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

VISCOUS EFFECTS OF STATIC PRESSURE DISTRIBUTION FOR A SLENDER CONE AT A NOMINAL MACH NUMBER OF 5.8, by L. C. Baldwin. June 14, 1955, 26p. incl. illus. refs. (Memorandum no. 28) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19)
AD 67097 Unclassified

The results of the investigation of pressure distribution on a 5° cone at a nominal Mach number of 5.8 indicate the following: (1) the induced pressure was approximately 45% greater than theoretical inviscid pressure for the lowest Reynolds number tested; (2) the use of the parameter $1/\sqrt{Re_{x_2}}$ correlated the data taken at various stagnation pressures quite well; and (3) the measured pressures nearest the apex were somewhat higher than theoretically predicted pressures. The unknown influence of the region in the immediate vicinity of the apex points to the need for further tests to determine this effect. (Contractor's conclusions)

CIT. 07:030

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

RAYLEIGH'S PROBLEM AT LOW MACH NUMBER ACCORDING TO THE KINETIC THEORY OF GASES, by H.-T. Yang and L. Lees. July 15, 1955, 88p. incl. illus. tables, refs. (Technical rept. no. 2) (Sponsored jointly by Army Ordnance and [Air Force] Office of Scientific Research under DA-04-495-ord-19)
AD 67093 Unclassified

Rayleigh's problem of an infinite flat plate set into uniform motion impulsively in its own plane is studied by using Grad's equations and boundary conditions developed from the kinetic theory of gases. For a heat insulated plate and a small impulsive velocity (low Mach number), only tangential shear stress and velocity and energy (heat) flow parallel to the plate are generated, while the pressure, density, and temperature of the gas remain unchanged. Moreover, no normal velocity, normal stress, or normal energy flow is developed. Near the start of the motion the flow behaves like a "free-molecule flow", and all physical quantities are analytic functions of the flow parameters and time. The results obtained for "large time", however, add to the growing lack of confidence in the Burnett-type series expansions in powers of mean free path. Although such expansions are obtained here, they are poorly convergent and inappropriate to the problem. To replace these unsatisfactory solutions, approximate closed-form solutions valid for all values of the time are developed, which agree with the free-molecule values for small time and the classical Rayleigh solution for large time. This technique may be useful in studying more general flow problems within the framework of the kinetic theory of gases. (Contractor's summary)

CIT. 07:031

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

INSTRUMENTATION OF GALCIT HYPERSONIC WIND TUNNELS, by P. E. Baloga and H. T. Nagamatsu. July 31, 1955, 28p. incl. illus. (Memorandum no. 29) [Sponsored jointly by Army Ordnance and Air Force Office of Scientific Research under DA-04-495-ord-19]
AD 70405 Unclassified

A brief description is given of 2 CIT 5- x 5-in. hypersonic wind tunnels, Leg no. 1 and Leg no. 2, having Mach number ranges of 2-7 and 4-11, respectively. The various instruments used in these tunnels at pressures down to about ¼ mm of mercury and temperatures up to about 1100°F are discussed. They include devices for determining: (1) inlet and outlet pressures for each stage of compression; (2) outlet air temperature for each stage; (3) compression ratio of various compressor stages; (4) stagnation pressure; and (5) stagnation temperature. Additional pressure measuring methods and equipment are considered, e.g., low-pressure silicone manometer banks, low-pressure micromanometer bank, and tilting U-tube micromanometer. Among the miscellaneous instruments described are a carbon dioxide concentration meter and a high pressure dewpoint indicator.

CIT. 07:032

California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

INVISCID HYPERSONIC FLOW OVER BLUNT-NOSED SLENDER BODIES, by L. Lees. Feb. 1, 1956, 12p. incl. illus. refs. (Memorandum no. 31) (Sponsored jointly by Army Ordnance and Air Force Office of Scientific Research under DA-04-495-ord-19)
AD 87696 Unclassified

CIT.08:001 - CIT.08:003

The theoretical considerations of an intense spherical blast wave analysis are shown to be applicable to the shock wave generated by a blunt nose of finite radius on an unyawed slender body. Constant energy conditions were used to develop equations which described the shape of the bow shock wave (not too close to the nose) for a body of revolution and for a planar body. The comparison of theoretical results with those of experiments on a flat plate with a blunt leading edge at $M_\infty = 13$ in helium indicated that the wave shape is predicted very accurately by this analysis. A consideration of energy and drag showed that at hypersonic speeds the inviscid surface pressures generated by blunt noses are larger than those produced by boundary layer growth on a flat surface over a distance of order 1 from the nose, where 1 is the influence length. At $M_\infty = 15$ the viscous interaction effects are important for $Re < 10^3$, but somewhere in the range $1500 < Re < 2000$ the inviscid effects must spread rapidly over the plate surface. For $Re > 3000$ the inviscid pressure is dominant and determines the boundary layer development, skin friction, and heat transfer over the forward portion of the body.

CIT.08:001

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

A SIMPLE LAMINAR BOUNDARY LAYER WITH SECONDARY FLOW, by H. G. Loos. June 1953 [13]p. incl. diagrs. (Technical rept. no. 1) (AF 18(600)178) AD 12626 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 35-40, Jan. 1955.

An exact calculation was made of the incompressible laminar boundary layer developed on a flat plate by a flow having streamlines which are parabolic in shape and parallel to the plane of the plate. The free stream was rotational with a constant vorticity directed normal to the plate. The solution, when the angle between the free-flow direction and the x-axis at the leading edge is zero, coincides with that of Mager and Hansen (NACA Technical note no. 2658) for small turning angles, and also remains valid for large angles. The cross flow does not separate because it transports fluid with high energy to the critical regions. Because of the variation of the total pressure from one streamline to another in the free stream, the total pressure within the boundary layer at a given point can exceed that of the corresponding free stream. (ASTIA abstract)

CIT.08:002

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

LAMINAR BOUNDARY LAYER PROBLEMS ASSOCIATED WITH FLOW THROUGH TURBOMACHINES, by A. Mager. June 1953 [113]p. incl. diagrs. refs. (Technical rept. no. 2) (AF 18(600)178) AD 13547 Unclassified

An analysis is presented of 3-dimensional boundary-layer flows of interest in the design of turbomachinery. A set of zero- and first-order equations were developed by assuming small lateral-pressure gradients and applying a perturbation procedure to the steady, laminar boundary-layer equations of motion. The zero-order equations are the 2-dimensional equations for flow over a flat plate. The first-order equations retain the characteristic Blasius similarity for a family of external flows expressible by $U^* = Bx^m z^l$ and $W^* = Ax^n z^r$, where U^* and W^* are the perturbation velocities, x and z the coordinates, and A and B the arbitrary constants. Boundary-layer velocity distributions were numerically determined for several types of external flows. The first part of the report deals with boundary-layer flows over plane surfaces; the second considers flows over surfaces with sharply varying lateral curvature. To obtain solutions, the equations were expanded in terms of the product of the local surface curvature and the boundary-layer thickness to obtain solutions for the curved surfaces. The effects of compressibility and rotation of the surface on the flows over a plane surface were quantitatively evaluated. The results qualitatively agreed with data from more exact solutions.

CIT.08:003

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

ANALYSIS OF SECONDARY FLOW IN THE STATOR OF AN AXIAL TURBOMACHINE, by H. G. Loos. Sept. 1953, 44p. diagrs. refs. (Technical rept. no. 3) (AF 18(600)178) AD 20614 Unclassified

A technique is developed to calculate the circulation along the blades and the gapwise average upwash behind the blades of a stator cascade in a nonlinear flow caused by wall boundary layers. The method takes into account both the self-transport of the secondary vorticity, and the influence of the excessive turning of the flow in the wall boundary layer on the generation of the secondary vorticity. The secondary flow with the given vorticity field is approximated by channel and lifting-line methods. In the former, the solution is obtained by extending the cascade blades downstream as rigid surfaces in the trailing edge direction. The velocity field in the Trefftz plane is determined through the boundary conditions at imaginary walls. The results of the 2 methods for the gapwise average upwash distribution downstream of the cascade are similar in the main part of the channel. The losses directly or indirectly attributed to the secondary flows are calculated to be about 5% of the energy input of the next moving blade row.

CIT. 08:004

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

PROPAGATION OF STALL IN A COMPRESSOR BLADE ROW, by F. E. Marble. Jan. 1954, 32p. illus. (Technical rept. no. 4) ([AF]OSR-TN-54-69) (AF 18(600)I78) AD 29759 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 541-554, Aug. 1955.

The experimental observations of Iura and Rannie (Am. Soc. Mech. Eng., Paper no. 53-SA-69, 1953) are used as a primary basis for a simple model of the propagation of stall in compressors. This model characterizes the stall process in an airfoil cascade by a static pressure loss across the cascade which increases discontinuously at the stall angle. The turning angle is assumed to be affected in only a minor way. The analysis for a 2-dimensional approximation of a stationary or of a rotating blade row which is free of adjacent blade-row interference reveals the extent of the stall region, the stall-propagation speed, and the pressure loss associated with stalled operation together with its effect on performance. The effect of stall propagation upon the performance of a single stage axial compressor is illustrated, and the mechanism of entering the stall-propagation regime is discussed. The essential points of the results are considered to be in agreement with the experimental evidence, and such discrepancies between theory and experiment as with regard to the propagation speed cannot be interpreted as an inadequacy of the model until either a more detailed experimental investigation is undertaken or the results are extended to situations more nearly approximating those on which the observations were made. (ASTIA abstract)

CIT 08:005

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

THICK LAMINAR BOUNDARY LAYER UNDER SUDDEN LATERAL PERTURBATION, by A. Mager. Apr. 1954 [22]p. incl. diagrs. (Technical rept. no. 5) (AF 18(600)178) AD 33652 Unclassified

The crosswise flow in a 3-dimensional boundary layer is treated; in its outer part the boundary layer is assumed essentially nonviscous, but next to the wall viscosity must be considered. These 2 boundary layer regions are joined, providing an approximate but rapid solution for the crosswise velocity profile. This technique is useful in treating 3-dimensional boundary layer problems which have 2 characteristic lengths, such as a layer which has time to thicken in the usual fashion, but then is suddenly laterally perturbed at a certain fixed distance away from the leading edge. A comparison is given, where possible, with velocity distributions obtained by more conventional procedures. (ASTIA abstract)

CIT. 08:006

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

COMPRESSIBILITY EFFECTS ON SECONDARY FLOW, by H. G. Loos. [Nov. 4, 1954] 5p. incl. illus. [AF 18(600)I78] Unclassified

Published in Jour. Aeronaut. Sciences, v. 23: 76-80, Jan. 1956.

The method of W. R. Hawthorne for the calculation of the secondary vorticity is generalized for compressible flow. It is shown that in the linearized theory (small vorticity) the influence of compressibility upon the secondary vorticity is due to: (1) the entropy gradient in the approaching flow; and (2) the compression of the fluid during the turning of the flow. The analysis is applied to the secondary vorticity which generates in a cascade or bend if the approaching flow has a boundary layer with a Prandtl number equal to unity, and has been developed along an insulated wall. For a cascade with a passage cross section which increases linearly with the turning angle and at the exit is 1.4 times the entrance cross-section area, the compressibility correction, to be applied upon the secondary vorticity, amounts to 24 per cent for a cascade entrance Mach number of 0.8. The problem of determination of the secondary flow downstream of the cascade, which is associated with a given secondary vorticity, is the same for compressible and incompressible flow.

CIT. 08:007

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

THREE-DIMENSIONAL LAMINAR BOUNDARY LAYER WITH SMALL CROSSFLOW, by A. Mager. [1954] 18p. illus. diagrs. refs. (AF 18(600)178) Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 835-845, Dec. 1954.

The analysis of three-dimensional, steady flow laminar boundary layer with small crossflow has indicated that many important problems in this class can be solved with relatively little effort, thus affording a greater understanding of real fluid flow. Although the accurate determination of the separation point is certainly beyond the scope of small perturbation analysis (and also beyond the standard boundary layer theory), the factors which affect the separation of three-dimensional boundary layers are clearly pointed out. Among these factors, the crosswise variation of flow is indicated as important in affecting the separation. In particular, the examples show the strong tendency toward the separation as a result of crosswise variation of crossflow, both on a cylindrical shell and in a simulated s-shaped duct. Similarly, the sharp, laterally varying, concave curvature of the sur-

CIT. 08:008 - CIT. 09:002

face tends to separate even the basic flow profile. (Contractor's abstract)

CIT. 08:008

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

A THEORY OF NON-STEADY STALL FLOW ARCUND AN AIRFOIL WITH APPLICATION TO ROTATING STALL IN COMPRESSOR BLADE ROWS, by H. G. Loos, Apr. 1956, 60p. illus. diagrs. refs. (Technical rept. no. 6) (AF 18(600)178) Unclassified

A mathematical model for the non-steady stall flow around a single airfoil is developed. The flow is assumed as inviscid and incompressible; the airfoils are approximated by flat plates. An airfoil together with the separated flow region on its "suction surface" is considered as a thin airfoil with partially fluctuating boundaries. The model is applied to an analysis of propagating stall in a two-dimensional compressor cascade. A simple, approximate solution of the resulting equations seems to be in agreement with experimental data for the propagation speed at stall inception. The theory predicts a transition from a two-region stall to a single-region stall. (Contractor's abstract)

CIT. 09:001

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

CARBON FORMATION FROM ACETYLENE IN THE SHOCK TUBE, by E. N. Bennett. June 1956, 85p. incl. diagrs. refs. [AFOSR-TN-56-333] (Sponsored jointly by Air Force Office of Scientific Research as technical rept. no. 2 under AF 18(603)2 and Office of Naval Research as technical rept. no. 20 under Nonr-22003) AD 95209 Unclassified

The use of the shock tube for the study of C formation from C_2H_2 was considered theoretically and studied experimentally. In the calculations, the state of the gas was determined behind incident and reflected shocks for a wide range of shock strengths and for various excitation models of the internal degrees of freedom. A simple mechanism was assumed for the thermal decomposition, namely, the formation of solid C and H. Upper and lower limits for the final temperatures are computed for incident and reflected shocks. Estimates are presented for the minimum times spent by the gas in a uniform state at the elevated temperatures behind reflected shocks. The shock strengths required to initiate decomposition of C_2H_2 at various pressures have been investigated experimentally. Temperature estimates and shock velocity measurements suggest that the effective specific heat ratio approaches the equilibrium value. The minimum pressure ratios p_4/p_1 (initial conditions of the high-(p_4) and the low-(p_1) pressure gas) required for C formation were found to be: for C_2H_2 at initial pressures of 10-, 50-, and 150-mm Hg, ratios of about 255, 170 and 160, respectively; for a mixture of 95% A and 5% C_2H_2 at initial pressures of 50-, 100-, and 150-mm Hg, ratios near 42, 39, and 38, respectively. Spectroscopic studies were carried out to determine the light emitted in a narrow wavelength region during chemical decomposition behind reflected shocks. The results show that the intensity distribution follows the black-body emission law. Therefore, a 2-color method may be used in future studies for determining the temperature as a function of time behind C-forming shocks. (Contractor's abstract)

CIT. 09:002

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

AN INTRODUCTION TO THE USE OF THE SHOCK TUBE FOR THE DETERMINATION OF PHYSICO-CHEMICAL PARAMETERS, by S. S. Penner, F. Harshbarger, and V. Vali. June 1956, 1v. incl. diagrs. refs. [AFOSR-TN-56-334] (Sponsored jointly by Air Force Office of Scientific Research as technical rept. no. 1 under AF 18(603)2 and Office of Naval Research as technical rept. no. 19 under Nonr-22003) AD 95210 Unclassified

Also presented at meeting of the AGARD Combustion Panel, Oslo (Norway), May 1956.

Also published in Combustion Researches and Reviews, London, Butterworths Scientific Publications, 1957, p. 134-172.

A qualitative survey was made of principles and methods which are useful for understanding the application of the shock tube as a research tool for high-temperature investigations. A survey of optical techniques is presented which are suitable for studying processes which occur in a gas behind incident and reflected shock fronts. The techniques include (1) interferometric procedures; (2) schlieren techniques; (3) ionization density and conductivity measurements; (4) temperature measurements behind shocks; (5) light absorption and emission measurements at selected wavelength regions; (6) spectroscopic studies behind shock fronts; and (7) light reflection at the shock front. A description is also given of some representative uses of the shock tube for the determination of physico-chemical parameters. The particular subjects considered are of possible application to problems important in combustion research. They include: (1) reaction-rate measurements for homogeneous gas reactions; (2) ionization rates; (3) measurement of vibrational relaxation times; (4) gas emissivities at elevated temperatures; (5) measurement of heats of dissociation; (6) determination of transport properties; (7) thickness of shock fronts and rotational heat capacities lags; and (8) initiation of detonation with shock waves, and thickness of detonation fronts.

CIT. 09:003

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

THEORETICAL STUDIES ON THE THERMAL DECOMPOSITION OF NITRIC OXIDE IN A SHOCK TUBE, by S. T. Demetriades and H. Aroeste. June 1956 [39]p. incl. diagrs. tables, refs. [AFOSR-TN-56-335] (Sponsored jointly by Air Force Office of Scientific Research as technical rept. no. 3 under AF 18(603)2 and [Office of Naval Research under Nonr-22003]) AD 95211 Unclassified

Favorable conditions are determined for the study of the kinetics of thermal decomposition of nitric oxide in a shock tube. If the pressure ratios across the diaphragm are of the order of 5000, a test section length between 20 and 25 ft is sufficient to decompose nitric oxide to within 1% of its equilibrium concentration. If the initial pressure and temperature before the shock are about 0.02 atm and 300°K, respectively, the final pressure behind the shock will be about 1 atm. The pressure behind the shock changes by only about 10% as the reaction proceeds to completion. Charts are presented for computing the length of test section necessary for various percentages of decomposition and various initial pressure ratios. (Contractor's abstract)

CIT. 09:004

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

ON THE PRODUCTION OF CHEMICALS AND CARBON FORMATION IN THE SHOCK TUBE, by F. Harshbarger. Aug. 1956, 1v. incl. illus. diagrs. tables, refs. (AFOSR-TN-56-335a) (Sponsored jointly by Air Force Office of Scientific Research as technical rept. no. 4 under AF 18(603)2 and Office of Naval Research as technical rept. no. 22 under Nonr-22003) Unclassified

Some unsuccessful attempts on the production of hydrazine from NH_3-O_2 mixtures in the shock tube are described. Preliminary results, relating to the mechanism of C formation from C_2H_2, are discussed together with some new and useful methods of instrumentation. (Contractor's abstract)

CIT. 09:005

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

SIMULTANEOUS LIGHT-ABSORPTION AND EMISSION MEASUREMENTS BEHIND A SHOCK WAVE, by F. Harshbarger. [1956] 2p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)2 and Office of Naval Research under Nonr-22003) Unclassified

Published in Jour. Chem. Phys., v. 24: 1261, June 1956.

The use of a Kerr cell made it possible to study simultaneously emission and absorption during the decomposition of acetylene behind weak shocks. The light source was a General Electric type 524 xenon lamp. Both the emitted and transmitted modulated light were detected on a single photomultiplier tube the output of which was displayed on an oscilloscope. The AC component of the phototube output represents the transmitted light, the DC component corresponds directly to the emitted light.

CIT. 09:006

California Inst. of Tech. Guggenheim Jet Propulsion Center, Pasadena.

A MULTIPLE-PATH TECHNIQUE FOR THE DETERMINATION OF PHYSICO-CHEMICAL DATA BEHIND SHOCK FRONTS, by W. [J.] Hooker, M. Lapp and others. [1956] 3p. incl. diagr. (Sponsored jointly by Air Force Office of Scientific Research under AF 18 (603)2 and Office of Naval Research under Nonr-22003) Unclassified

Also published in Jour. Chem. Phys., v. 25: 1087, Nov. 1956.

A procedure for studying carbon formation and gas emissivities at elevated temperatures behind shock fronts is given. It involves simultaneous spectral recording of an unchopped single-path beam and of a chopped double-path beam. A slotted air turbine wheel and a mechanical chopper are employed in the process.

CIT. 10:001

California Inst. of Tech. Hydrodynamics Lab., Pasadena.

THE DYNAMICS OF PARTICULATE MATTER IN FLUID SUSPENSIONS, by V. A. Vanoni and E.-Y. Hsu. Dec. 31, 1951, 37p. incl. illus. diagrs. tables. (Rept. no. E-34) (AF 33(038)17207; continued by AF 18(600)582) ATI-152345 Unclassified

A program of diffusion experiments were carried out in a small low-speed water tunnel, and analytical studies were made. Results of the experimental program are presented.

CIT. 11:001

California Inst. of Tech. Hydrodynamics Lab., Pasadena.

TURBULENCE AND DIFFUSION AS FACTORS IN SEDIMENT TRANSPORTATION, by V. A. Vanoni and E.-Y. Hsu. [1952] [30]p. incl. illus. diagrs. tables, refs. (Convention preprint paper no. 67) (AF 18(600) 582; continuation of AF 33(038)17207) Unclassified

CIT. 11:002 - CIT. 12:003

Presented at ASCE-ASME Centennial Convocation, Chicago, Ill., Sept. 3-13, 1952.

This paper discusses briefly some observations of the effect of sediment flows and studies of turbulence in channels, including the presentation of some recent turbulence and diffusion studies.

CIT. 11:002

California Inst. of Tech. Hydrodynamics Lab., Pasadena.

A STUDY OF TURBULENCE AND DIFFUSION USING TRACERS IN A WATER TUNNEL, by V. A. Vanoni and N. H. Brooks. Jan. 31, 1955, 51p. incl. illus. diagrs. tables, refs. (Rept. no. E-46) [AFOSR-TR-55-18] (AF 18(600)582) AD 66182 Unclassified

A study of turbulence in a water tunnel was made by observing the motion of small liquid droplets having the same density as water. These tracers were injected into the flow, and their trajectories were photographed with a fixed camera using a stroboscopic light. From measurements of the photographic plates, it was possible to calculate instantaneous velocities, turbulence intensities, and Lagrangian correlation coefficients. Runs were made both with and without a turbulence-producing grid. From 11 to 35 separate trajectories were measured for each run. Each point value of the turbulence characteristics is an ensemble average. The biggest limitation on the practical application of this method is the inevitable sampling error in the calculated intensities and correlations. These errors were large, even when 35 trajectories were measured; they can be reduced only by greatly increasing the number of trajectories analyzed. A satisfactory experimental technique for photographing and measuring the trajectories of the tracers was developed, but the computations involved are still very laborious. Results showed that a large fraction of the turbulent energy of the field may be attributed to substantial differences between the mean velocities of different tracers over the 3-ft observation reach. The decay of turbulence energy with distance showed a linear relation between the reciprocal of the energy and the distance, but a strong Reynolds number effect was observed. The correlation curves indicated that the time scale was fairly large; practically all of the energy was associated with relatively low frequencies. Unfortunately, the data were not extensive enough to permit calculation of the diffusion coefficients from the Lagrangian correlations in accordance with Taylor's theory. (Contractor's abstract, modified)

CIT 12:001

California Inst. of Tech. Norman Bridge Lab. of Physics, Pasadena.

COMPOSITE PIEZOELECTRIC RESONATOR, by W. G. Cady. Apr. 7, 1954. 10 p. incl. illus. tables, refs. (Technical note no. 1) (AFOSR-TN-54-86) (AF 18(600)593) AD 61827 Unclassified

Also published in Amer. Jour. Phys., v. 23: 31-40, Jan. 1955.

Various types of composite resonators and their uses are summarized. The general equations are given for the transducer for plane ultrasonic waves, consisting of a crystal assembly with back and front plates. Applications are made to several simple cases, and expressions are tabulated for the amplitude of vibration for various combinations of half- and quarter-wave components. Consideration is given to the effect of the acoustic load on the frequency for maximal amplitude. Theoretical formulas are compared with experimental results for rods of aluminum and fused quartz excited in vibration by piezoelectric crystals. (Contractor's abstract)

CIT. 12:002

California Inst. of Tech. Norman Bridge Lab. of Physics, Pasadena.

ON THE SPECIFIC DIRECTIONS OF LONGITUDINAL WAVE PROPAGATION IN ANISOTROPIC MEDIA, by F. E. Borgnis. Dec. 1954, 25p. incl. diagrs. (Technical note no. 2) (AFOSR-TN-54-253) (AF 18(600)593) AD 50987 Unclassified

Also published in Phys. Rev., v. 98: 1000-1005, May 15, 1955.

A method is developed to obtain specific directions in a medium of given anisotropy along which the displacement of 1 of the 3 possible waves is parallel to the direction of wave propagation. If the matrix of elastic coefficients is known, the method leads to the complete set of such longitudinal directions. The method is applied to the trigonal, hexagonal, tetragonal, and cubic groups of crystal symmetry, and general conditions are established under which pure longitudinal waves exist. A numerical calculation shows that there are 5 such distinct directions for α-quartz not counting the ones which are equivalent by symmetry properties. Special conditions are obtained between the elastic constants under which longitudinal waves can be propagated in any direction in a hypothetical anisotropic medium fulfilling these conditions. (ASTIA abstract)

CIT. 12:003

California Inst. of Tech. Norman Bridge Lab. of Physics, Pasadena.

RESEARCH IN HIGH-FREQUENCY ULTRASONICS, by W. G. Cady. Final rept. Mar. 1955, 17p. incl. diagrs. (AFOSR-TN-55-79) (AF 18(600)593) AD 61828 Unclassified

This final report summarizes the work done during

the 2-yr contract. After a survey of proposed undertakings, abstracts are given of completed work on composite piezoelectric resonators, theory of acoustic filters having a periodic structure, and theory of compressional waves in crystals. A report is given on the attempts to generate acoustic vibrations at a frequency of 3000 mc/sec. Descriptions are given of the transducer and cavity resonator used in the unsuccessful experimental tests. As a result of this research study, it was suggested that improvements should be made by: (1) obtaining a microwave generator with very high frequency stability, and at the same time having the frequency adjustable over a small range, at least; (2) constructing and mounting a transducer in such a manner as to ensure exposure to a strong electric vector without undue heating; (3) providing greater uniformity in the thickness of quartz or other transducer material; and (4) searching for other substances having piezoelectric properties in high-frequency fields which can be prepared as uniform thin films. (Contractor's abstract, modified)

CIT. 12:004

California Inst. of Tech. [Norman Bridge Lab. of Physics] Pasadena.

THEORY OF THE PLANE WAVE ACOUSTIC FILTER WITH PERIODIC STRUCTURE, by W. G. Cady. [1955] [20]p. incl. diagrs. refs. (Technical note no. 3) [AFOSR-TN-55-112] (AF 18(600)593) Unclassified

After a brief discussion of the general properties of filters of different types (e.g., optical, electrical, mechanical), attention is given to an acoustic filter consisting of an arbitrary number of identical sections placed between any 2 media. Each section consists of 2 plane-parallel layers, which may be of any materials and thicknesses. It is assumed that there are no losses due to absorption in these materials, and that plane waves of arbitrary frequency are incident normally on the filter. The theory of filters of this type is developed, involving an expression for the specific acoustic impedance at any point, and also a convenient iteration factor which facilitates the calculation of reflection and transmission. The formulas are then specialized for the case in which the thickness of each layer is the same fraction of a wavelength, including a discussion of quarter-wave layers. A proof is given of the reversibility of the filter. Numerical calculations have been carried out for filters with assumed constants. The results for one case are presented in the form of curves relating the coefficient of reflection to the frequency. (Contractor's abstract)

CAL. 01·001

California U. [Dept. of Mathematics] Berkeley.

ASYMPTOTIC EXPANSIONS. 1. FUNDAMENTAL THEOREMS OF ASYMPTOTICS, by J. G. van der Corput. June 1954. 66p. (Technical rept. no. 1) [AF 18(600)958] Unclassified

Summary published in Nederl. Akad. Wetensch. Proc., Indag. Math., Ser. A., v. 57: 206-217, 1954. (Title varies)

This is the first of a number of self-contained reports on asymptotic expansions. As the author points out, the theory of asymptotic expansions is at present incomplete and has suffered neglect over a long period. This is probably due to the fact that, in practice, asymptotic expansions are largely used in certain kinds of boundary-value problems and the methods established by Poincaré are regarded as satisfactory for this purpose. They have also been used in analytic number theory, in statistical mechanics and in coefficient theory, often in conjunction with the method of steepest descent, but in all these cases conventional methods suffice. Recently extensions of the Poincaré theory have been developed by R. San Juan in dealing with asymptotic expansions arising out of the moment problems associated with different kinds of transform [see, e.g., Revista Mat. Hisp. Amer. (4) 11, 65-110 (1951); these Rev. 13, 214]. On the other hand, attempts to sharpen the existing theory have also been made in relation to asymptotic expansions near an irregular singularity (see, e.g., Evans, Quart. Appl. Math., v. 12: 295-300, (1954)). Neither of these are referred to in the present work. The author's aims are both extensive and precise. His intention is to assist mathematicians in the practical use of asymptotic expansions while at the same time building up a rigorous theory on a wide basis. The several reports will cover three successive stages. In the first, the Poincaré theory is subjected to a rigorous analysis. Here a numerical upper bound is not known for the remainder term; all that is known is that its order is the same as that of the first neglected term. For many purposes in applied mathematics this is sufficient. The second stage deals with asymptotic expansions in which the upper bound of the remainder is known. The third stage deals with the transformation of an asymptotic series into one in which the error of approximation may be prescribed. It is with the first stage that this report is largely concerned. The subjects dealt with are asymptotic equality; asymptotic limits; asymptotically convergent series, single and multiple; uniform asymptotic convergence; analytic functions with prescribed asymptotic expansions; and equations involving asymptotic expansions. The chapter on analytic functions deals with conditions under which a function, analytic in a given region, may have an asymptotic expansion about one or more boundary points of that region. The last chapter concerns solutions in s of the equation $f(s) = t$, where $f(s)$ and t are given asymptotically. The treatment is logical and rigorous throughout. All the terms used are clearly defined from the start and the basic ideas are subjected to a detailed analysis. There are many examples, carefully chosen to illustrate the points at issue. Although the author does not claim the work to be exhaustive, if the remaining reports maintain the same standard, then the author's aim to provide a rigorous and com-

CAL. 01:002 - CAL. 01:003

plete basis for the theory of asymptotic expansions will have been largely achieved. (Math. Rev. abstract)

CAL. 01:002

California U. [Dept. of Mathematics] Berkeley.

ASYMPTOTIC EXPANSIONS. II. ELEMENTARY METHODS, by J. G. van der Corput. Dec. 18, 1954, 54p. (Technical rept. no. 2) [AF 18(600)958] Unclassified

Summary published in Nederl. Akad. Wetensch. Proc., Indag. Math., Ser. A, v. 58: 139-150, 1955. (Title varies)

In section 1 the theory Pólya and Szegö (Aufgaben und Lehrsätze aus der Analysis, Bd. I, Springer, Berlin, 1925, p. 26) of enveloping series is extended to series of complex terms in the following way: $|\zeta|<\pi$; E_ζ is the closed circle segment bounded by the line segment (0, 1) and by the circle arc with end-points 0 and 1. Which makes at the origin an angle ζ with the + real axis. A number s is enveloped by the formal series Σa_n ($n\geq 0$) with respect to the circle segment Σ_ζ if it is possible to find for each integer $n\geq 0$ an element ϑ_n of E_ζ such that $s = a_0+a_1+\cdots+a_{n-1}+\vartheta_n a_n$. Notation: $s \propto \Sigma_{n=0}^{\infty} a_n(E_\zeta)$; e.g.

$$(1+z)^{-1} \propto \sum_{n=0}^{\infty} (-)^n z^n (E_\zeta) \text{ for } |\zeta| = |\arg z| < \pi.$$

In section 2 this theory is applied to the Γ-function (a.o. determination of general sharp upper bounds for the error term of $\log \Gamma(z)$). In section 3 it is shown that under general conditions for each point z on the line segment (0, w) (w real or complex $\neq 0$) in the Maclaurin expansion

$$f(z) = \sum_{h=0}^{\infty} \frac{f^{(h)}(0)}{h!} z^h + \frac{\lambda_n z^n}{n!},$$

λ_n belongs to a convex set E_n, assuming that $f^{(n)}(z)$ belongs to the same set. In section 4 the author obtains by integration by parts of $\int_a^b g(x)e^{i\omega f(x)}dx$ (a and b real) the expansion $\sum_{h=0}^{n-1} (a_h+\beta_h)\omega^{-1-h} + \omega^{-n}\eta_n$, where the last term is under specified conditions $= O(|\omega|^{-n})$. The asymptotic sum of the asymptotically convergent series

$$\sum a_h \omega^{-1-h} (h>0) \leftrightarrow A$$

is called the asymptotic residue between a and a^+; notation $\int_{a^+} g(x)e^{i\omega f(h)}dx$. In an analogous way

$$B \leftrightarrow \sum \beta_h \omega^{-1-h} = \int_{b^-} g(x)e^{i\omega f(x)}dx.$$

The author proposes to treat, in later reports, the complete theory of asymptotic residues. In section 5 absolutely monotonic and completely monotonic functions are treated. A function f(x) is called absolutely monotonic in an interval j if $f^{(n)}(x)\geq 0$ in j ($n = 0, 1, 2, \ldots$) and completely monotonic in j if $(-1)^n f^{(n)}(x) \geq 0$ in j ($n = 0, 1, 2, \cdots$). For the restricted class of integrals containing such functions a very sharp numerical upper bound for the error term is obtained. In the last chapter 6 sufficient conditions are obtained for

$$\lim_{h\to\infty} \sum_{0<n<mh} f_n(h) = \sum_{n=1}^{\infty} \phi_n \quad (m_h = \text{or} \to\infty \text{ for } h\to\infty)$$

where the last series converges (absolutely resp. unconditionally). Many applications are given (e.g. Γ-function, polynomials of Legendre, ultraspherical polynomials, formula of LaPlace-Heine, values of derivatives of polynomials of Legendre at $x = \pm 1$, (formula of Grosswald, with generalisation), upper bound for the derivatives of the polynomials of Legendre (Picone), generalisation of the formula of Picone for ultraspherical polynomials, polynomials of Fejer, etc.). (Math. Rev. abstract)

CAL. 01:003

California U. [Dept. of Mathematics] Berkeley.

ASYMPTOTIC EXPANSIONS. III. THE ASYMPTOTIC BEHAVIOR OF THE REAL SOLUTIONS OF CERTAIN SECOND ORDER DIFFERENTIAL EQUATIONS, by J. G. van der Corput. June 1955, 171p. (Technical rept. no. 3) [AF 18(600)958] Unclassified

Summary published in Nederl. Akad. Wetensch. Proc. Indag. Math., Ser. A, v. 59: 1-14, 1956. (Title varies)

$Y(x)$ and $\eta(x)$ are two linearly independent solutions of

(1) $y''+P(x)y' + Q(x)y = 0.$

It is possible to determine the asymptotic behaviour for large positive x of the real solutions of the differential equation (2) $y'' + \{P(x) + f(x)\}y'+\{Q(x)+g(x)\}y = 0$ provided that $f(x)$ and $g(x)$ (perturbations) and their derivatives are sufficiently small for large positive x. (1) is called the related equation. In section 2 are introduced certain transformations, e.g. $y = r(x)(Y \sin\theta+\eta\cos\theta)$; $y' = r(x)(Y'\cos\theta+\eta'\cos\theta)$, by which (2) is transformed into (3) $\theta' = \cdot(x,\theta)$; (4) $2r'r^{-1} = M(x,\theta)$. The advantage is that (3) is a differential equation of the first order not involving r(x). After determination of the asymptotic behaviour of $\theta(x)$ (4) gives the asymptotic behavior of $2\log r(x)$, and therefore also $y(x)$ and $y'(x)$. Special case: $P(x) = 0$, $Q(x) = 1$, $f(x)$ and $g(x)$ absolutely integrable to infinity.

$\cdot(x) \to \nu$; $2\log r(x) \to \nu^*$ for $x \to +\infty$ (ν and ν^* finite).

By putting $2\{\cdot(x) - \nu\} = \epsilon(x)$ it is shown in section 4 that $\epsilon(x)$ satisfies an integral equation of the form

$$\epsilon(x) = \int_x^{\cdot} \{\kappa(t)+\lambda(t)\sin\epsilon(t)+\mu(t)(1-\cos\epsilon(t))\}dt$$

$\kappa(x)$, $\lambda(x)$, $\mu(x)$ given functions, absolutely integrable to $\cdot$). In order to write $\epsilon(x)$ in a simple form an operation called bar-multiplication is introduced, de-

fined as follows:

$$j(x) = \int_{t_1 \geq \cdots \geq t_m \geq x} \cdots \int f(x, t_1, \cdots, t_m) dt_1, \cdots dt_m;$$

$$J(x) = \int \cdots \int_{t_{m+1} \geq \cdots \geq t_{m+M} \geq x} F(x, t_{m+1}, \cdots, t_{m+M}) dt_{m+1} \cdots dt_{m+M}$$

The bar-product $j \cdot J$ is by definition the m+M-tuple integral:

$$\int \cdots \int_{t_1 \geq \cdots \geq t_{m+M} \geq x} f(x_1, t_1, \cdots, t_m) F(x, t_{m+1}, \cdots, t_{m+M}) dt_1 \cdots dt_{m+M}.$$

In section 4 it is shown that $\varepsilon(x)$ possesses an asymptotic expansion of the form

$$\varepsilon(x) \sim k\omega + \overline{kl} + \overline{kll} + \overline{kkm} - \overline{kkll} + \cdots \quad (k = \int_x^\infty \varkappa(t)dt \text{ etc}).$$

The remainder is at most of the order ω^{-r} (r = the number of bar-factors in the first neglected term). An analogous result is obtained for $2 \log r - \int_x^\infty f(t)dt - \gamma^*$. In a purely formal manner the asymptotic expansion for

$$U(x) + iV(x) = \exp\left\{ -\tfrac{1}{2} \int_x^\infty f(t)dt - \tfrac{1}{2}\gamma^* \right\} r \exp\left\{ \tfrac{1}{2} i \varepsilon \right\} \qquad (\tfrac{1}{2}\varepsilon = \theta - \gamma)$$

is computed. In this expansion certain regularities in the formation of the bar-products and in the signature of the terms lead to a conjecture, which is verified in section 4. In the more complicated case in which there is no absolute integrability, the author restricts himself in the sections 5 and 8 to differential equations of the form

$$5)\quad y'' + y'\Big(\sum_{\nu=1}^{n} L_\nu f_\nu(x) \cos 2\alpha_\nu(x) + y\Big(1 + \sum_{\nu=1}^{n} K_\nu f_\nu(x) \cos 2\alpha_\nu(x)\Big) = 0,$$

f_ν and α_ν are given, real, infinitely differentiable functions, K_ν and L_ν are given constants. To determine the asymptotic behaviour of the real solution of $\theta' = \Lambda(x, \theta)$ a certain "smoothness condition" is imposed on the functions f_ν. On the functions α_ν a certain "resonance condition" is imposed which can be formulated roughly by saying that there is either complete resonance or no resonance at all. Under these two conditions it is possible to construct for each real solution $\theta(x)$ a real constant γ such that $\theta(x) - \gamma$ is for large positive x asymptotically equal to the asymptotic sum of an asymptotically convergent series. These two conditions however are not sufficient to deduce from this asymptotic equation an asymptotic expansion whose terms do not involve $\theta(x)$ itself. To that end a certain supplementary condition is needed (section 6). In section 8 the author demonstrates under these three conditions: 1. Uniqueness theorem. If θ and θ^* denote two real solutions of $\theta' = \Lambda(x, \theta)$ with the same constant γ in their asymptotic equation, then $\theta = \theta^*$. II. Existence theorem. If γ denotes an arbitrary given real constant number, then it is possible to construct a real solution θ of $\theta' = \Lambda(x, \theta)$ such that γ is the constant term in the asymptotic equation of that solution. By I this solution is uniquely defined by γ. In the sections 9 and 10 the asymptotic behaviour of the solutions of some more complicated differential equations is investigated. In section 11 the case is treated that in (5) f_ν and α_ν possess asymptotic expansions according to powers of x. In section 12 $\alpha_\nu(x) = a_\nu x + \eta_\nu$ denotes a linear function of x. It is shown that the rationality properties of α_ν play an important role. In section 13 n = 1, $\eta = 0$, f(x) is continuous of bounded variation. In this case however, there are some rational values which may not be assumed by α, e.g. the value zero. In the last section 14 the author obtains a first approximation to θ and $\log \gamma$ under much weaker conditions. This section is closely related to stability theory. (Math. Rev. abstract)

CAL. 01:004

California U. [Dept. of Mathematics] Berkeley.

ON SEQUENCES WITH DIVERGENT TOTAL VARIATION, by W. Stenberg. Dec. 18, 1954 [13]p. [AF 18(600)958] Unclassified

Published in Nederl. Akad. Wetensch. Proc., Indag. Math., Ser. A, v. 58: 178-190, 1955.

The paper proves that if $\{a_n\}$ is a sequence of positive terms with $a_n \to 0$ such that $\sum a_n = \infty$, then there exists a "rearrangement" $\{b_n\}$ of $\{a_n\}$ with $\sum b_n = \infty$ such that for every subsequence $\{c_n\}$ of $\{b_n\}$ it is true that

$$\sum_{j=1}^{n-1} |c_j - c_{j+1}| > 2 \sum_{j=1}^{n} |c_j| - 5b^*,$$

where b^* is the largest b_n. Here $\{b_n\}$ is a "rearrangement" of $\{a_n\}$ if $b_n = a_{h(n)}$ where h(n) is a univalent function on the positive integers to the positive integers and includes the notion of rearrangement of a subsequence. This theorem has as corollary an unpublished result of Besicovitch and Erdös that there exists a sequence $\{a_n\}$ of positive terms with $a_n \to 0$ and $\sum a_n = \infty$ such that for every subsequence $\{b_n\}$ with $\sum b_n = \infty$ it is true that $\sum_n |b_n - b_{n+1}| = \infty$. (Math. Rev. abstract)

CAL. 02:001

California U. Dept. of Mathematics, Berkeley.

ON SOME PROBLEMS IN TRANSONIC FLOW, by M. H. Protter. Nov. 1954, 23p. incl. diagrs. (Technical rept. no. 1) (AF OSR-TN-54-307) (AF 18(600)1117) AD 48548 Unclassified

A uniqueness theorem previously proved (Jour. Rational Mech. and Analysis, v. 2, 1953) for the

CAL. 02:002 - CAL. 02:004

Tricomi problem for equations of the form $K(y)u_{xx} + u_{yy} = 0$ is extended to a general uniqueness theorem for the problem of the existence of transonic potential flows out of a jet in which K(y) is a specific monotone function. The results are presented as 2 theorems. (1) Let D be the domain enclosed by Γ, γ_1 and γ_2 and suppose that $K(\eta)$ has a continuous third derivative satisfying the condition $K'''(\eta) \leq 0$ whenever $F(\eta) < 0$, $\eta < 0$. If ψ is a solution of $K(\eta)\psi_{\xi\xi} + \psi_{\eta\eta} = 0$ in D which vanishes on Γ and γ_2 then ψ vanishes identically. Γ is a simple rectifiable arc in the upper half-plane with end points on the x-axis; γ_1 is the characteristic of $\frac{d\eta}{d\xi} = \pm \frac{1}{\sqrt{-K(\eta)}}$ passing through the origin and extending into the portion of the plane $\xi > 0$, $\eta < 0$; γ_2 is the characteristic of $\frac{d\eta}{d\xi} = \pm \frac{1}{\sqrt{-K(\eta)}}$ passing through $P(\xi_0, 0)$ which intersects γ_1; and $P(\xi_0, 0)$ is one of the end points of Γ. (2) Let D be the domain described above and suppose Γ coincides with the normal curve of $K(\eta)\psi_{\xi\xi} + \psi_{\eta\eta} = 0$ in some neighborhood of the origin and $P(\xi_0, 0)$; then either there exists a unique quasi-regular solution of $K(\eta)\psi_{\xi\xi} + \psi_{\eta\eta} = 0$ with prescribed values on Γ and γ_2 or there exist nonidentically vanishing solutions of $K(\eta)\psi_{\xi\xi} + \psi_{\eta\eta}$ which vanish on Γ and γ_2. Combining these 2 theorems yields an existence theorem in the hodograph plane for the transonic flow out of a nozzle.

CAL. 02:002

California U. Dept. of Mathematics, Berkeley.

THE PERIODICITY PROBLEM FOR PSEUDO-ANALYTIC FUNCTIONS, by M. H. Protter. Oct. 1955, 45p. (Technical rept. no. 2) ([AF]OSR-TN-55-308) (AF 18(600)1117) AD 75262 Unclassified

Also published in Ann. Math., v. 64: 154-174, July 1956.

The basic theory of pseudo-analytic functions, a theory based on systems of elliptic partial differential equations which parallels the ordinary theory of functions derived from the Cauchy-Riemann equations, is given together with a definition of a generalized derivative. The periodicity problem involves the determination of the circumstances under which the system (B)

$$\begin{cases} u_{1x} - v_{1y} = \eta_{11}u_1 + \eta_{12}v_1 \\ u_{1y} + v_{1x} = \eta_{21}u_1 + \eta_{22}v_1 \end{cases}$$

is identical with the system (A)

$$\begin{cases} u_x - v_y = b_{11}u + b_{12}v \\ u_y + v_x = b_{21}u + b_{22}v \end{cases}$$

when $w = u + iv$ is a pseudo-analytic function which satisfies A, and $\dot{w}$ is its generalized derivative which satisfies B. Stated alternatively, the periodicity problem concerns the existence of sequences $\alpha, \beta, \gamma, \ldots$ in which the members of each class are the generalized derivatives of the functions in the preceding class. Such a sequence has a minimum period n if it has period n, and if it does not have period less than n for all possible choices in the definition of the generalized derivative. The principal results state that for each integer n there exist sequences of minimum period n. Classes α can be found such that the sequences generated by α for all possible choices for the generalized derivative are nonperiodic.

CAL. 02:003

California U. Dept. of Mathematics, Berkeley.

ON THE SOLUTION OF PARABOLIC EQUATIONS BY DIFFERENCE METHODS. I, by M. Lees. Nov. 1955, 26p. (Technical rept. no. 3) ([AF]OSR-TN-55-439) (AF 18(600)1117) AD 80361 Unclassified

A method of obtaining approximate solutions to

$$\frac{\partial u}{\partial t} - a(x,t)\frac{\partial^2 u}{\partial x^2} - 2b(x,t)\frac{\partial u}{\partial x} - c(x,t)u - d(x,t)$$

is given that involves the solution of a suitable backward difference equation over a rectangular lattice. The specific boundary-value problem to which the method applies is the following. Let D be a domain contained in the rectangle $0 \leq t \leq T$, $0 \leq x \leq 1$ such that (1) $\bar{D}$, the closure of D, contains a line segment $\bar{l}$ in which $t = T$, $a_0 \leq x \leq b_0$, and (2) if (x,t) and (x',t) are any 2 points in $\bar{D}$ with the same t-coordinate, then the line segment joining these 2 points lies entirely in $\bar{D}$. Find a function $u(x,t)$ defined in $\bar{D}$ that satisfies the differential equation in D and that takes on prescribed values on the boundary of D minus l. (ASTIA abstract)

CAL. 02:004

California U. Dept. of Mathematics, Berkeley.

ON PARTIAL DIFFERENTIAL EQUATIONS OF MIXED TYPE, by M. H. Protter. [1955] [16]p. incl. refs. (AF 18(600)1117) Unclassifted

Published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 91-106.

This is a survey of results (by the author and others) concerning initial and boundary value problems for second order partial differential equations of hyperbolic type which become parabolic on part of the boundary, and includes an extensive bibliography. Confining himself mainly to the theory of equations of the form (1) $K(y)h(x,y)u_{xx} - u_{yy} + au_x + bu_y + cu = f$ in the half plane $y > 0$, with K(y) positive in $y > 0$ and vanishing on $y = 0$, and h positive in $y \geq 0$, the author describes the theory of two problems: (1) the singular Cauchy problem -- where $u(x,0)$, $u_y(x,0)$ are prescribed;

(ii) the boundary value problem in a triangular shaped domain bounded by a segment Γ on the x axis and the characteristics Γ_1, Γ_2 from its end points which are defined by the equations $dy/dx = \pm 1/\sqrt{(Kh)}$. In problem (ii) the boundary values of u on Γ and on one of the characteristics, say Γ_1, are prescribed; this is a problem of Goursat type. We mention just a few results. Berezin has treated problem (i) for $K(y) = y^{\alpha}$, and has shown that it is well posed for $0 < \alpha < 2$ but not for $\alpha > 2$. The author has extended this by showing that the problem is well posed in general provided that (2) $ya(x, y)/\sqrt{K(y)} \rightarrow 0$ as $y \rightarrow 0$; a similar result holds for semi-linear equations (i.e., equations that are linear in the second order derivatives). Hellwig has shown that the critical case $\alpha = 2$ in Berezin's work is well posed provided that $|a(x, 0)| < 2$. The author states some results on existence and uniqueness for problem (ii), and proves a new result of this type, assuming that K(y) is monotonic increasing and satisfies (2). The paper also contains some results for semi-linear equations, and for certain equations in higher dimensions. (Math. Rev. abstract)

CAL. 02:005

California U. Dept. of Mathematics, Berkeley.

GENERALIZED GOURSAT PROBLEM FOR A HYPERBOLIC SYSTEM, by R. P. Holten. Mar. 1956, 47p. incl. diagrs. (Technical rept. no. ') (AFOSR-TN-56-30) (AF 18(600)1117) AD 88701 Unclassified

A study was made of the existence and uniqueness of functions $U^1, \ldots, U^N$ which satisfy the differential equations $U^i_y(x, y) + A^i(x, y)\, U^i_x(x, y) = D^i(U^1(x, y), \ldots, U^N(x, y))$, $i = 1, 2, \ldots, N$, in some region including the origin, and which also satisfy the equations $\sum_{j=1}^{N} a_{ij}(x)U^j(x, y_i(x)) = P^i(x)$, and $y_i(0) = 0$, $i = 1, 2, \ldots, N$.

(ASTIA abstract)

CAL. 02:006

California U. Dept. of Mathematics, Berkeley.

A GENERALIZATION OF COMPLETELY CONVEX FUNCTIONS, by M. H. Protter. May 1956, 14p. (Technical rept. no. 5) (AFOSR-TN-56-145) (AF 18(600)1117) AD 86303 Unclassified

Also published in Duke Math. Jour., v. 24: 205-214, June 1957.

The theorem is given that, if f(x) is almost completely convex in an interval (a, b), it is an entire function of exponential type. A function f(x) defined in an interval (a, b) is said to be almost completely convex, if it possesses derivatives of all orders and if $f^{(4k)}(x) \geq 0$, $a \leq x \leq b$, and $f^{(4k+2)}(a) + f^{(4k+2)}(b) \leq \frac{\pi^2}{(b-a)^2}\left[f^{(4k)}(a) + f^{(4k)}(b)\right]$, $k = 0, 1, 2, \ldots$. The theorem of Widder (Proc. Nat. Acad. Sci. U. S., v. 26: 657-659, 1940), that if f(x) is completely convex in (a, b) it is an entire function of exponential type, is extended to functions of 2 variables as follows: if f(x, y) is completely convex in a domain D, it is a real analytic function defined in the entire plane and of exponential type. A function f(x, y), defined in a domain D, is completely convex if it possesses derivatives of all orders with respect to x and y and $\frac{\partial^{2(p+q)}f}{\partial x^{2p}\partial y^{2q}} \geq 0$ for p+q even and $\frac{\partial^{2(p+q)}f}{\partial x^{2p}\partial y^{2q}} \leq 0$ for p+q odd. No conditions are imposed on odd derivatives of the forms $\frac{\partial^{2(p+q)+1}f}{\partial x^{2p}\partial y^{2q+1}}$, $\frac{\partial^{2(p+q)+1}f}{\partial x^{2p+1}\partial y^{2q}}$ or on even derivatives of the form $\frac{\partial^{2(p+q)}f}{\partial x^{2p+1}\partial y^{2q-1}}$. (ASTIA abstract)

CAL. 02:007

California U. Dept. of Mathematics, Berkeley.

A MAXIMUM PRINCIPLE FOR HYPERBOLIC EQUATIONS IN A NEIGHBORHOOD OF AN INITIAL LINE, by M. H. Protter. Aug. 1956, 20p. (Technical rept. no. 6) [AFOSR-TN-56-304] (AF 18(600)1117) AD 106712 Unclassified

Also published in Trans. Amer. Math. Soc., v. 87: 119-129, Jan. 1958.

Consideration is given to the equation $Lu = (au_y)_x - (bu_y)_y + cu_x + du_y + fu = 0$, $a > 0$, $b > 0$ with respect to a curvilinear triangle T bounded by a segment AB of the x-axis and the characteristic arcs AC and BC which extend into $y > 0$. Proofs of the following theorems are given. Theorem 1. Let $Lu \leq 0$ in D, the common part of T and $0 \leq y \leq y_0$, and suppose that $f \geq 0$ in D, $d(x, 0) \leq 0$. If $u(x, 0) \geq 0$ on AB and $\left(\frac{u}{v}\right)_y \leq 0$ on AB with $v(y) = 1 - \beta e^{-\alpha y}$, $\alpha > 0$, $0 < \beta < 1$, then the maximum of u in D occurs on AB. Theorem 2. Let $Lu \geq 0$ in D and suppose $f \geq 0$ in D, $b(x, 0) = 0$, $d(x, 0) \leq 0$. If $u(x, 0) < 0$ and AB then the maximum of u in D occurs on AB. These theorems are used to obtain certain results for ordinary differential equations among which is a comparison theorem on the distance between zeros of the ordinary differential equations $[f_1(x)\xi'(x)]' + g_1(x)\xi(x) = 0$, $f_1(x) > 0$, $0 \leq x \leq x_0$, and $[f_2(y)\eta'(y)]' + g_2(y)\eta(y) = 0$, $f_2(y) > 0$, $0 \leq y \leq x_0/2$ for which $u(x, y) = \xi(x)\eta(y)$ satisfies a hyperbolic partial differential equation Lu.

CAL. 03:001 - CAL. 03:004

CAL. 03:001

Caltfornia U. Dept. of Physics, Berkeley.

GENERAL THEORY OF SPIN-WAVE INTERACTIONS, by F. J. Dyson. June 1, 1956 [14]p. tncl. refs. (Technical rept. no. 76) (Sponsored jotntly by [Air Force Offtce of Sctentiftc Research] under AF 18(603)46 and National Science Foundation) AD 108432
Unclassifted

Also published tn Phys. Rev., v. 102: 1217-1230, June 1, 1956.

An ideal model of a ferromagnet is studied, consststng of a lattice of tdentical sptns wtth cubtc symmetry and with isotropic exchange coupling between nearest netghbors. Thts aim ts to obtain a complete descrtptton of the thermodynamic properttes of the system at low temperatures, far below the Curte potnt. In thts temperature regton the natural descrtptton of the states of the system ts in terms of Bloch sptn waves. The nonorthogonality of sptn-wave states raises bastc difft-culties whtch are examined and overcome. The following new results are obtained: a practical method for calculating thermodynamic quantities tn terms of a nonorthogonal set of basic states; a proof that tn 3 dtmenstons there do not extst states (shown by Bethe to exist in one-dtmensional chain of spins) tn whtch two sptns are bound together into a stable complex and travel together through the lattice; a calculatton of the scattertng cross section of two sptn waves, gtving a mean free path for spin-sptn collisions proporttonal to $T^{-7/2}$ at low temperatures and an exact formula for the free energy of the system, showtng explttctly the effects of spin-wave interactions. (Contractor's abstract)

CAL. 03:002

California U. Dept. of Physics, Berkeley.

THERMODYNAMIC BEHAVIOR OF AN IDEAL FERRO-MAGNET, by F. J. Dyson. June 1, 1956, [15]p. tncl. refs. (Technical rept. no. 77) (Sponsored jotntly by [Air Force Office of Scientific Research] under AF 18(603)46 and National Science Foundation)
Unclassified

Published in Phys. Rev., v. 102: 1230-1244, June 1, 1956.

The free energy of an ideal Heisenberg-model ferromagnet is calculated as a power series in the temperature T. The spontaneous magnetization in zero external field is given by: $[M(T) - M(0)] = S - a_0 T^{3/2} - a_1 T^{5/2} - a_2 T^{7/2} - a_3 S^{-1} T^4 + O(T^{9/2})$. Here T is the temperature in dimensionless units and a_0, a_1, a_2, a_3, are positive numerical coefficients which are computed for the three types of cubic crystal lattice. The first two terms are the result of the simple Bloch theory in which spin waves are treated as noninteracting Bose particles with constant effective mass. The a_1 and a_2 corrections come from the variation of effective mass with velocity. The a_3 term is the lowest order correction arising from interaction between spin waves. Thts result ts in violent contradtctton to earlier published calculations which gave tnteraction effects proportional to $T^{7/4}$ and T^2. The smallness of the thermodynamic effects of spin-wave interactions is discussed in physical terms and partially explained. A general proof is gtven that the thermodynamic effects of the "exclusion prtnctple," whtch forbtds more than (2S) spin deviations to occupy the same atom, are of order $\exp(-a\theta^{-1})$ and gtve zero contributton to any finite power of θ. The restdual dynamical interaction between 2 spin waves gtves rtse to a second virial coeffictent b_2' which is calculated and shown to be of order $T^{5/2}$. The a_3 term tn the magnetization ts proportional to b_2'. Effects of tnteraction of 3 or more sptn waves are estimated and found to be of order θ^5 or higher. (Contractor's abstract)

CAL. 03:003

Californta U. Dept. of Phystcs, Berkeley.

ELECTRON AND NUCLEAR SPIN RESONANCE AND MAGNETIC SUSCEPTIBILITY EXPERIMENTS ON DILUTE ALLOYS OF Mn IN Cu, by J. [M.] Owen, M. Browne and others. June 15, 1956 [7]p. incl. refs. (Sponsored jotntly by [Air Force Offtce of Sctentiftc Research under AF 18(603)46], Offtce of Naval Research under Nonr-22201, and Signal Corps)
AD 108431 Unclassifted

Also published in Phys. Rev., v. 102: 1501-1507, June 15, 1956.

Dtlute alloys of Mn tn Cu are expected to show marked effects of the exchange tnteraction between the $3d^5$ ton core electrons of the Mn atoms and the 4s conduction electrons of the crystal. The simple model leads to the prediction of indirect exchange ferromagnettsm; electronic Knight shtft of the electron spin resonance line; nuclear Knight shtft of the copper nuclear resonance; electron spin relaxatton by the coupltng with the conductton electrons; and a contrtbution to the electrtcal resistivity by the Elltott-Schnitt mechantsm. The observed wtdth of the electron sptn resonance ltne suggests that the sd exchange tnteraction may be of the order of 0.2 of the interaction tn the free ton. The dilute alloys appear to be anttferromagnettc, but with a ferromagnettc interactton also present which is rather stronger than calculated on the tndtrect exchange model. An unexpected experimental result is that the nuclear Knight shift is unaffected by the presence of Mn, suggesting that the conduction electron magnetization by the coupling is less than 1/50 of what might be expected. (Contractor's abstract)

CAL. 03:004

California U. Dept. of Physics, Berkeley.

PROCEEDINGS OF THE SYMPOSIUM ON HIGH TEMPERATURE - A TOOL FOR THE FUTURE.

Berkeley, Calif. June 25-27, 1956, 218p. incl. illus. diagrs. refs. (In cooperation with Stanford Research Inst., Calif.) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)46, Office of Naval Research under Nonr-22201, National Science Foundation, and Office of Ordnance Research)
Unclassified

Emphasis in the symposium was placed on the whys of high-temperature limitations and on the identification of the areas most fruitful for further work. It was believed that an advance in production of high temperatures may help solve problems in materials for high temperatures or in processes employing them. The program was divided into three sections: (1) methods for reaching high temperatures; (2) materials for containing high temperatures; and (3) processes occurring at high temperatures. In the first section, consideration was given to (a) images of very high temperature sources, (b) electrical methods for obtaining high temperatures, and (c) chemical and nuclear methods of obtaining high temperatures.

CAL. 03:005

California U. Dept. of Physics, Berkeley.

TRANSMISSION OF SUPERCONDUCTING FILMS AT MILLIMETER-MICROWAVE AND FAR INFRARED FREQUENCIES, by R. E. Glover, III and M. Tinkham. [1956] [4]p. incl. diagr. [Technical rept. no. 78] (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(603)46], Office of Naval Research under [Nonr-22201], and Signal Corps) AD 126802 Unclassified

Also published in Phys. Rev., v. 104: 844-845, Nov. 1, 1956.

Results are reported of measurements of the surface resistance of superconducting lead and tin at microwave frequencies having photon energy comparable with kT_c. Experimental transmission ratios of superconducting and normal states are compared.

CAL. 03:006

California U. Dept. of Physics, Berkeley.

ENERGY GAP INTERPRETATION OF EXPERIMENTS ON INFRARED TRANSMISSION SUPERCONDUCTING FILMS, by M. Tinkham. [1956] [6]p. incl. diagr. [Technical rept. no. 79] (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(603)-46], Office of Naval Research under [Nonr-22201], and Signal Corps) AD 126803 Unclassified

Also published in Phys. Rev., v. 104: 845-846, Nov. 1, 1956.

The transmission and reflection properties of a film which is thin compared to a skin depth and in transverse dimensions large compared to a wavelength were determined completely by the complex admittance per square of the film. A means of determining the high frequency limit is given. With the use of an energy-gap model, the observed peak in transmission at intermediate frequencies is obtained and explained.

CAL. 03:007

California U. Dept. of Physics, Berkeley.

THERMAL EQUILIBRIUM IN NUCLEAR MAGNETIC COOLING OF METALS, by C. Kittel. [1956] [2]p. (Technical rept. no. 82) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)46, Office of Naval Research under Nonr-22201, and [Signal Corps]) AD 126804 Unclassified

Also published in Phys. Rev., v. 104: 1807-1808, Dec. 15, 1956.

Recently there has been reported the attainment of a temperature of 20 μdeg K by nuclear magnetic cooling of metallic copper from an electronic cooling stage at 0.01°K, about 1% of the nuclear entropy being removed during isothermal magnetization at the latter temperature. The purpose of the present paper is to discuss the rate at which conduction electrons and lattice phonons initially at 0.01°K come into thermal equilibrium with the nuclear spins at 20 μdeg. (Contractor's abstract, modified)

CAL. 03:008

California U. Dept. of Physics, Berkeley.

POLARIZATION OF STARLIGHT BY FERROMAGNETIC PARTICLES, by J. Henry. [1956] [11]p. incl. diagrs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)46, Office of Naval Research under Nonr-22201, and Signal Corps)
Unclassified

Published in Astrophys. Jour., v. 128: 497-507, Nov. 1958.

In an attempt to explain interstellar polarization by scattering and absorption of starlight by oriented dust particles, Davis and Greenstein's (1951) relaxation mechanism is generalized to ferromagnetic particles. It is shown that a magnetic field of about 10^{-6} oersted is sufficient to align the particles so as to produce the observed ratio of polarization to color excess. (Contractor's abstract)

CAL. 04:001

California U. Electronics Research Lab., Berkeley.

DISCRETE COMPENSATION OF SAMPLED-DATA AND CONTINUOUS CONTROL SYSTEMS, by E. I. Jury and W. Schroeder. Dec. 14, 1955 [80]p. incl. diagrs. refs. (Series no. 60, issue no. 154) ([AF OSR-TN-55-445]) (AF 18(600)1521) AD 85717
Unclassified

CAL. 04:002 - CAL. 05:001

A method of compensation ts presented, to be applied to continuous as well as to sampled-data systems, which reduces to zero any overshoot or error after a prescribed finite time. This prescribed response is applicable to step or ramp inputs and could be extended to acceleration or higher order inputs. It is shown that this response can be accomplished using the modified z-transform which yields the systems response for all instants of time. The procedure of this method, illustrated in examples, is mainly applicable to general linear physical systems with no inherent delays. The compensated system is so designed that shifts in gain or other dynamical disturbances have a small effect on the prescribed response. In conclusion, the method presented is powerful in synthesizing control systems to tally to a prescribed response and furthermore is straightforward in its appltcation. (Contractor's abstract)

CAL. 04:002

Californta U. Electronics Research Lab., Berkeley.

HIDDEN OSCILLATIONS IN SAMPLED-DATA CONTROL SYSTEMS, by E. I. Jury. Dec. 14, 1955 [19]p. incl. diagrs. refs. (Series no. 60, issue no. 155) (AFOSR-TN-56-24) (AF 18(600)1521) AD 101911
Unclassified

Oscillations between sampling instants in the response of sampled-data control systems impose certain limitations on the z-transform method and other methods available for synthesis of such systems. It is shown that these oscillations appear in the response because of certain forms of the open loop transfer function G(s). If the impulsive response of these functions is oscillatory then these oscillations occur in the response, and if the sampling period is larger or equal to half the period of these oscillations, the z-transform method fails to indicate their presence. The modified z-transform can be advantageously applied in these cases. This method is straightforward and simple in detecting the presence of these oscillations and indicating their values. Theorems relating to initial and final values of the response in the form of modified z-transform have been presented. Two examples have been discussed in which such oscillations occur and the modified z-transform method has been applied in their analysis. (Contractor's abstract)

CAL. 04:003

California U. Electronics Research Lab., Berkeley.

ANALYSIS OF LINEAR SAMPLED-DATA SYSTEMS WITH FINITE PULSE WIDTH (OPEN-LOOP), by G. Farmanfarma. Apr. 12, 1956. 57p. incl. diagrs. tables, refs. (Series no. 60, issue no. 157) (AFOSR-TN-56-186) (AF 18(600)1521) AD 87058
Unclassified

Also published in Trans. Amer. Inst. Elec. Engineers, v. 75: 808-819, Jan. 1957.

An exact method for analysis of sampled-data systems wtth ftntte pulse width ts presented. The results make tt possible to obtain the output of such systems in a closed form, as a continuous function of time, and without recourse to any approximations. The analysis is based on introducing a new transform method analogous to the z-transform, except that the actual pulse width and pulse shape are considered. Thts ts called the p-transform where "p" denotes pulse wtdth. By utiliztng the modifted z-transform, a method for obtaining the inverse Laplace transform of functions involving both e^{Ts} and "s" is developed. This technique has been advantageously applied to evaluate the inverse p transform in a closed form. The limiting cases of the p-transform are investigaged. It is concluded that the p-transformation method provides a powerful technique for analysis of sampled-data systems wtth finite pulse width.

CAL. 04:004

California U. Electronics Research Lab., Berkeley.

ANALYSIS AND SYNTHESIS OF SAMPLED-DATA AND CONTINUOUS CONTROL SYSTEMS WITH PURE TIME DELAYS, by W. Schroeder. June 8, 1956 [86]p. incl. diagrs. refs. (Series no. 60, issue no. 156) (AFOSR-TN-56-476) (AF 18(600)1521) AD 97360
Unclassified

The investigation has shown that the modified z-transform can be extended so that linear sampled-data systems with arbitrary pure delays can be analyzed and synthestzed to obtain responses with zero steady-state error after a finite transient response. The duration and form of the transient response is also controllable. The advantage of the modified z-transform is that the continuous response is obtained or synthesized, rather than only the sampled response. In addition, the analysis and synthesis procedures for sampled-data systems have been applied to continuous systems with or without pure time delays by approximating the continuous system with a sampled-data system. The synthesis procedure presented for sampled-data systems could have a wide variety of applications. It is particularly well-suited for the compensation of control systems with digital or analog computers. More generally it may be used for compensation with any device capable of processing data, which includes human beings, pulsed networks, delay lines, and mechanical devices, to mention but a few. Examples of systems compensated by the procedure have been analyzed to determine the effect of small shifts in the parameters and the systems were found moderately insensitive to such shifts. This is not always true and therefore, a method of determining a rough idea of the systems sensitivity to shifts is suggested. (Contractor's abstract)

CAL. 05:001

California U. Inst. of Engineering Research, Berkeley.

AN EXPERIMENTAL DETERMINATION OF

TION COEFFICIENTS FOR AIR ON ALUMINUM, by E. Merlic. Aug. 31, 1956 [5f]p. incl. iffus. diagrs. tables, refs. (Rept. no. HE-150-f4f; series no. 20, issue no. 111) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under Nonr-22245) AD 120913 Unclassified

A measurement of the molecufar reflection coefficient for air on aluminum was made using a rotating cylinder apparatus. The value of the reflection coefficient was found to be dependent upon the pressure history of the apparatus. The reflection coefficient was found to be 0.9 for a surface held at 0.01 μ, while for the same surface held at approximatefy 250 μ, the reflection coefficient was measured to be as fow as 0.6. (Contractor's abstract, modified)

CAL. 05:002

California U. Inst. of Engineering Research, Berkeley.

FLOW OF AN INCOMPRESSIBLE VISCOUS FLUID ALONG A SEMI-INFINITE PLATE, by S. Goldstein. Summary interim rept. Dec. 1, f956, 17p. (Rept. no. HE-150-144; series no. 20, issue no. f13) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under Nonr-22245) AD 123087 Unclassified

Discussions are presented of the solution of the boundary-fayer equations with slip, and the sofution of the Navier-Stokes equations for laminar flow along a semi-infinite ffat plate without slip.

California U. fnst. of Engineering Research, Berkeley. N6ori-f0503, Project Squid see under Princeton U. James Forrestaf ftesearch Center, N. J. (Project SQUID) item nos. PRI. f1:024 - PRI. f1:025.

CAL. 06:00f

California U. fnst. of Engineering Research, Berkeley.

STAMLITY OF A VISCOUS COMPRESSIBLE FLOW BETWEEN ROTATING CYLINDERS, by P. L. Chambré. Technicaf rept. June f5, 1951, 33p. ilfus. diagrs. tables, refs. (Rept. no. lfE-150-85; series no. 20, issue no. 73) (Sponsored jointly by Office of Naval ftesearch and [Air Force] Office of Scientific ftesearch under N7onr-29503) U18758; ATf-195088 Unclassified

This is a theoretical investigation concerned with the hydrodynamic stability of the curved Couette motion of a viscous compressible flow towards a 3-dimensionaf-type disturbance. The problem has been investigated according to the method of small oscillations. The origin of the unstable motion is thought to be due to the centrifugal force field which can be created in a rotating cylinder apparatus in which the inner cylinder is rotating and the outer cylinder is at rest. The effects of slippage of the gas at the boundaries and of compressibility due to high speed motion have been investigated. A study of these effects clarifies the 3-dimensionaf instability mechanism in a gas ffow since previous theoretical investigations have been confined to incompressibfe fluid ffows. (Contractor's summary)

CAL. 06:002

California U. Inst. of Engineering Research, Berkeley.

A MOLECULAR BEAM INVESTIGATION OF FREE MOLECULE FLOW THROUGH SHORT TUBES, by F. C. Hurlbut. Technical rept. Oct. 15, 1951 [24]p. incl. illus. diagrs. tables. (Rept. no. HE-150-94; series no. 20, issue no. 99) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N7onr-29503) U20183, ATI-155160 Unclassified

An investigation of free molecule flows of nitrogen through short tubes was made, employing a molecular beam device. Probabilities W(i) were experimentally determined, where W(i) is defined as the probability that a molecufe, originating from a gas at rest and striking the entrance and pfane of a short cylindrical tube, passes through the tube without returning to the end pfane. The length to radius ratio $\frac{1}{r}$ of tubes for these tests ranged from 0 to 25. An empirical function E (W(i)) was passed by least squares through the experimental W(i). E (W(i)) was seen to agree within 11% with the Clausing function in the range of the experiment. These results indicate that the basic assumption of diffuse reflection is vafid to a first approximation. The derivation of the empirical function from the Clausing function was such as to suggest a value of the quantity (1-F) of the order of 0.05. (Contractor's abstract)

CAL. 06:003

California U. fnst. of Engineering Research, Berkeley.

VISCOUS EFFECTS ON STAGNATION-POINT TEMPERATURES, by S. F. Mack and S. A. Schaaf. Technical rept. Nov. 29, f951, 8p. incl. diagrs. table. (Rept. no. HE-f50-96; series no. 20, issue no. 84) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N7onr-29503) U21266; ATf-f95983 Unclassified

An analysis of viscous effects on stagnation-point temperatures based on continuum-flow in compressible boundary layer theory for the case of the sphere is presented. The principaf result of the analysis is contained in the theoretical expressions obtained for the focal recovery factor, or, at the forward stagnation-point and are indicated in tabular form. ft was concluded that an analysis based on continuum theory for the sphere in a low Reynolds number flow predicts a stagnation-point temperature which is higher than the local reservoir temperature. An approximate extension of the stagna ion-point theory to the case of the sphere in over-all thermal equilibrium provides an empirical result which agrees favorably with experiment.

CAL. 06:004

California U. Inst. of Engineering Research, Berkeley.

DESIGN AND PERFORMANCE OF AN ADJUSTABLE TWO-DIMENSIONAL NOZZLE WITH BOUNDARY LAYER CORRECTION, by G. H. Backer. Technical rept. Feb. 4, 1952, 33p. illus. diagrs. table, refs. (Rept. no. HE-150-97; series no. 20, issue no. 86) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U21636; ATI-196312 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 21: 50-56, Jan. 1954.

A 2-dimensional adjustable throat nozzle was designed to operate in a rarefied-gas stream at an ideal M = 3.106 and a static jet pressure of 85 μ of Hg. A boundary layer correction, applied to both the shaped and parallel walls, required a divergence of 5°14' on the side walls and produced an exit height of 1.31 in. In earlier wind-tunnel tests, the nozzle showed an M = 3.07 and static jet pressure of 93 μ of Hg after correcting pressure instrumentation. A uniform shock-free stream of approximately 0.3-in. square was secured. A 2-dimensional nozzle with diverging side walls appears entirely feasible in a low-density gas flow. No detectable disturbances to the exit flow resulted from the diverging of the side walls. The assumption of a uniform momentum gradient instead of velocity gradient would give better agreement with measured results. A relatively constant static pressure across the nozzle resulted from applying viscous corrections to pressure instrumentation. The inclusion of a variable-nozzle throat produced a nozzle which is operable over a limited Mach-number range without loss in uniformity of flow. The subsonic contour apparently had little effect on the nozzle exit flow. The nozzle substantially met the design conditions and operated adequately over a limited Mach-number range. (ASTIA abstract)

CAL. 06:005

California U. Inst of Engineering Research, Berkeley.

VISCOSITY CORRECTION TO IMPACT PRESSURE ON PROLATE SPHEROID, by D. C. Ipsen. Technical rept. Mar. 12, 1952 [20]p. incl. illus. tables. (Rept. no. HE-150-89; series no. 20, issue no. 85) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U21567; ATI-162662 Unclassified

The influence of viscosity on the pressure at the forward stagnation point on a prolate spheroid is estimated analytically. Potential flow, Stokes flow, and Oseen flow are utilized in turn to approximate the viscous term of the Navier-Stokes equation for the stagnation streamline. The approximations so obtained establish a basis for estimating the viscosity corrections to the stagnation pressure at any Reynolds number. The effects of slip and compressibility are not considered. The results provide a possible indication of the viscous effect on a source-shaped impact probe at low Reynolds number. (Contractor's abstract)

CAL. 06:006

California U. Inst. of Engineering Research, Berkeley.

GENERALIZED THEORY OF CONVECTIVE HEAT TRANSFER IN A FREE-MOLECULE FLOW, by A. K. Oppenheim. Technical rept. Mar. 18, 1952, 11p. illus. diagrs. tables. (Rept. no. HE-150-93; series no. 20, issue no. 81) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U22064; ATI-158453 Unclassified

The theory of the convective heat transfer in free molecule flow with Maxwellian velocity distribution was generalized by reducing all the relationships to a form common to all gases irrespective of their molecular structure. The heat-transfer characteristics of simple surfaces consisting of a flat plate in the direction of flow, a flat plate normal to flow, a transverse cylinder and a sphere were computed and correlated. A simple method is outlined for extrapolating the results to a flat plate at any angle of incidence, a wedge or a cone, and for the evaluation of heat-transfer parameters for a compound surface. The effect of shape on convective heat-transfer characteristics was small. At low Mach (M) numbers the Stanton number of all shapes approached the value of $\frac{\gamma+1}{\gamma}\cdot\frac{\alpha}{4\sqrt{\pi S}}$, where γ = ratio of specific heat, S = surface area of the body, α = accomodation coefficient. The difference between various shapes grew more distinct at high M numbers. For M > 2 the magnitude of the Stanton number did not exceed the value of $\frac{\gamma+1}{2\gamma}\alpha$. The effect of shape on the recovery factor was more distinct at low Mach numbers and was hardly noticeable for M numbers higher than 5. For the temperature ratio T_{aw}/T_o (T_{aw} = adiabatic wall temperature, T_o free stream temperature), this effect was small for both low and high M numbers and was most noticeable in the vicinity of M = 1.

CAL. 06:007

California U. Inst. of Engineering Research, Berkeley.

THEORETICAL AERODYNAMIC PROPERTIES FOR AN INCLINED FLAT PLATE IN SLIP FLOW, by S. F. Mack. Technical rept. Mar. 21, 1952, 14p. illus. diagrs. (Rept. no. HE-150-98; series no. 20, issue no. 67) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 1908 Unclassified

A theory concerning the drag coefficient for the flat plate at zero angle of attack in slip flow was extended

to include the aerodynamic coefficients for drag, lift, and moment at very small angles of attack. The lift coefficient may be taken to equal the skin-friction coefficient. The skin-friction stresses tend to reduce the lift coefficient at high-altitude, high-speed conditions. The moment coefficient will not be significantly greater than $2\alpha/\sqrt{M_\infty^2 - 1}$, the value derived from the ideal linearized 2-dimensional supersonic continuum-flow theory, where α is angle of attack and M_∞ is the free-stream Mach number. Except for the skin-friction coefficient, the corrections to he applied to the aerodynamic formulas of linearized supersonic theory, which account for viscosity and slip, will not generally be significant in the slip-flow region.

CAL. 06:008

California U. Inst. of Engineering Research, Berkeley.

HEAT TRANSFER FROM RIGHT CIRCULAR CONES TO A RAREFIED GAS IN SUPERSONIC FLOW, by R. M. Drake, Jr. and C. J. Maslach. Technical rept. Apr. 8, 1952, 13p. diagrs. tables, refs. (Rept. no. HE-150-91; series no. 20, issue no. 91) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U22770; ATI-158797 Unclassified

The heat transfer from 10°, 20°, 40°, and 60° right circular cones to a rarefied gas was measured at M = 2.16 to 3.54 and Re = 78 to 3270 in the slip-flow region. The 2 nozzles used had diameters at the exit plane of 5.5 and 5.25 in.; the cones were made of Ag, mounted on hollow glass stings, and arranged with cylindrical afterbodies made of horn fiber. Results show that the heat transfer coefficient in the region is a linear function of $\sqrt{Re}/M$ over the range investigated. Comparison of the data with those of Eber indicates that in the continuum region the data can best be represented by the boundary-layer analysis, while in the slip-flow region slip-flow analysis is to be favored. Overall free stream recovery factors exhibited a sharp increase as the gas was rarefied.

CAL. 06:009

California U. Inst. of Engineering Research, Berkeley.

DRAG ON A ROTATING CYLINDER AT LOW PRESSURES, by S.-F. Chiang. Technical rept. May 19, 1952, 35p. incl. illus. diagrs. tables, refs. (Rept. no. HE-150-100; series no. 20, issue no. 88) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) U23199; ATI-158799 Unclassified

Presented at meeting of the Amer. Phys. Soc., Puyokern, Calif., Dec. 27-30, 1952.

Published in Phys. Rev., v. 92: 535, Oct. 15, 1953.

The investigation of the torque transmitted by a rarefied gas, laminar air flow between two concentric cylinders for the case wherein the inner cylinder is rotating while the outer one is held stationary is discussed. A theoretical expression of drag coefficient is derived by the thirteen moment method and the equations of drag coefficient by Millikan and Schamberg are presented. The theoretical results of drag are calculated by these three drag equations and are discussed and compared in the appendices. From the experimental results it was concluded that: (1) the data over the ranges, $0.14 \leq M \leq 0.55$ and $0.0119 \leq M/Re \leq 2.61$, show that the rotor aerodynamic drag is proportional to the speed of rotation and the reduction of drag at low pressures is independent of Mach number; and (2) the critical Reynolds number is found to be 135. No effect of compressibility or slip on the critical Reynolds number has been observed.

CAL. 06:010

California U. Inst. of Engineering Research, Berkeley.

SKIN FRICTION IN SUBSONIC LOW DENSITY GAS FLOW, by F. S. Sherman. Technical rept. July 15, 1952, 11p. diagrs. tables. (Rept. no. HE-150-105; series no. 20, issue no. 92) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U23371; ATI-168736 Unclassified

Skin friction drag was measured on 0.003-in.-thick flat Ta plates at Re = 15 to 480 and M = 0.2 and 0.6. The ISA subsonic nozzle had a 9-in.-diam throat. Total drag coefficients (C_D) were obtained for plate lengths of 0.2, 0.5, 1, and 2 in. with aspect ratios of 0.5, 1, 2, and 5, respectively; the proportional probable error ranged from 0.7 to 4.1%. The lack of correlation of C_D with Re and of C_DM with the slip-flow parameter ($\sqrt{Re}/1.5M$) was attributed to effects of plate geometry and oversimplification of theory. A comparison of subsonic- and supersonic-flow data showed that boundary-layer theory more accurately predicted skin-friction values in supersonic flows; however, the supersonic data showed more slip at the boundary. The best agreement for supersonic and subsonic air streams was exhibited by C_DM vs $\sqrt{Re}/1.5M$ curves, which were considered adequate for design purposes.

CAL. 06:011

California U. Inst. of Engineering Research, Berkeley.

DESIGN AND TESTING OF A MACH-4 AXIALLY SYMMETRIC NOZZLE FOR RAREFIED GAS FLOWS, by J. M. Owen and F. S. Sherman. Technical rept. July 23, 1952, 60p. illus. diagrs. tables, refs. (Rept. no. HE-150-104; series no. 20, issue no. 91) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) U24721; ATI-169962 Unclassified

An improved method of design for supersonic axially

CAL. 06:012 - CAL. 06:015

symmetric nozzles emphasizes a more direct specification of the desired rate of expansion of the supersonic flow, an analysis of the throat section flow, better matching of the converging and diverging sections of the nozzle, a more unique determination of the isentropic core contour from the characteristics solution, and possible improvements in the choice of initial conditions and velocity profile for the boundary layer calculation. The method is applied to the design of a nozzle for M = 4. This nozzle was tested with satisfactory results, i.e., the test value for the exit-plane Mach number was 3.98 as compared with a design value of 4.00. Appendixes include the solution of the potential equation for axially symmetric potential flow by an adaptation of the method of characteristics, and an experimental evaluation of the Mach-4.00 nozzle. (ASTIA abstract)

CAL. 06:012

California U. Inst. of Engineering Research, Berkeley.

NOZZLE CHARACTERISTICS IN HIGH-VACUUM FLOWS — RAREFIED GAS DYNAMICS, by R. G. Folsom. Technical rept. Sept. 10, 1952, 5p. incl. diagrs. (Rept. no. HE-150-102; series no. 20, issue no. 90) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) U24514; ATI-167105 Unclassified

Also published in Trans. Amer. Soc. Mech. Engineers, v. 74: 915-918, Aug. 1952.

Some results of experiments on small ASME shaped nozzles at very low Reynolds numbers, achieved by operating at extremely low pressures over a wide range of pressure ratios are presented. Calibration data were obtained for two small converging ASME nozzles and one large ISA nozzle with dry air in the viscous-compressible flow regime. The discharge-coefficient magnitudes were in the expected range, but no direct comparison with viscous (incompressible) flow regime was possible because of the lack of suitable published coefficients. The results demonstrate the importance of pressure-tap location and installation geometry on coefficients, and a distinctive breakaway characteristic which developed as the pressure ratio across the nozzle decreased. Slip flow may influence the results since tests were conducted in the region where the slip effects are known to be appreciable, but it was not possible to separate the low Reynolds number and slip phenomena.

CAL. 06:013

California U. Inst. of Engineering Research, Berkeley.

AERODYNAMIC FORCES ON A CYLINDER FOR THE FREE MOLECULE FLOW OF A NON-UNIFORM GAS, by S. Bell and S. A. Schaaf. Technical rept. Dec. 19, 1952, 10p. illus. tables, refs. (Rept. no. HE-150-110; series no. 20, issue no. 93) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 1910 Unclassified

An analysis is made of the free molecular flow of a nonuniform gas by an extension of the method for the Maxwellian case used by Tsien (Jour. Aeronaut. Sciences, v. 13: 643-664, 1946) and Stalder and Zurick (NACA Technical note no. 2423, 1951). The results are sufficiently general to include arbitrary (small) stresses and heat flux. The body geometry is confined to that of a right circular cylinder oriented perpendicular to the gas-flow velocity; the body's thermal conductivity is assumed so large that it is at a uniform temperature. The aerodynamic force characteristics are determined. The lift and drag forces are shown to be affected by the nonuniformity. Force contributions from the stress and heat-flux terms are generally small compared to the force for the uniform case, except in regions of low flow velocity where the heat-flux terms become important. A method is indicated for obtaining the heat-transfer characteristics and data for other body geometries and bodies of low internal conductivity.

CAL. 06:014

California U. Inst. of Engineering Research, Berkeley.

HEAT TRANSFER FROM SPHERES TO A RAREFIED GAS IN SUBSONIC FLOW, by L. L. Kavanau and R. M. Drake, Jr. Technical rept. Jan. 23, 1953 [19]p. incl. diagrs. tables, refs. (Rept. no. HE-150-108; series no. 20, issue no. 94) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 1911 Unclassified

As a result of this investigation experimental average overall heat coefficients were obtained for spheres in a rarefied subsonic air stream where the Mach number and Reynolds number varied from 0.1 to 0.69 and 1.7 to 124, respectively. A semi-empirical formulation of the Nusselts number for sphere in a rarefied subsonic air stream was obtained by correcting the continuum solution for an effective thermal contact resistance as a result of the temperature jump boundary conditions.

CAL. 06:015

California U. Inst. of Engineering Research, Berkeley.

VACUUM FACILITIES FOR THE STUDY OF SUPERSONIC FLOW, by G. J. Maslach. Technical rept. Mar. 13, 1953 [5]p. incl. illus. diagr. refs. (Rept. no. HE-150-112; series no. 20, issue no. 83) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 4588 Unclassified

Also published in Chem. Engineering Progress, v. 48: 594-598, Dec. 1952.

A discussion is presented of design and construction

of large scale aerodynamic test equipment which simulates high altitudes flight conditions. Criteria which should be used in the choice of materials, fabrication methods, and gasketing principles are cited. Instruments which would be most suitable for various measurements required in aerodynamic investigations are suggested. Recent experimental results pertaining to instrumentation development are also mentioned.

CAL. 06:016

California U. Inst. of Engineering Research, Berkeley.

DESIGN AND OPERATION OF A ROTATING CYLINDER APPARATUS FOR RAREFIED GAS DYNAMICS RESEARCH, by G. J. Maslach and J. Frisch. Technical rept. Apr. 30, 1953, 14p. illus. refs. (Rept. no. HE-150-101; series no. 20, issue no. 89) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 13194 Unclassified

A high-speed rotating-cylinder apparatus is described for studying gas-surface interaction phenomena. The concrete enclosure is equipped with a hand-operated overhead hoist to handle the balance and drive mechanism before vacuum operation. During operation, measurements of drag, pressure, and rotor velocity can be made outside the enclosure. The instrument can be used to provide a shear flow field for the development of instrumentation for nonuniform streams or boundary layers. Initial tests indicated that the apparatus was satisfactory over a wide range of flow conditions from the continuum region ($M/Re < 1/100$) to the free molecular flow region ($M/Re < 10$).

CAL. 06:017

California U. Inst. of Engineering Research, Berkeley.

CONE DRAG IN A RAREFIED GAS FLOW, by D. C. Ipsen. Technical rept. Aug. 10, 1953, 39p. illus. diagrs. tables, refs. (Rept. no. HE-150-114; series no. 20, issue no. 95) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 20149 Unclassified

The tests were conducted to obtain empirical cone-drag information about the intermediate slip-flow regime. The mean free path of the gas adjacent to the cone surface ranged from 10 to 15% of the calculated displacement-thickness of the boundary layer at the base of the cone. The total drag on the fore portion of a 15° half-angle cone (3.70-in. slant length) was investigated. A compact remote balance was developed which gave sufficient accuracy for the measurement of the small forces involved. Drag coefficient curves were obtained which are probably accurate to within 2 to 3% or better at $M = 4.0$ and possibly 5% at $M = 2$. The experimental results for viscous drag were 10 to 30% above the predictions based on first-order boundary-layer analysis of shear and pressure distribution. A description of the experimental apparatus and details of the calibration and testing techniques are appended.

CAL. 06:018

California U. Inst. of Engineering Research, Berkeley.

HEAT TRANSFER TO A CYLINDER FOR THE FREE MOLECULE FLOW OF A NON-UNIFORM GAS, by S. Bell. Technical rept. Sept. 14, 1953, 10p. illus. (Rept. no. HE-150-115; series no. 20, issue no. 96) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 20150 Unclassified

The work described in report HE-150-110 (item no. CAL. 06:013) in which the aerodynamic forces on a cylinder were determined for the case of a nonuniform gas was continued. It was assumed that the right circular cylinder, which is oriented perpendicular to the gas flow, has so large a thermal conductivity that it has a uniform wall temperature. Possible end effects are neglected. The results depend on a knowledge of the molecular velocity distribution, and the distribution assumed is the one proposed by Grad (Commun. on Pure and Appl. Math., v. 2: 331-407, 1949). The results are complete for the monatomic case but only approximate for the polyatomic case. (ASTIA abstract)

CAL. 06:019

California U. Inst. of Engineering Research, Berkeley.

RESULTS OF SOME BASE PRESSURE EXPERIMENTS AT INTERMEDIATE REYNOLDS NUMBERS WITH $M = 2.84$, by L. L. Kavanau. Technical rept. Oct. 22, 1953, 6p. illus. tables. (Rept. no. HE-150-117; series no. 20, issue no. 97) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 23271 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 21: 257-260, 274, Apr. 1954.

Tests were conducted in a supersonic wind tunnel to determine the effect of Reynolds number on models over the range of $Re = 45,000$ to 400,000. The models (fabricated from combinations of aluminum and brass) were 60° apex angle right circular cones with cylindrical afterbodies 2.50 calibers in length. A control for adjusting the effective sting length was provided by moving a coaxial 60° apex angle cone-cylinder along the sting of the desired location. Base pressure data were obtained for a model at $M = 2.84$ over the range of Reynolds numbers. The maximum coefficient of 0.75 occurred at $Re = 140,000$. The variation in size of the critical wake region resulted in increases of the critical sting length from 3.3 to 10.4 as the Reynolds number decreased from 430,000 to 49,000. The base pressure orifice location and the sting diameter had no observable effects on the base pressure coefficient.

CAL. 06:020 - CAL. 06:023

CAL. 06:020

California U. Inst. of Engineering Research, Berkeley.

AN EXPERIMENTAL MOLECULAR BEAM INVESTIGATION OF THE SCATTERING OF MOLECULES FROM SURFACES, by F. C. Hurlbut. Technical rept. Dec. 1, 1953, 1v. incl. illus. diagrs. tables, refs. (Rept. no. HE-150-118; series no. 20, issue no. 98) [AFOSR-TN-54-97] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 30192 Unclassified

A molecular beam apparatus was used to investigate the scattering of air and N_2 molecules from surfaces of polished low-C steel, etched low-C steel, polished Al, and polished and unpolished window glass. A beam of molecules was directed against the surface at representative angles of incidence, and polar flux distributions of the scattered molecules were measured by a movable ionization gage beam detection system. Spatial polar plots of the flux distributions approximated closely the form of the cosine scattering distribution for the steel and Al surfaces. Similar plots for the glass surfaces showed well-defined small bulging deviations from the cosine scattering shape on the side away from the incident beam. A procedure was devised for the computation of the specular-reflection coefficient (f), and values were obtained for an unpolished glass surface, oriented tangentially to the direction of mass motion in a free molecular flow, in order to illustrate an aerodynamic application. If all scattered molecules are assumed to have the distribution in speed in the particular direction which they would have had had they issued from a gas in equilibrium at the temperature of the surface, $f \sim 0.97$ as $s \to 0$ while $f \sim 0.99$ at $s = 10$; s is the molecular speed ratio. If those molecules contributing to the deviations from cosine scattering are assumed to issue from the surface with their incident speed while the remainder are assumed to be diffusely scattered, f varies from $f \sim 0.97$ as $s \to 0$ to $f \sim 0.93$ at $s = 10$. These values are in disagreement with the Millikan value for air on glass of 0.89 ($s \sim 0$) (Phys. Rev., v. 21: 217. 1923).

CAL. 06:021

California U. Inst. of Engineering Research, Berkeley.

A NOTE ON THE EFFECT OF SLIP ON THE DRAG OF A FINITE FLAT PLATE, by J. A. Laurmann. Technical rept. July 12, 1954, 7p. (Rept. no. HE-150-123; series no. 20, issue no. 99) [AFOSR-TN-54-296] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 42324 Unclassified

A method of solution of the two-dimensional Navier-Stokes equations for incompressible flow over a finite flat plate introduced by Kuo (Jour. Math. and Phys., v. 32: 83-101, 1953) has been applied to the same problem for the case in which there is a finite velocity of slip at the surface of the plate. It is found that, just as for the semi-infinite plate, with the solution expressed as an ascending power series in $(Re_L)^{-1/2}$ (Re_L is the Reynolds number based on the plate length), the over-all drag of the plate is independent of slip to the second approximation, i.e., up to and including the term of order Re_L^{-1}. (Contractor's abstract)

CAL. 06:022

California U. Inst. of Engineering Research, Berkeley.

DESIGN OF A TWO-COMPONENT MICROBALANCE FOR LOW DENSITY WIND TUNNELS, by R. N. Latz. Technical rept. Aug. 10, 1954, 1v. incl. illus. diagrs. tables, refs. (Rept. no. HE-150-124; series no. 20, issue no. 100) [AFOSR-TN-54-297] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 42325 Unclassified

The balance consists of a balance group, a power drive and force-measuring system, a null-indicating system, and mounting structure. Tests based on the forces of a model mounted 6 in. from the pivot axis indicated a null sensitivity of 0.019 mg/scale division of the galvanometer, an angular null sensitivity of 0.001°/galvanometer scale division, and a reproducibility of 0.04 mg. The balance met the design requirements of measuring lift and drag to 0.1 mg, had a minimum variation in model displacement from null during the force measurements, and provided remote observations and control. Measurement of lift and drag for various angles of attack can be obtained by mounting the balance so it can rotate about a vertical axis, or by combining 2 of the balances along with an angle-of-attack mechanism to make a platform which will measure lift and drag simultaneously. (ASTIA abstract)

CAL. 06:023

California U. [Inst. of Engineering Research] Berkeley.

SKIN FRICTION IN SLIP FLOW, by S. A. Schaaf and F. S. Sherman. [1954] 7p. incl. illus. diagrs. table, refs. (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under [N7onr-29503]) Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 85-90, 144, Feb. 1954.

Skin-friction data in the slip flow regime are presented, covering the range: $0.008 < M/\sqrt{Re} < 0.38$; $34 < Re < 2,020$ for $2.5 < M < 3.8$; $3 < Re < 500$ for $M \sim 0.2$ and 0.6. The results are discussed in terms of the various relevant theories, and it is inferred that, in the neighborhood of $Re = 1,000$, the dominant effect is the interaction between boundary layer and external flow which increases the skin friction, but that, in the neighborhood of $Re = 50$, the dominant effect is that of slip that decreases the skin friction. (Contractor's abstract)

CAL. 06:024

California U. [Inst. of Engineering Research] Berkeley.

MOLECULAR BEAM INVESTIGATION OF THE SCATTERING OF MOLECULES FROM SURFACES (Abstract), by F. C. Hurlbut. [1954] [1]p. (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under [N7onr-29503]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 754-755, May 1, 1954.

Polar flux distribution of air and N_2 molecules scattered from surfaces of mild steel, aluminum, and glass were obtained using molecular beam techniques. Several values of incident angle were used. Polar traverses were not confined to the incident plane. An ionization gauge-beam detection system was devised to accomplish these measurements. Spatial polar plots of the measure flux distributions for the steel and aluminum surfaces were found to approximate the form of cosine distribution. Similar plots for the glass surfaces were found to have small, broad, bulging deviations from the cosine scattering shape. These findings are discussed in relation to the Maxwell surface interaction model. A modification of the present concepts concerning the formulation of low-density gas-flow boundary conditions is discussed. (Contractor's abstract)

CAL. 06:025

California U. Inst. of Engineering Research, Berkeley.

RECENT IMPROVEMENTS IN A ROTATING CYLINDER APPARATUS FOR RAREFIED GAS DYNAMICS RESEARCH, by J. M. Bowyer, Jr. Technical rept. Dec. 28, 1954, 1v. incl. illus. diagrs. tables, refs. (Rept. no. HE-150-127; series no. 20, issue no. 103) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 54563 Unclassified

An outline is presented of the design and development of a modified rotating cylinder apparatus. Problems are discussed which seem tractable with the modified apparatus. In the regimes of free-molecule flow and near free-molecule intermediate flow, the major problem discussed is the study of the flow between concentric cylinders when only a few of the molecules experience one or more collisions in traversing the annulus. In the slip-flow regime, the major problem discussed is the determination of possible deviations from the first-order solution, i.e., from the solution of the Navier-Stokes equations with slip-boundary conditions and with an accounting for variable viscosity. Tests accomplished with this apparatus demonstrated a nutation of the torsion balance when the chamber pressure exceeded that corresponding to free-molecule flow between the cylinders. Data analysis of the exploratory tests was limited to the free molecule flow regime owing to the nutation of the torsion cage-drag cylinder combination. On the basis of the limited data, a definite prediction of the trend of f (reflection coefficient) with s (the molecular speed ratio) was considered impossible. (ASTIA abstract)

CAL. 06:026

California U. Inst. of Engineering Research, Berkeley.

EXPERIMENTAL INVESTIGATION OF THE FLOW ABOUT THE LEADING EDGE OF A FLAT PLATE, by J. A. Laurmann. Technical rept. Oct. 15, 1954, 16p. illus. (Rept. no. HE-150-126; series no. 20, issue no. 102) [AFOSR-TN-55-2] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 48460 Unclassified

A free-molecule-flow wire probe was used to study the nature of the shock wave and boundary-layer regions in 2-dimensional low-density flow. Measurements were made of the wire temperature (a function of the local velocity and temperature) over a 1-in. length of plate at $M \cong 2$ and 4 and Reynolds numbers/inch from about 150 to 900. For $M \cong 2$, there existed an extensive region of boundary-layer shock-wave interaction extending over approximately 10 free-stream mean paths and reaching in front of the leading edge. At $M = 4$, the scale of the interaction zone was reduced considerably, and details of the flow structure were not so easily seen.

CAL. 06:027

California U. Inst. of Engineering Research, Berkeley.

BASE PRESSURE STUDIES IN RAREFIED SUPERSONIC FLOWS, by L. L. Kavanau. Technical rept. Nov. 1, 1954, 88p. illus. refs. (Rept. no. HE-150-125; series no. 20, issue no. 101) [AFOSR-TN-55-4] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 48459 Unclassified

Base pressures were measured on a simple cone-cylinder configuration over a range of Mach number M and Reynolds number Re_L (based on model length): $159 < Re_L < 800$ for $M \approx 2$ and $920 < Re_L < 7400$ for $M \approx 4$. These data extend into the slip flow regime since the rarefaction parameter $M/\sqrt{Re}$ covered the range $0.05 < M/\sqrt{Re} < 0.15$. The final results indicated that the base pressure decreased with decreasing Reynolds number and increasing Mach number which was attributed to the completely laminar character of the boundary layer and critical wake region. Preliminary tests showed a considerable variation of pressure existing over the base area, thus requiring an area-mean determination of the base pressure for every flow condition. Investigations were made of support interference effects arising from the relative size of both the sting diameter and sting length as compared to the model diameter. Some effects due to heat

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transfer were also studied. Supplementary pressure distributions were taken on the model surface upstream of the base and in the wake at one Mach and Reynolds number which was characteristic of this flow regime. The base pressure coefficient in free molecule flow is calculated for comparison purposes. A discussion is presented of these results together with experimental and theoretical works of other investigators. A precision thermistor manometer was developed for measuring wind tunnel model pressures in the range from 1 to 1000 microns of mercury with an accuracy of better than 1 percent. In addition, a study was made of the effects of "thermal creep" and "drift rate" on the measurement of low pressures. (Contractor's abstract)

CAL. 06:028

California U. Inst. of Engineering Research, Berkeley.

NEW EXPERIMENTS ON CONE DRAG IN A RAREFIED GAS FLOW, by D. C. Ipsen. Apr. 1955, 14p. illus. diagrs. tables. (Rept. no. HE-150-128; series no. 20, issue no. 104) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N7onr-29503) AD 67423 Unclassified

Further investigation is made of the total drag on the fore portion of a circular cone of 15° half angle in a rarefied air flow. With new data, the drag curves are extended to Reynolds numbers of about half the previous lower limit, giving a free-stream Reynolds number range based on cone slant length of 70-1500 at Mach 2 and 500-7000 at Mach 4. The experimental drag curves are in fair agreement with available boundary-layer predictions if certain induced-pressure and transverse-curvature effects are included, although the trends of the experimental and theoretical curves are somewhat different.

CAL. 06:029

California U. Inst. of Engineering Research, Berkeley.

LIFT ON FLAT PLATES IN LOW-DENSITY SUPERSONIC FLOW, by D. M. Tellep. Technical rept. Aug. 30, 1955 [60] p. incl. illus. diagrs. tables. (Rept. no. HE-150-131; series no. 20 issue no. 104) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 74291 Unclassified

Presented at meeting of the Amer. Phys. Soc., Pasadena, Calif., Mar. 19-21, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 362, Nov. 23, 1956.

Normal forces on rectangular flat plates in supersonic, rarefied flow were measured over the range 228 $\leq$ R $\leq$ 2412 and 3.69 $\leq$ M $\leq$ 4.12 at angles of attack up to eight degrees. In addition, the effect of aspect ratio on normal forces was determined with a series of models having an aspect ratio range from 1.0 to 2.0. The results were compared to linearized theory and indicated normal forces which were 33 to 77% greater than values predicted by theory, the experimental normal forces decreasing with increasing Reynolds number. The decrease in normal force with decreasing aspect ratios was found to be from 3 to 7% greater in magnitude than predicted by inviscid theory and substantially independent of Reynolds number over the range tested. Weak interaction theory was used to derive a simple expression for the normal force and was found to predict the order of magnitude of the increased normal force as well as the trend of the normal force with Reynolds number. (Contractor's abstract)

CAL. 06:030

California U. [Inst. of Engineering Research] Berkeley.

NORMAL FORCES ON FLAT PLATES IN LOW-DENSITY SUPERSONIC FLOW, by D. M. Tellep and L. Talbot. [Dec. 6, 1955] 10p. incl. illus. (Sponsored jointly by the Office of Naval Research and Air Force Office of Scientific Research under [N7onr-29503]) Unclassified

Published in Jour. Aeronaut. Sciences, v. 23: 1099-1108, Dec. 1956.

Normal forces on rectangular flat plates in supersonic, rarefied flow were measured over the range 200 < Re < 2,400 and 3.7 < M < 4.1 at angles of attack up to 8°. In addition, the effect of aspect ratio on normal forces was determined with a series of models having an aspect ratio range from 1.0 to 2.0. The results were compared to linearized inviscid theory, and indicated normal forces which were 33 to 77% greater than values predicted by theory, the experimental normal forces decreasing with increasing Reynolds number. The decrease in normal force with decreasing aspect ratios was found to be from 3 to 7% greater in magnitude than predicted by inviscid theory, and substantially independent of Reynolds number over the range tested. Weak interaction theory was used to derive a simple expression for the normal force, and was found to predict the order of magnitude of the increased normal force as well as the trend of the normal force with Reynolds number. (Contractor's abstract)

CAL. 06:031

California U. Inst. of Engineering Research, Berkeley.

STUDIES OF BOUNDARY LAYER SLIP SOLUTIONS AND ALDEN'S METHOD FOR BOUNDARY LAYER CORRECTION, by S. Bell. Technical rept. Dec. 6, 1955, 23p. incl. illus. refs. (Rept. no. HE-150-133; series no. 20, issue no. 106) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 81483 Unclassified

Two aspects of incompressible laminar boundary layer flow on a semi-infinite flat plate at zero incidence are discussed. First, Alden's proposed scheme of solution of the Navier-Stokes equations for this problem in terms of an expansion in inverse powers of the local Reynolds number is demonstrated to be invalid, inasmuch as the boundary conditions in the free stream cannot be satisfied to all orders. Second, an account is given of the effect of a velocity slip boundary condition on the solution of the Oseen boundary layer equations for the same problem. It was found that an additional non-uniformity in the solution was caused by the introduction of slip. (Contractor's abstract)

CAL. 06:032

California U. Inst. of Engineering Research, Berkeley.

FREE MOLECULE FLOW FORCES AND HEAT TRANSFER FOR AN INFINITE CIRCULAR CYLINDER AT AN ANGLE OF ATTACK, by L. Talbot. Technical rept. Mar. 26, 1956, 8p. illus. (Rept. no. HE-150-136; series no. 20, issue no. 107) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 94187 Unclassified

Expressions are derived for the recovery factor and heat transfer and the normal and tangential force characteristics of an infinite circular cylinder at arbitrary angle of attack in free molecule flow. The results are expressed in closed form for a cylinder at arbitrary uniform temperature in terms of three gross molecular surface interaction coefficients, the normal and tangential momentum transfer coefficients and the thermal accommodation coefficient. (Contractor's abstract)

CAL. 06:033

California U. Inst. of Engineering Research, Berkeley.

USE OF A DOUBLE EXPANSION METHOD FOR SOLUTION OF THE INCOMPRESSIBLE VISCOUS FLOW OVER A FLAT PLATE, by J. A. Laurmann. Technical rept. May 28, 1956, 34p. refs. (Rept. no. HE-150-138; series no. 20, issue no. 108) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 106930 Unclassified

A double expansion method, in the form of an inner "boundary layer" series and an outer "potential flow" series, is used to study the solution of the problem of viscous incompressible flow about a semi-infinite flat plate. Validity is checked by comparison with the closed form solution in the linearized (Oseen) case, and it is found that there is agreement only if an "integrable drag" condition (or some equivalent condition) is imposed on each term of the inner series. For the Navier-Stokes equation the same condition is required for uniqueness of the solution, but in this case the assumption cannot be justified.

CAL. 06:034

California U. Inst. of Engineering Research, Berkeley.

NEAR-FREE-MOLECULE COUETTE FLOW BETWEEN CONCENTRIC CYLINDERS, by J. M. Bowyer, Jr. and L. Talbot. Technical rept. July 10, 1956 [29]p. incl. illus. tables, refs. (Rept. no. HE-150-139; series no. 20, issue no. 109) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 108061 Unclassified

The drag forces on a fixed outer cylinder, caused by the rotation of a concentric inner cylinder, were measured under conditions of near-free-molecule flow in the annulus. The gases tested were argon, air, helium and krypton, and the Knudsen numbers based on annulus width ranged from 0.92 to 67.0. The experimental results were compared with the Wang Chang-Uhlenbeck analysis for near-free-molecule flow between parallel plates, which is based on the solution of the linearized Boltzmann equation. Agreement was found to be fairly good. (Contractor's abstract)

CAL. 06:035

California U. Inst. of Engineering Research, Berkeley.

FORCED CONVECTION HEAT TRANSFER FROM SPHERES TO A RAREFIED GAS, by D. K. Eberly. Technical rept. July 31, 1956 [52]p. incl. illus. tables, refs. (Rept. no. HE-150-140; series no. 20, issue no. 110) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N7onr-29503) AD 107185 Unclassified

A description is given of a wind tunnel study of the forced-convection heat transfer from spheres in a supersonic, rarefied gas flow at nominal Mach numbers of 4 and 6. Three silver models were used in an effort to obtain the infinite conductivity specification of the transient cooling technique of measurement. The models were polished to minimize radiation losses from the surface, and pyrex sting mountings were used to minimize heat losses by conduction. The models simulate the fluid dynamic (but not thermal) conditions for a sphere of one-foot diameter at altitudes from 45 to 60 miles in steady motion at M = 4 and 6. The free stream Reynolds numbers were in the range of

$59 \cdot \frac{u_1 D}{\nu_1} \cdot 6800$, and the free stream Knudsen numbers were in the range $0.073 \cdot M_1 \Big/ \sqrt{\frac{u_1 D}{\nu_1}} \cdot 0.43$. The results showed that Nusselt numbers are approximately related to $\frac{u_2 D}{\nu_2}$ by an equation of the form

$\frac{h_{aw} D}{k_{aw}} \quad C \frac{(u_2 D)^{0.6}}{\nu_2}$ for $9 \cdot \frac{u_2 D}{\nu_2} \cdot 800$ where $C \approx 0.3$.

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Over-all free-stream recovery factors are primarily dependent upon the stream Reynolds number, $\frac{u_1 D}{\nu_1}$, and are sensibly independent of M_1 for $20 < \frac{u_1 D}{\nu_1} < 6800$. (ASTIA abstract)

CLA. 01:001

California U. Dept. of Chemistry, Los Angeles.

CRYSTALLOGRAPHIC CALCULATIONS ON THE HIGH-SPEED DIGITAL COMPUTER SWAC, by R. A. Sparks, R. J. Prosen and others. Aug. 1955 [24]p. incl. diagrs. refs. (Perchlorates technical note no. 1) ([AF]OSR-TN-54-356) (AF 18(600)857) AD 71977 Unclassified

Also published in Acta Crystallographica, v. 9: 350-358, Apr. 1956.

The high-speed digital computer SWAC [National Bureau of Standards Western Automatic Computer] has been used extensively for calculations needed in the determination and refinement of crystal structures. Programs for calculations of structure factors, normal Fourier summations, differential Fourier summations, and least squares refinement are described briefly, and some practical experience with them is discussed. In general, these programs may be used with only minor specified changes for almost any crystal of any symmetry. All programs include provision for use of individual anisotropic atomic temperature factors. A few other programs for more trivial, but nevertheless tedious, calculations are also described. (Contractor's abstract)

CLA. 01:002

California U. Dept. of Chemistry, Los Angeles.

THE CRYSTAL STRUCTURE OF THE SILVER PERCHLORATE-DIOXANE COMPLEX, $AgClO_4 \cdot 3CH_4 \cdot li_6O_2$, by R. J. Prosen and K. N. Trueblood. Sept. 1955 [19 p. incl. diagrs. tables, refs. (Perchlorates technical note no. 3) ([AF]OSR-TN-55-346) (AF 18-(600)857) AD 74791 Unclassified

Also published in Acta Crystallographica, v. 9: 741-746, Sept. 1956.

The structure of the crystalline complex formed by silver perchlorate with 3 molecules of dioxane has been determined. The crystals are cubic (a_o = 7.67Å) with Laue symmetry m3m and probable space group $Pm\bar{3}m$; there is 1 molecule of the complex in the unit cell. The silver atoms, at the corners of the cube, are surrounded by a regular octahedron of dioxane oxygen atoms at a distance of 2.46Å. Both the perchlorate ion, whose center is at (1/2, 1/2, 1/2), and the dioxane molecules, which lie along the axes of the unit cube, appear to be rotating with little or no hindrance. (Contractor's abstract)

CLA. 01:003

California U. Dept. of Chemistry, Los Angeles.

SYMMETRY TRANSFORMATIONS OF GENERAL ANISOTROPIC TEMPERATURE FACTORS, by K. N. Trueblood. Oct. 1955, 9p. incl. tables. (Perchlorates technical note no. 4) ([AF]OSR-TN-55-373) (AF 18(600)857) AD 74700 Unclassified

Also published in Acta Crystallographica, v. 9: 359-361, Apr. 1956.

The effects of all possible crystallographic symmetry operations on general ellipsoidal atomic temperature factor are presented in tabular form. Examples of the application of these tables are given. (Contractor's abstract)

CLA. 01:004

California U. Dept. of Chemistry, Los Angeles.

PRECISE STUDIES OF THE CRYSTAL STRUCTURES OF LITHIUM PERCHLORATE TRIHYDRATE, ANHYDROUS LITHIUM PERCHLORATE, AND POTASSIUM PERCHLORATE, by R. J. Prosen and K. N. Trueblood. Nov. 1956 [80]p. incl. diagrs. tables, refs. (Perchlorates technical note no. 2) (AFOSR-TN-56-563) (AF 18(600)857) AD 110384 Unclassified

A structural study is made of the structure of the perchlorate ion and the structural effect of the environment is investigated. Precise position parameters and generalized temperature factor parameters of three crystalline perchlorates are determined by applying three-dimensional Fourier analysis and least squares techniques with the high speed digital computer SWAC. $LiClO_4 \cdot 3H_2O$, $LiClO_4$ and $KClO_4$ are studied.

CLA. 02:001

California U. Dept. of Engineering, Los Angeles.

OPERATIONAL METHODS IN NON-LINEAR MECHANICS, by L. A. Pipes. Dec. 10, 1951, 92p. incl. diagrs. (AF 33(038)14763) ATI-168567 Unclassified

Perturbation methods and sequence methods are applied to the solution of problems in the fields of physics and engineering involving autonomous or non-autonomous differential equations. Wherever possible operational processes are introduced to reduce the algebraic labor of the solution.

CLA. 03:001

California U. Dept. of Engineering, Los Angeles.

UNSTEADY SUPERSONIC FLOW, by J. W. Miles. Aug. 1954, 569p. incl. diagrs. tables, refs. [AFOSR-TR-54-36] (AF 18(600)432) AD 76856 Unclassified

A survey is made of the application of the theory of perfect fluid flow to the prediction of the aerodynamic forces that act on thin wings and slender bodies as a result of small, unsteady motions with respect to an equilibrium configuration of uniform, supersonic flight. The topics treated are: (1) the linearized equations; (2) the transformation of the subsonic wing equations; (3)the transformation of the supersonic wing equations; (4) separation of variables; (5) reduction to steady flow; (6) simple planforms; (7) the rectangular wing; (8) the quadrilateral wing; (9) slender wing methods; (10) the delta wing; (11) the low aspect-ratio rectangular wing; (12) slender nonplanar bodies; (13) accelerated flight; (14) nonlinear problems; and (15) reverse flow theorems.

CLA. 04:001

California U. Dept. of Engineering, Los Angeles.

X-RAY LATTICE STRAINS IN PLASTICALLY DEFORMED METALS, by M. Kaufman and D. Rosenthal. May 1955 [46]p. incl. illus. diagrs. tables, refs. (Rept. no. 55-31) (AFOSR-TN-55-183) (AF 18(600)-1022) Unclassified

It has been observed in the diagrams of lattice strains plotted vs the applied stress that a departure from proportionality occurs with the onset of yielding. In the present study, specimens of an Al alloy (face-centered-cubic structure), a Mg alloy (hexagonal structure), and a mild steel (body-centered-cubic structure) were examined. Data indicated that following the initial departure from proportionality a tendency toward the recovery of the original trend occurs after a few % of plastic strain. This tendency is corroborated by the levelling off of the residual lattice strain diagrams. Similar results were obtained at subzero temperatures (-202° and -320°F). The tendency toward recovery coincides with the change of the strain-hardening exponent found in the ordinary stress-strain diagrams of Al and Al alloys. It can be interpreted in the same way as the changes observed in single crystals and bicrystals of face-centered-cubic metals; that is, the departure from proportionality is associated with the phenomenon of easy slip, while the tendency toward recovery marks the advent of the difficult slip. A simplified model of heterogeneous plastic deformation based on the above interpretation accounts satisfactorily for the magnitude of the variations which have been observed in the Al alloy. (Contractor's abstract, modified)

CLA. 04:002

California U. Dept. of Engineering, Los Angeles.

X-RAY LATTICE STRAINS IN PLASTICALLY DEFORMED METALS, by D. Rosenthal, M. Kaufman and others. Aug. 1955, 84p. incl. illus. diagrs. tables, refs. (AFOSR-TR-55-31) (AF 18(600)1022) AD 88702 Unclassified

In this study, the following subjects are considered and discussed: Part I. Influence of temperature and crystal structure. Specimens representing face-centered-cubic, body-centered cubic, and hexagonal crystal structures were subjected to uniaxial tension. Macroscopic strain-stress, as well as lattice strain-stress history, was secured for all specimens in both the elastic and plastic range. Lattice strains were determined under load and after unloading, and at room and subzero temperatures. Specimens showed a departure from proportionality at the onset of the plastic flow, and a subsequent tendency toward the recovery of the original trend. These trends were related to the easy and difficult slip observed in single crystals and bicrystals of face-centered-cubic metals. The trends were also accounted for by a simplified model of the heterogeneous plastic deformation in polycrystalline metals. Part II. Influence of grain size. The influence of grain size on the above trends was studied in conjunction with the behavior of the lattice strain in the individual crystals of the aggregate. The study showed the necessity of exploring a large population of grains by means of x-rays to offset the scatter of data resulting from the variation of the lattice strain in the individual grains. The study revealed that the behavior of the grain in the aggregate can be governed by factors other than orientation with respect to the applied stress. Part III. Tests in compression by means of the Geiger counter. Compression tests on 61S aluminum alloy revealed the same general lattice trends as in the strain-stress tests, however, values of stress for equal strains were about 5% higher.

CLA. 04:003

California U. Dept. of Engineering, Los Angeles.

GEIGER-COUNTER DETERMINATIONS OF X-RAY LATTICE STRAINS IN PLASTICALLY DEFORMED ALUMINUM ALLOY, by D. Hadanovitsh, M. Kaufman, and D. Rosenthal. 1956 [2]p. incl. diagrs. (AF 18(600)1022) Unclassified

Published in Acta Metallurgica, v. 4: 218-219, Mar. 1956.

Recent tests performed on various materials at subzero as well as at room temperature, suggested that for the so-called soft orientations the trends in the plastic stage are of a twofold nature. First there was a departure from proportionality at the start of plastic flow, following which the lattice strain-stress diagram showed an opposite trend, toward the recovery of the initial slope. A series of new tests were performed to

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secure additional evidence of this tendency. These were carried out in compression instead of tension, and the Gelger-counter technique of recording the x-ray intensity was substituted for photographic procedures. Reasonable agreement between experiment and computation provided additional proof of the twofold trend observed in the plastic range under load.

CAR. 01:001

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

STUDIES IN PLASTIC COLLAPSE AND ASSOCIATED RESEARCH, by H. J. Greenberg. Final rept. Oct. 2, 1953 - Oct. 1, 1954. 16p. refs. (Rept. no. CIT-AF-12) ([AF]OSR-TR-54-33) (AF 18(600)1009) AD 49492 Unclassified

A summary of research is given under the following topics: (1) variational theorems and the eigenvalue problem for plane strain in perfect plasticity; (2) limit analysis of frames including axial forces based on an elementary mechanism technique; (3) linear-programming methods in limit analysis of structures; (4) canonical structures; and (5) a plasticity theory for powdered metals.

CAR. 02:001

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON OSEEN FLOWS IN TWO DIMENSIONS, by R. C. Meacham. Final research rept. Oct. 1, 1954, 9p. (Rept no. CIT-1-AF-t3) [AFOSR-TR-54-30] (AF t8(600)t0t3) AD 45136 Unclassified

An introductory analysis is made of viscous flow problems in which the stream function obeys the Oseen differential equation. The mapping $w = 1/z$ is considered where the stream function is transformed by setting $(z, \bar{z}) = t/_w\bar{w}\, \phi(w, \bar{w})$. These mappings map a biharmonic function of $(z, \bar{z})$ into a biharmonic function of $(w, \bar{w})$, but the Oseen stream function $\psi(z, \bar{z})$ maps into a $\phi(w, \bar{w})$ which satisfies a completely different differential equation in terms of w, $\bar{w}$. A product form of solution is obtained from this equation. The following problems remain unsolved: (1) finding solutions other than product-type solutions; (2) giving a physical interpretation to flows in $(w, \bar{w})$ space; (3) obtaining a family of solutions of the type $f_n(w) = w^n f_n(w)$; and (4) discovering transformations of the type discussed which leave the Oseen equation invariant in $(w, \bar{w})$. (ASTIA abstract)

CAR. 03:001

Carnegie Inst. of Tech. [Dept. of Mathematics] Pittsburgh, Pa.

A NEW MODIFICATION OF CLASSICAL ELECTRO-MAGNETIC THEORY, by A. Schild. Nov. 15, 1953 [6]p. incl. diagrs. [AF 18(600)1019] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 27-28, 1953.

Published in Phys. Rev., v. 92: 1009-1014, Nov. 15, 1953.

A fundamental particle is treated as a unit charge whose rest mass and space time coordinates are variables of its motion. Classical electrodynamics, in its action at a distance formulation, is obtained from an action principle which is simpler than the usual one. In this new action principle the rest mass of a particle is varied as well as the coordinates. The rest masses of interacting particles, although not assumed constant a priori, become constants as a consequence of the equations of motion. Modifications of the old action principle can yield purely electromagnetic rest masses which are, however, the same for all particles. Similar modification of the new action principle gives purely electromagnetic rest masses to all charged fundamental particles. In this new modification of electrodynamics, particles interacting at small distances no longer have constant rest masses. (Contractor's abstract)

CAR. 03:002

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

CONSERVATION THEOREMS IN MODIFIED ELECTRODYNAMICS, by J. W. Dettman and A. Schild. Apr. 1954, 16p. (Rept. no. CIT-325-7) ([AF]OSR-TN-54-109) (AF 18(600)1019) AD 35960 Unclassified

Also published in Phys. Rev., v. 95: 1057-1060, Aug. 15, 1954.

A system of interacting particles with variable rest masses is considered, whose motion is governed by a variational principle of general form, in which there are self action terms instead of the usual specifically inertial terms. For suitable restrictions of the action principle it is shown that, when the particles are at distances large compared to the classical electron radius, the new theory reduces to classical electrodynamics, and that the variable rest masses become constants of the motion. The conservation laws of energy-momentum and of angular momentum are derived from the Lorentz invariance of the general action principle. (Contractor's abstract)

CAR. 03:003

Carnegie Inst. of Tech. Dept of Mathematics, Pittsburgh, Pa.

STUDIES IN RELATIVITY THEORY, QUANTUM MECHANICS LOW TEMPERATURE PHENOMENA, by S. A. Friedberg. Final rept. Nov. 5, 1953-Sept. 30, 1955. Oct. 5, 1955 4 p. (Rept. no. 1;

CIT-AF-13) [AFOSR-TR-55-30] (AF 18(600)1019)
AD 81188 Unclassified

Three studies concerning the properties of solids at low temperature are briefly reviewed. In the first, the thermal conductivity of metals at temperatures down to approximately 1.5°K was measured using a cryostat having carbon resistors as thermometers in the 1.5°K to 22°K range. In the second, a series of electrical and galvanometric measurements was made on germanium at low temperatures. In the third, a new method was developed for measuring, with an error of only 1 or 2%, the heat capacity of diamond at temperatures down to 15°K.

CAR. 04:001

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

AN INTEGRAL EQUATION ASSOCIATED WITH A FUNCTION-THEORETIC EXTERMAL PROBLEM, by Z. Nehari. [1954/1955] [20]p. [AF 18(600)1138] Unclassified

Published in Jour. Analyse Math. (Jerusalem), v. 4: 29-48, 1954/1955.

Let $L^2(D)$ be the family of functions, single-valued and regular in a finite domain D and square-integrable over the boundary C which consists of a finite number of rectifiable Jordan curves. The starting problem is to minimize $\int_C |f(z)|^2 ds$, $ds = |dz|$, for $f(z) \in L^2(D)$ under the condition that $\int_{C_1} |f(z)|^2 ds = 1$, where C_1 is an assigned subset of D consisting of a finite number of rectifiable Jordan arcs or curves. It is shown that $\int_C |g(z)|^2 ds \geq \lambda_1$ for any admissible g(z), where λ_1 ($\neq 0$) is the lowest eigenvalue of the integral equation

$$f(\zeta) = \lambda \int_{C_1} K(z, \zeta) f(z) ds,$$

$K(z, \zeta)$ being the Szegö kernel function of $L^2(D)$; the equality can appear only if g(z) is a solution of the integral equation associated with $\lambda = \lambda_1$. On the other hand, the author proves the following result: Let ζ_ν ($\nu = 1, \cdots, n$) be any points in a subdomain D_1 bounded by C_1 of D; then

$$\lambda_1 \sum_{\nu,\mu=1}^{n} a_\nu \bar{a}_\mu K(\zeta_\mu, \zeta_\nu) \geq \sum_{\nu,\mu=1}^{n} a_\nu \bar{a}_\mu K_1(\zeta_\mu, \zeta_\nu) \quad (n = 1, 2, \cdots),$$

where $K_1(z, \zeta)$ is the kernel associated with D_1 and the a's are indeterminate variables; every inequality is sharp. Analogous problems for the Bergman kernel function are discussed. (Math. Rev. abstract)

CAR. 04:002

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON BOUNDED BILINEAR FORMS, by Z. Nehari. Apr. 1955, 24p. ([Technical] rept. no. 1) ([AF]OSR-TN-55-115) (AF 18(600)1138) AD 63406 Unclassified

Also published in Ann. Math., v. 65: 153-162, Jan. 1957.

If $a_0, a_1, \ldots, b_0, b_1, \ldots$, are complex numbers such that $\sum_{\eta=0}^{\infty} |a_n|^2 = \sum_{\eta=0}^{\infty} |b_n|^2 = 1$, the bilinear form

$A(a, b) = \sum_{\nu=0}^{\infty} \sum_{\mu=0}^{\infty} A_{\nu\mu} a_\nu a_\mu$ is said to be bounded if there exists a number M such that $|A(a, b)| \leq M$ for all such sequences $\{a_\nu\}$, $\{b_\nu\}$. The smallest such number M is called the bound of the form A(a, b). In this study a determination is made of the bound of the particular form A(a, b) for which $A_{\nu\mu} = \alpha(\nu + \mu)$, a form studied by Hilbert, Toeplitz and others. The methods employed are function-theoretic. (Contractor's abstract)

CAR. 04:003

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON THE NUMERICAL SOLUTION OF THE DIRICHLET PROBLEM, by Z. Nehari. May 1955, 31p. refs. ([Technical] rept. no. 2) ([AF]OSR-TN-55-144) (AF 18(600)1138) AD 63250 Unclassified

Also published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 157-178.

This study develops a number of different procedures for the numerical solution of the harmonic boundary value problem. The approximation mechanism is based on orthogonal expansions of various types. In all cases, it is possible to estimate the error committed in replacing infinite orthogonal sets by finite ones, and the estimates tend to zero if the sets employed are complete in the appropriate Hilbert spaces. (Contractor's abstract)

CAR. 04:004

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON THE CONFORMAL MAPPING OF NEARLY-CIRCULAR DOMAINS, by Z. Nehari and V. Singh. May 1955, 13p. ([Technical] rept. no. 3) ([AF]OSR-TN-55-145) (AF 18(600)1138) AD 81189; AD 64234 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 370-378, June 1956.

The principal result is stated in the following theorem. Let D be a domain bounded by a Jordan curve C with the

CAR. 04:005 - CAR. 04:008

equation $r = 1 + \varepsilon p(\theta)$, $0 \leq \theta \leq 2\pi$, where $p(\theta)$ and its derivative $p'(\theta)$ are continuous, $p(\theta) > 0$, $p(2\pi) = p(0)$, $|p(\theta)| \leq M$, $|p'(\theta)| \leq M'$, and ε is a small positive quantity. If $K(z, \xi)$ denotes the Szegö kernel of D and $|z| \leq \eta$, $|\xi| \leq \eta$, where η is such that

$\eta \leq 1 - \sqrt{2\varepsilon}\sqrt[4]{M(M+M')}$, then $K(z, \xi)$

$$= \frac{1}{4\pi^2}\int_C \frac{ds}{(z-t)(\xi^* - t^*)} + \varepsilon^2 R(z, \xi),\ ds = |dt|$$

where * denotes the complex conjugate, and $|R(z, \xi)|^2 \leq \rho(|z|)\rho(|\xi|)$, and $\rho(\eta)$

$$= \frac{1}{2\pi(1-\eta^2)}\left\{\frac{(2M+M')^2}{(1-\eta)^4 - 4\varepsilon^2 M(M+M')} + \frac{4M^2}{[1-\eta(1+\varepsilon M)]^2}\right\}.$$

For $z = \xi = 0$, we have the particularly simple estimate $R(0, 0) \leq \frac{1}{2\pi}(M^2 + M'^2)$. (Contractor's abstract, modified)

CAR. 04:005

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

SAFETY FACTORS AND SUPERPOSITION IN THE ELASTIC AND PLASTIC ANALYSIS OF FRAMES, by W. S. Dorn and H. J. Greenberg. May 1955, 23p. incl. diagrs. (Technical rept. no. 4) [AFOSR-TN-55-166] (AF 18(600)1138) AD 64233 Unclassified

In this study, upper bounds are found for the elastic safety factor for plane structures. This provides an estimate of the plastic safety factor in terms of the elastic safety factor and vice versa for a given system. In addition, upper and lower bounds to both the elastic and plastic safety factors for a superimposed load system are found in terms of bounds on the component load systems. (Contractor's abstract)

CAR. 04:006

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

THEORY OF PLASTICITY FOR POWDERED METALS, by E. M. Shoemaker and H. J. Greenberg. June 1955, 35p. refs. (Technical rept. no. 5) [AFOSR-TN-55-173] (AF 18(600)1138) AD 63408 Unclassified

A plasticity theory is developed to represent the mechanical behavior of a powdered metal in the green state prior to sintering. The theory includes a family of smooth, convex, stress-hardening surfaces and a family of smooth, convex, yield surfaces. Corresponding yield and stress-hardening surfaces intersect and "interact". The theory is chosen to be consistent with the requirements of positivity of plastic work as postulated by D. C. Drucker (Proceedings of the First National Congress of Applied Mechanics, p. 487-491) and to be consistent with the previous perfectly plastic and stress-hardening theories. Stress-strain laws and corresponding loading criteria are developed, and the uniqueness theorems and minimum principles appropriate to the theory are proved. (Contractor's abstract)

CAR. 04:007

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

PICARD'S THEOREM AND LINEAR DIFFERENTIAL EQUATIONS, by Z. Nehari and R. J. Duffin. July 1955, 15p. (Technical rept. no. 6) ([AF]OSR-TN-55-218) (AF 18(600)1138) AD 73980 Unclassified

The principal result is the following theorem: let $f_1(z), \ldots, f_n(z)$ $(n \geq 3)$ be entire functions for which $a_1 f_1(z) + \ldots + a_n f_n(z) = 0$ and where the coefficients $a_1, \ldots, a_n$ are nonzero constants, then either at least one of the functions $f_\nu(z)$ takes on the value zero or the functions $f_\nu(z)$ are not all essentially different. An immediate consequence of the theorem is the corollary that the linear differential equation

$$y^{(n)}(z) + p_{n-1}(z)\, y^{(n-1)}(z) + \ldots + p_1(z)y'(z) + p_0(z)y(z) = 0$$

$(n \geq 2)$ cannot have more than n essentially different solutions which are entire and do not vanish. Functions are considered essentially different if no function of the set is a constant nonzero multiple of any other function of the set. A sharpened version of the first theorem is that if $f_1(z), \ldots, f_n(z)$ $(n \geq 2)$ are entire functions such that $a_1 f_1(z) + \ldots + a_n f_n(z) = 0$, then either at least one of the functions $f_\nu(z)$ takes all finite values an infinity of times or else the linear relation holds trivially in the following way: the set $\{f_\nu(z)\}$ consists of subsets $f_{\nu 1}, \ldots f_{\nu k}$ $(k \geq 2)$ such that $f_{\nu m}(z) = a_m + l'_m(z)g(z)$, where $g(z)$ is a zero-free entire function, $l'_1(z), \ldots, l'_k(z)$ are polynomials such that

$a_{\nu 1} l'_1(z) + \ldots + a_{\nu k} l'_k(z) = A$ = a constant, and $A = 0$ unless $g(z)$ reduces to a constant.

CAR. 04:008

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

LINEAR PROGRAMMING AND PLASTIC LIMIT ANALYSIS OF STRUCTURES, by W. S. Dorn and H. J. Greenberg. Aug. 1955, 30p. incl. diagrs. tables. (Technical rept. no. 7) ([AF]OSR-TN-55-274) (AF 18(600)1138) AD 74111 Unclassified

Also published in Quart. Appl. Math., v. 15: 155-167, July 1957.

In this study, the problems of limit analysis are reduced to 3 basic types of linear programming problems chosen so as to keep the size of the problem as small as possible. Appropriate methods of solution for each of these problem types are reviewed, and are adapted

for the special systems adapted. Procedures for determining an initial feasible solution (extreme point solution) for each of these methods are discussed including a new procedure for determining an initial feasible solution for use with Lemke's dual method (The Dual Method of Solving the Linear Programming Problem, Naval Research Logistics Quarterly, v. 1: 36-47, Mar. 1954) The various linear programming solutions of the limit analysis problem are compared, and a simple example is carried through for each method of solution. It is pointed out that the structures considered are plane pin-jointed trusses for the sake of simplicity of description; however, the setup would be the same for the equations governing rigid frames or continuous beams, and for space as well as plane structures. A quantitative comparison of the 3 methods (simplex, dual, and bounded variables formulation) is given by the number of arithmetical operations necessary to obtain a solution. As a measure of these operations, the number of multifications to be performed/1 iteration is (r+2) (s+1) for the first 2 methods, and (s-r+1) (s+2) for the bounded variables method, where s = the number of bars and r = the number of redundancies of the truss.

CAR. 04:009

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON THE COEFFICIENTS OF MEROMORPHIC SCHLICHT FUNCTIONS, by Z. Nehari and E. Netanyahu. Feb. 1956, 12p. (Technical rept. no. 8) [AFOSR-TN-56-86] (AF 18(600)1138) AD 81539
Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 15-23, Feb. 1957.

It has been conjectured for some time that the coefficients a_n of functions $z^{-1} + a_1 z + a_2 z^2 + \ldots$, which are univalent in the unit disk, are subject to the inequality (i) $|a_n| \leq 2(n+1)^{-1}$ (which was known to hold for $n = 1, 2$). This conjecture was recently disproved by M. Schiffer and P. Garabedian, who showed that the largest value of $|a_n|$ is $1 + e^{-6}$. E. Netanyahu showed, moreover, that (i) does not hold for any odd index larger than 3. In the present study, it is shown that if the univalent function f(z) is, in addition, starlike with respect to the origin, the sharp inequality (i) holds for $n = 3, 4, 5, 6$. (Contractor's abstract)

CAR. 04:010

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON THE SINGULARITIES OF LEGENDRE EXPANSIONS, by Z. Nehari. Feb. 1956, 10p. (Technical rept. no. 9) (AFOSR-TN-56-96) (AF 18(600)1138) AD 82009
Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 5: 987-992, Nov. 1956.

Let $\limsup_{n \to \infty} |a_n|^{1/n} < 1$, and set $f(z) = \sum_{n=0}^{\infty} a_n z^n$, $g(z) = \sum_{n=0}^{\infty} a_n P_n(t)$, where $P_n(t)$ denotes the Legendre polynomial at degree n. If σ and τ denote, respectively, the singularities of f(z) and g(t), it is proved that to each σ there corresponds a τ such that $1 + 2\sigma\tau + \sigma^2 = 0$, and vice versa. The only exceptions are the points $t = \pm 1$ which may be singularities of g(t) without f(z) being singular for $z = \pm 1$. This theorem generalizes a recent result of Szegö (On the Singularities of Zonal Harmonic Expansions, Jour. Rational Mech. and Anal., v. 3: 561-564, 1954) who proved that the point $(1, \theta)$ will be a singular point of the harmonic function $u(r, \theta)$

$= \sum_{n=0}^{\infty} a_n r^n P_n (\cos\theta)$ ($\limsup |a_n|^{1/n} = 1, a_n$ real)

if, and only if, $z = e^{i\theta}$ is a singularity of $\sum_{n=0}^{\infty} a_n z^n$. (Contractor's abstract)

CAR. 04:011

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

OSCILLATION CRITERIA FOR SECOND-ORDER LINEAR DIFFERENTIAL EQUATIONS, by Z. Nehari. July 1956, 26p. (Technical rept. no. 12) ([AF]OSR-TN-56-262) (AF 18(600)1138) AD 88982
Unclassified

Also published in Trans. Amer. Math. Soc., v. 85: 428-445, July 1957.

More general oscillation criteria (or nonoscillation criteria) are developed for the equation $y'' + p(x)y = 0$, where p(x) is a continuous nonnegative function for $0 < x < \infty$. The equation is called nonoscillatory, without the interval being mentioned, if there exists a number a such that the equation is nonoscillatory in (a, ∞). The equation is said to be oscillatory, if one (and therefore all) of its solutions have an infinite number of zeros for $x > 0$. The general oscillation criteria developed contains Hille's criteria (Trans. Amer. Math. Soc., v. 64: 234-252, 1948) for the oscillatory and nonoscillatory conditions of the above equation. The basic idea used is the fact that there exists an intimate connection between the oscillation problem for the equation and the eigenvalue problem for the equation $u'' + \lambda p(x)u = 0$, with suitable boundary conditions.

CAR. 04:012

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON CURVES OF MINIMAL LENGTH WITH A CONSTRAINT ON AVERAGE CURVATURE, AND WITH

CAR. 04:013 - CAR. 05:002

PRESCRIBED INITIAL AND TERMINAL POSITIONS AND TANGENTS, by L. E. Dubins. Apr. 1956 [32]p. incl. diagrs. (Technical rept. no. 10) (AFOSR-TR-56-12) (AF 18(600)1138) AD 86304 Unclassified

Also published in Amer. Jour. Math., v. 79: 497-516, July 1957.

For fixed vectors u, U, v, V in real n-dimensional Euclidean space E_n, and for a fixed positive number R, an investigation is made of the existence and nature in E_n of a path of minimal length among those curves whose average curvature is everywhere less than or equal to 1/R. A curve X in real Euclidean n-space, when parameterized by arc length, is said to have an average curvature less than or equal to 1/R provided its first derivative X' exists everywhere and satisfies the Lipschitz condition $|X'(s_1) - X'(s_2)| \leq \frac{1}{R} |s_1 - s_2|$ for all s_1 and s_2 in the interval of definition of X. Such paths of minimal length are called R-geodesics. The principal result, for n = 2, is given by the following theorem: Every planar R-geodesic is necessarily a continuously differentiable curve which is either (1) an arc of a circle of a circle of radius R, followed by a line segment, followed by an arc of a circle of radius R; or (2) a sequence of 4 arcs of circle of radius R; or (3) a sub-path of one of the former types. A corollary implies that 4 is the least integer for which this is true. The nature of R-geodesics for n > 3 is open. (ASTIA abstract)

CAR. 04:013

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

ON THE COEFFICIENTS OF UNIVALENT FUNCTIONS, by Z. Nehari. Apr. 1956, 5p. (Technical rept. no. 11) (AFOSR-[TR]-56-14) (AF 18(600)1138) AD 86583 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 291-293, Apr. 1957.

The conjecture of Littlewood (Proc. London Math. Soc., v. 23: 481-519, 1925) that $|a_n| < 4|d|n$, $f(z) \neq d(|z| < 1)$ is shown to follow from the proof of the asymptotic Bieberbach conjecture that $\limsup_{n\to\infty} \frac{A_n}{n} = 1$, where $A_n = \sup |a_n|$, and $f(z) = z + a_2z^2 + a_3z^3 + \ldots$ belongs to the family S of regular univalent functions in the unit disk. The result is given in the following theorem. If f(z) is a function of S and d is a value such that $f(z) \neq d$ in $|z| < 1$, then $|a_n| < 4|d|n$ where $= \limsup_{n\to\infty} \frac{A_n}{n}$. The proof is based on the lemma that if $F(z) = b_1z + b_2z^2 + \ldots$ is regular and univalent, and $F(z) \neq 1$ in $|z| < 1$, then the same is true of the function $F_1(z) = b_1^{(1)}z + b_2^{(2)}z^2 + \ldots = 2F(z^2) \cdot 2\sqrt{F(z^2).F(z^2) - 1}$.

CAR. 05:001

Carnegie Inst. of Tech. [Dept. of Mathematics] Pittsburgh, Pa.

SOME EFFECTS OF THE ADDITION OF MASS TO VIBRATING SYSTEMS II, by H. Cohen and G. [H.] Handelman. Jan. 17, 1955 [15]p. incl. diagrs. (Technical rept. no. 1) ([AF]OSR-TN-55-26) (AF 18-(600)1236) AD 56334 Unclassified

A determination is made of the lowest frequency of vibration of a rectangular plate to which a rigid mass of finite area has been rigidly attached. The plate is taken to be simply supported along 2 opposite edges and free on the other 2 edges. The mass is rectangular in shape, centrally located, and runs completely across the plate in a direction parallel to the simply supported edges. The analysis shows that in order to predict the change in vibration characteristics with added mass, it is necessary to know the distribution of the mass and the relationship between the density of the added mass and that of the plate. For concentrated loads of small density, the plate is stiffened and the frequency μ increases. For loads of large density the frequency also increases, but not until the load is distributed across a large portion of the plate.

CAR. 05:002

Carnegie Inst. of Tech. [Dept. of Mathematics] Pittsburgh, Pa.

A NOTE ON THE TRANSVERSE VIBRATION OF A TUBE CONTAINING FLOWING FLUID, by G. H. Handelman. Feb. 1, 1955, 9p. (Technical rept. no. 2) ([AF]OSR-TN-55-50) (AF 18(600)1236) AD 56337 Unclassified

A study was made to determine the characteristics of the low-vibration frequencies for various end conditions for 2 ranges of the flow velocity solely from the structure of the differential equation without determining specific solutions. The differential equation in nondimensional form, developed by Long (Experimental and Theoretical Study of Transverse Vibration of a Tube Containing Flowing Fluid, American Society of Mechanical Engineers, Preprint 54-A-22), was used. A discussion is included on the determination of small flow velocities and velocities near the critical velocity. Data indicated that the perturbation terms can be computed step-by-step by quadratures. In the supported-end cases, the critical velocity can be determined first; perturbation from this point in powers of D serve as a check on the perturbation solution in terms of power u, where D is the eigenvalue found by removing the time-dependent term from the partial differential equation, and u is the flow velocity in nondimensional terms.

CAR. 05:003

Carnegie Inst. of Tech. [Dept. of Mathematics] Pittsburgh, Pa.

EFFECT OF HUB RADIUS ON THE VIBRATIONS OF A UNIFORM BAR, by W. E. Boyce. Feb. 25, 1955 [13]p. incl. diagrs. tables. (Technical rept. no. 3) ([AF]OSR-TN-55-64) (AF 18(600)1236) AD 56340 Unclassified

An investigation was made to determine the frequencies of vibration of a uniform beam rotating at a constant angular speed about an axis at one end perpendicular to the axis of the beam and vibrating transversely to the plane of rotation. The derivation of equations is presented. Upper and lower bounds were computed for the first 2 frequencies for ratios of the hub radius to beam length of 0.005, 0.01, 0.02, 0.05, and 0.10. The frequencies depended almost linearly on the hub radius for various rotational speeds; this behavior differed from that previously found for the case of a nonzero hub radius (Vibrations of Rotating Beams of Constant Section, by W. E. Boyce, R. C. DiPrima, and G. H. Handelman, presented at Proc. of the Second U. S. National Congress of Applied Mechanics). (ASTIA abstract)

CAR. 05:004

Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.

VIBRATIONS OF ELASTIC SYSTEMS UNDER INITIAL STRESS, by G. H. Handelman. Final rept. Sept. 1, 1954-Aug. 31, 1955. Sept. 1955, 10p. ([Technical] rept. no. 4) ([AF]OSR-TR-55-28) (AF 18(600)1236) AD 74113 Unclassified

A summary is given of work accomplised on the effects of the addition of mass to vibrating systems (item no. CAR. 05:001), the transverse vibration of a tube containing flowing fluid (item no. CAR. 05:002), and the effect of hub radius on the vibrations of a uniform bar (item no. CAR. 05:003). Study is continuing on the vibrations of: (1) rotating, twisted beams, (2) elastic systems under initial stress, and (3) a circular plate with a rigidly attached concentric circular mass. (ASTIA abstract)

CAR. 06:001

Carnegie Inst. of Tech. Dept. of Mech. Engineering, Pittsburgh, Pa.

FINITE DIFFERENCE METHODS FOR THE SOLUTION OF FLUID FLOW PROBLEMS DESCRIBED BY THE PRANDTL EQUATIONS, by W. T. Rouleau and J. F. Osterle. June 4, 1954, 72p. incl. diagrs. tables, refs. (Technical note no. 1; rept. no. CIT-AF11-TN1) ([AF]OSR-TN-54-122) (AF 18(600)969) AD 32660 Unclassified

The stepwise procedure developed by Friedrich and Forstall is extended to flows characterized by the presence of solid or porous boundaries where the downstream, or longitudinal, velocity is zero. In determining velocities near such a boundary, stability considerations restrict the extended stepwise procedure so that if the mesh spacing in the direction normal to the boundary is reduced, the mesh spacing in the downstream, or tangential, direction must be reduced an even greater amount. An implicit difference representation of the Prandtl equations is developed which is always stable and which does not require a reduction of the tangential mesh spacing as the normal mesh spacing is reduced. These difference equations cannot be solved in stepwise fashion but may be solved by either relaxation or iteration methods, both of which are completely described. Stability criteria are developed, and the dependence of the inherent error on the mesh is determined. The following 4 problems are worked: (1) the flow in the wake behind a flat plate immersed longitudinally in a uniform stream, (2) longitudinal flow over a porous flat plate with an initial boundary layer and an arbitrary distribution of normal velocity at the plate surface; (3) flow of a 2-dimensional jet discharging parallel and adjacent to a flat plate into a uniform stream; and (4) longitudinal flow over a flat plate.

CAR. 06:002

Carnegie Inst. of Tech. [Dept. of Mech. Engineering] Pittsburgh, Pa.

THE APPLICATION OF FINITE DIFFERENCE METHODS TO BOUNDARY-LAYER TYPE FLOWS, by W. T. Rouleau and J. F. Osterle. June 2, 1954, 6p. illus. tables, refs. [AF 18(600)969] Unclassified

Published in Jour. Aeronaut. Sciences, v. 22: 249-254, Apr. 1955.

Finite difference techniques are applied to the problem of slightly viscous, incompressible, constant pressure flow confined by boundaries (solid or porous) on which the "non-slip" condition prevails. The "stepwise" representation and method of solution developed by Friedrich and Forstall, which is unstable at boundaries on which there is no slip, is extended to include this case. An always stable "implicit" form of the difference equations is developed, and for it methods of solution by relaxation and iteration techniques are presented. Both the stepwise and implicit procedures are suitable for programming on digital computers. Several original solutions are obtained by these methods, including the important problems of the boundary layer over a flat plate with an arbitrary distribution of suction and the slot jet issuing adjacent to a plate into a moving stream. (Contractor's abstract)

CAR. 07:001

Carnegie Inst. of Tech. Metals Research Lab., Pittsburgh, Pa.

THE MECHANISM OF SULFATE FORMATION DURING

CAR. 08:001 - CAR. 08:004

THE ROASTING OF CUPROUS SULFIDE, by C. L. McCabe and J. A. Morgan. June 1955 [4]p. incl. diagr. (AFOSR-TN-55-154) (Also bound in its AFOSR-TR-57-9; AD 120402) (AF 18(600)1147) AD 120402(a) Unclassified

Also published in Jour. Metals, v. 8: 800A, June 1956.

A sample of Cu_2S was roasted and the phases formed were located and identified. Results show that cuprous oxide Cu_2O is formed at the sulfide surface whether or not the sulfate, a reaction product of the Cu_2O and gaseous SO_2 (or SO_3), is formed. The sulfate does not form at the sulfide surface.

CAR. 08:001

Carnegie Insl. of Tech. Metals Research Lab., Pittsburgh, Pa.

SOME OBSERVATIONS OF SUBSTRUCTURES PRODUCED BY THERMAL ETCHING (Abstract), by M. T. Simnad and A. Spilners. Feb. 1956 [1]p. (AFOSR-TN-56-80) (AF 18(600)1572) AD 81532 Unclassified

Presented at Research in Progress Session, annual meeting of the Amer. Inst. of Mining and Metallurgical Engineers, New York, Feb. 19-23, 1956.

A technique of "equilibrium thermal etching" has been employed to show up substructures in Cu and Ag crystals. The behavior of these structural defects as preferential sites for the initiation of surface reactions, and for the nucleation of deposits is being studied. (Contractor's abstract)

CAR. 08:002

Carnegie Inst. of Tech. Metals Research Lab., Pittsburgh, Pa.

ADSORPTION OF OXYGEN BY A SILVER CATALYST, by W. W. Smeltzer, E. L. Tollefson, and A. Cambron. [1956] [15]p. incl. diagrs. table, refs. [AF 18(600)-1572] Unclassified

Published in Canad. Jour. Chem., v. 34: 1046-1060, Aug. 1956.

An apparatus is described to measure volumetrically the amount of gas adsorbed by a catalyst at constant pressure and at exposure times as short as 0.1 min. The volumes of oxygen adsorbed by a technical silver catalyst at pressures of 200, 400, and 700 mm and in the temperature range of 180° to 300°C have been measured. Surface area determinations of 0.33 to 0.38 sq meter per gm of catalyst by physical adsorption and chemisorption methods show that each silver atom of the surface is associated with approximately one oxygen adatom at a monolayer coverage. The initial rate of adsorption of oxygen is directly proportional to its pressure. Observed transitions in the oxygen adsorption rates indicate that more than one type of oxygen complex occurs on the catalyst surface. The Elovich equation provides the best approximation of the adsorption rate data but is of limited applicability in interpretation of the mechanism of adsorption. Values of 22-29 kcal/mole and 17-25 kcal/mole have been calculated for the apparent activation energy and isosteric heat of adsorption respectively.

CAR. 08:003

Carnegie Insl. of Tech. Metals Research Lab., Pittsburgh, Pa.

DIFFUSION AND OXIDATION OF METALS, by M. T. Simnad. Mar. 1956 [16]p. incl. refs. (Sponsored jointly by Atomic Energy Commission, Office of Naval Research, and Air Force Office of Scientific Research under [AF 18(600)1572]) Unclassified

Published in Indus. Engineering Chem., v. 48: 586-601, Mar. 1956.

A review is presented of developments during 1955 in the field of diffusion and oxidation of metals; 271 references are cited. The following topics are discussed: (1) volume self-diffusion in pure metals and in alloys; (2) chemical diffusion in substitutional and interstitial alloys; (3) grain boundary and surface diffusion; (4) phase transformations; (5) sintering; (6) effects of impurities and imperfections on mechanical properties and on semiconductors; (7) irradiation damage; (8) metal and alloy oxidation; and (9) oxides and related crystals.

CAR. 08:004

[Carnegie Inst. of Tech. Metals Research Lab., Pittsburgh, Pa.]

NUCLEAR IRRADIATION AND RADIOISOTOPES IN METAL RESEARCH, by M. T. Simnad. Nov. 1956 [27]p. (Sponsored jointly by Atomic Energy Commission, Office of Naval Research, and Air Force Office of Scientific Research under [AF 18(600)1572]) Unclassified

Published in Internat. Jour. Appl. Radiation and Isotopes, v. 1: 145-171, Nov. 1956.

The uses of nuclear irradiation and radioisotopes are reviewed in the field of metal research, including: (1) activation analysis; (2) irradiation effects; (3) segregation; (4) friction of metals; (5) vapor deposition; (6) vapor pressure; (7) slag-metal reactions; (8) electrolytic action on metal surfaces; (9) metallic diffusion; and (10) metallic oxidation. Developments throughout the twentieth century are covered; 497 references are cited.

CER. 01:001

Carter Labs., Pasadena, Calif.

INVESTIGATION OF ACCELERATION OF REACTION RATES OF SOLIDS BY MEANS OF RAPID DEFORMATION, by F. J. Ewing. Technical rept. Oct. 6, 1955, 1v. incl. diagrs. tables. ([AF]OSR-TR-55-32) (AF 18(600)1396) AD 82476 Unclassified

The use of metals as fuels in place of gasoline is indicated where volume is limited (up to 250% increase) or where oxidizer is also to be carried (up to 350% increase). Aluminum, however, is so well protected by its oxide coating that the only explosive-or rapid reactions with O_2 or H_2O are limited to powdered aluminum. It seemed possible that new surfaces formed by rapid deformation of Al might lead to high velocity reactions. This has been studied in contact with H_2O at explosive deformation rates, and in contact with air at machine rates of 100 ft/sec. No reaction rates of substantial magnitude were observed in either circumstance. A deformation device is also described, and its operation is explained. It is designed to pull a test specimen with a maximum force of 500 lb at a maximum rate of deformation of 100 ft/sec, and for a travel distance of up to 12 in.

CAT. 01:001

Catholic U. of America. [Dept. of Chemistry] Washington, D. C.

THE MECHANISM OF THE THERMAL DECOMPOSITION OF ETHANE-d_6, by F. O. Rice and R. E. Varnerin. Technical note no. 1, Nov. 1, 1952-Aug. 15, 1953. Feb. 11, 1954, 20p. incl. illus. tables, refs. ([AF]OSR-TN-54-50) (AF 18(600)64, Task 2) AD 29027 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 324-327, Jan. 20, 1954.

C_2D_6 decomposes at about 1/3 the rate of C_2H_6 and is inhibited by NO. The inhibition curve for C_2D_6-NO mixtures is similar to that for C_2H_6-NO mixtures, the maximum reduction being to 18%, respectively, of the rate of the uninhibited reaction. When C_2D_6 was decomposed with an equal quantity of CH_4, the amount of isotopic mixing as measured by the CH_3D/CH_4 ratio depended only on the fractional decomposition. The CH_3D/CH_4 ratio for constant fractional decomposition of the C_2D_6 was independent of NO concentration changes. Results indicated that the thermal decomposition of C_2D_6 was a chain reaction and that the direct separation of D_2 occurred to a negligible extent.

CAT. 01:002

Catholic U. of America. [Dept. of Chemistry] Washington, D. C.

MASS SPECTROMETRIC ANALYSIS OF THE PRODUCTS OF THE HOMOGENEOUS REDUCTION OF ETHYLENE WITH DEUTERIUM, by R. E. Varnerin. June 1, 1954, 11p. incl. table, refs. ([AF]OSR-TN-54-96) (AF-18(600)64, Task 2) AD 34457 Unclassified

An analysis was made to determine the products of the interaction of ethylene and deuterium at 570° to 660°C. The main products, in the order of abundance, were C_2H_3D, HD, C_2H_5D, H_2, $C_2H_2D_2$, $C_2H_4D_2$, CH_3D, C_2H_6, and CH_4. The other isotopic ethanes, ethylenes, and methanes appeared when the reaction proceeded towards equilibrium. Analysis for the ethylenes was made at electron accelerating potentials below the appearance potential of ethane; the patterns for the isotopic ethanes, ethylenes, and methanes were calculated according to the method of Schissler, Thompson and Turkevich (Discussions Faraday Soc., v. 10: 46, 1951). The analyses gave results in close agreement with the stoichiometry of the reaction. (ASTIA abstract)

CAT. 01:003

Catholic U. of America. [Dept. of Chemistry] Washington, D. C.

THE THERMAL DECOMPOSITION OF ACETALDEHYDE AND ACETALDEHYDE-d_4, by F. O. Rice and R. E. Varnerin. Technical note no. 2, Sept. 1-Dec. 1, 1953. Mar. 22, 1954, 16p. incl. diagrs. refs. ([AF]OSR-TN-54-99) (AF 18(600)64, Task 2) AD 32315 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 2629-2633, May 20, 1954.

When 50/50 mixtures of CH_3CHO/C_2D_6 or CD_3CDO-C_2H_6 were decomposed, the amount of isotopic mixing, as measured by the CH_3D/CH_4 or CD_3H/CD_4 ratios, was proportional to the fraction of aldehyde decomposed. When different amounts of NO were added to the aldehyde-ethane mixtures, the ratios were independent of the concentration of NO or increased as the NO concentration increased. The decomposition of 50/50 mixtures of CD_3CDO/CH_3CHCH_2 and of CD_3CDO/C_2H_6 gave a CD_3H/CD_4 ratio of 1.8/1 for the 2 reactions. Results indicated that: (1) the thermal decomposition of CH_3CHO and CD_3CDO was similar; (2) both were chain reactions unaccompanied by any significant amount of direct separation into product molecules; and (3) the thermal decomposition of a substrate in the presence of an indicator (in which either the substrate or indicator was fully deuterated) provided a general method for studying elementary reactions.

CAT. 01:004

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

THE METATHETICAL REACTIONS OF METHYL

CAT. 01:005 - CAT. 01:007

RADICALS WITH ETHANE, DIMETHYL ETHER, ACETONE, AND PROPYLENE, by R. E. Varnerin. May 1, 1954, 16p. incl. tables, refs. ([AF]OSR-TN-54-139) (AF 18(600)64, Task 2) AD 52799 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 1426-1429, Mar. 20, 1955.

The reactions of methyl radicals with shielded C atoms, O atoms, carbonyl C atoms, and C-C doubly bonded C atoms in organic molecules were investigated. CD_3 radicals, produced in the thermal decomposition of CD_3CHO, were allowed to react with CH_3CH_3, CH_3CCH_3, CH_3COCH_3, and $CH_3CH=CH_2$. According to the CD_3H/CD_3CH_3, CD_3H/CD_3OCH_3, and CD_3H/CD_3COCH_3 ratios, the reactions

$CD_3 + CH_3CH_3 \rightarrow CD_3CH_3 + CH_3$,

$CD_3 + CH_3OCH_3 \rightarrow CD_3OCH_3 + CH_3$, and

$CD_3 + CH_3COCH_3 \rightarrow CD_3COCH_3 + CH_3$ occur to the extent of less than 1 part in 1500, 2500, and 90, respectively, as compared with the reactions

$CD_3 + CH_3CH_3 \rightarrow CD_3H + CH_3CH_2$,

$CD_3 + CH_3OCH_3 \rightarrow CD_3H + CH_3OCH_2$, and

$CD_3 + CH_3COCH_3 \rightarrow CD_3H + CH_3COCH_2$. The reaction $CD_3 + CH_3CH=CH_2 \rightarrow CD_3CH=CH_2 + CH_3$ could not be detected with high precision; the $CD_3H/CD_3CH=CH_2$ ratio indicates that it takes place to the extent of less than 1 part in 10 as compared with the reaction $CD_3 + CH_3CH=CH_2 \rightarrow CD_3H + CH_3CH=CH$. (Contractor's abstract)

CAT. 01:005

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

A MOLECULAR ORBITAL TREATMENT OF THE QUADRATIC FORM OF H_4, by V. [F.] Griffing and A. Mecek. Jan. – June 1954, 19p. incl. tables, refs. (Technical note no. 3) ([AF]OSR-TN-54-140) (AF 18(600)64, Task 1) AD 36233 Unclassified

Molecular orbital calculations of the quadratic arrangement of four H atoms were carried out as a function of internuclear distance. The complex was shown to have orbital degeneracy in the ground state. The approximation, which included the lowest orbital and the degenerate orbitals only, yielded a triplet and three singlet states. The triplet was the lowest state in accordance with Hund's rule. Calculations showed that the quadratic H_4 was unstable with respect to a totally symmetrical displacement at all points of the potential energy surface.

CAT. 01:006

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

ACTIVATION ENERGIES OF REACTIONS OF METHYL RADICALS WITH ORGANIC MOLECULES, by F. O. Rice and R. E. Varnerin. July 1, 1954 [15]p. incl. diagr. tables. ([AF]OSR-TN-54-155) (AF 18(600)64, Task 2) AD 39094 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 221-224, Jan. 5, 1955.

A study was made (1) of the thermal decomposition, at several temperatures, of various organic compounds in the presence of equimolecular amounts of ethane-d_6 and (2) of the thermal decomposition of acetaldehyde-d_4 in the presence of various organic compounds. Fifty-fifty mixtures of propane, butane, isobutane, pentane, neopentane, CH_3CHO, CH_3COCH_3, and CH_3OCH_3 with ethane-d_6 were decomposed at 580°C. The CH_4/CH_3D values were determined at different temperatures for several of these reactions. The activation energies (E) were obtained for the different reactions represented by the general equation $CH_3 + RH \rightarrow CH_4 + R$ by plotting the log $[CH_4]/[CH_3D]$ against 1/T and assuming E=12.1 for the reaction $CH_3 + C_2D_6 \rightarrow CH_3D + C_2D_5$. These values of E were compared with values taken directly from a review of A. F. Trotman-Dickenson (Quart. Revs. (London), v. 7: 198, 1953). Similar experiments were performed on 50-50 mixtures of CH_3CHO, CH_4, C_2H_6, butane, isobutane, pentane, neopentane, 2, 3-dimethylbutane, ethylene, $CH_3CH=CH_2$, CH_3COCH_3, and CH_3OCH_3 with acetaldehyde-d_4 at 527°C. Results were similar to those obtained with the 50-50 mixtures of ethane-d_6 and various compounds. Measurements were also made at different temperatures; the activation energies were compared with published data.

CAT. 01:007

Catholic U. of America. [Dept. of Chemistry] Washington, D. C.

A MATRIX FORMULATION OF THE MOLECULAR ORBITAL AND THE HEITLER-LONDON METHODS, AND OF CONFIGURATIONAL INTERACTION (Abstract), by P. F. Wacker. 1954, 27p. [AF 18-(600)64, Task 1] Unclassified

In quantum-mechanical computations upon many-particle systems, the number and complexity of the elementary mathematical operations present major difficulties. It is the purpose of this work to present a method which reduces the time required for calculations, reduces the probability of computational error, and prevents tedious details from obscuring the essentials. Further, the MO method is generalized to treat additional types of systems. (Contractor's abstract, modified)

CAT. 01:008

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

THE MECHANISM OF THE HOMOGENEOUS THERMAL REACTION BETWEEN ETHYLENE AND DEUTERIUM, by R. E. Varnerin and J. S. Dooling. Oct. 15, 1955, 17p. incl. diagr. tables, refs. (Technical note no. 7) ([AF]OSR-TN-55-407) (AF 18(600)64, Task 2) AD 86322 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1119-1122, Mar. 20, 1956.

The reaction $C_2H_4 + D_2$ has been studied and the initial rates of formation of the products have been measured at a series of temperatures. Initially, CH_2=CHD is formed predominantly, accompanied by smaller quantities of HD and C_2H_5D, and still smaller quantities of C_2H_6, $C_2H_4D_2$, and H_2. The results are interpreted on the basis of a free radical mechanism.. (Contractor's abstract)

CAT. 01:009

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

THE THERMAL DECOMPOSITION OF ETHANE, by R. E. Varnerin and J. S. Dooling. Nov 1, 1955, 12p. incl. diagrs. tables. (Technical note no. 8) ([AF] OSR-TN-55-408) (AF 18(600)64, Task 2) AD 86321 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 2042-2044, May 20, 1956.

It has been shown that, in the thermal decomposition of 50-50 mixtures of C_2H_6 and CD_4, the CD_3H/CD_4 ratio is approximately independent of the concentration of nitric oxide. In addition, it has been demonstrated that, in the thermal decomposition of 50-50 mixtures of C_2D_6 and CH_4, the D_2/CH_4 ratio is approximately independent of the concentration of nitric oxide, but the CD_3H/CH_4 ratio increases greatly with increasing concentration of nitric oxide. Mechanisms for these decompositions are proposed and discussed. (Contractor's abstract)

CAT. 01:010

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

MOLECULAR ORBITAL CALCULATIONS OF SOME DIATOMIC MOLECULES, PRINCIPALLY C_2, by M. I. Frye. 1955, 34p. incl. tables. refs. (AF 18 (600)64, Task 1) Unclassified

Calculations are made of the energy of the two lowest electronic states of C_2, using LCAO (linear combination of atomic orbitals) MO approach, and treating C_2 first as a four-, then as an eight-, and finally as a twelve-electron problem.

CAT. 01:011

Catholic U. of America. [Dept. of Chemistry] Washington, D. C.

BOND STRENGTHS AND ACTIVATION ENERGIES [Part 1], by V. F. Griffing. DECOMPOSITION KINETICS OF SIMPLE MOLECULES [Part 2], by F. O. Rice. (Final rept.) May 1956, 7p. incl. refs. (AFOSR-TR-56-18 [Pts. 1 and 2]) (AF 18(600)64) AD 87527 Unclassified

Part 1: The work undertaken under this project is reviewed. The Born-Oppenheimer assumption was critically evaluated and used to develop theories to study unimolecular processes. A semi-empirical theory was developed based on a classical mechanical picture and activation energies and reaction mechanisms were elucidated. A quantum mechanical theory of unimolecular processes was also developed. Part 2: The work herein undertaken proved definitely for the first time that in the thermal decomposition of ethane any reaction other than a free radical chain occurs to an insignificant extent. Also, a method was developed for measuring the activation energies of elementary reactions in the course of an ordinary pyrolysis.

CAT. 02:001

Catholic U. of America. Dept. of Chemistry, Washington, D. C.

STABILITY AND REACTIVITY OF MOLECULES FROM THE STANDPOINT OF MOLECULAR ORBITALS, by V. F. Griffing and J. S. Dooling. June 15, 1956 [9]p. incl. diagrs. refs. (Technical note no. 1) (AFOSR-TN-56-564) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1537 and Office of Naval Research) AD 110385 Unclassified

Also published in Jour. Phys. Chem., v. 61: 11-19, Jan. 1957.

The usefulness of the molecular orbital approximate solution of the Schroedinger equation is shown in the discussion of the stability and reactivity of atoms and molecules. The nature of the activated complex is discussed and the activation energy is identified with promotion energy as the internuclear parameters are adiabatically varied. Four center systems are used to discuss the general aspects of chemical problems which then have the necessary degree of complexity. The importance of the occurrence and removal of orbital and spin degeneracy is demonstrated for atomic systems. Accidental degeneracies are seen to play a similar role in heteronuclear systems.

CHA. 01:001 - CDC. 02:001

CHA. 01:001

[Charyk, J. V., Princeton, N. J.]

SELECTED COMBUSTION PROBLEMS, FUNDAMENTALS AND AERONAUTICAL APPLICATIONS: COMBUSTION COLLOQUIUM, CAMBRIDGE U. (ENGLAND), Dec. 7-11, 1953, [ed. by J. V. Charyk] London, Butterworths Scientific Publications, 1954, 534p. incl. illus. diagrs. tables, refs. [AF 18(600)972]
Unclassified

A series of 18 review papers and discussion contributions are presented on various phases of laminar flame propagation, turbulent combustion, solid and liquid propellants, as well as on some technical combustion problems.

CHA. 01:002

[Charyk, J. V., Princeton, N. J.]

SPONTANEOUS IGNITION OF LIQUID FUELS, by B. P. Mullins. London, Butterworths Scientific Publications, 1955, 117p. incl. illus. diagrs. refs. (NATO AGARDograph rept. no. 4) (AF 18(600)972)
Unclassified

A survey and review are presented of the present status of knowledge in the field of spontaneous ignition. It deals with the spontaneous ignition of combustibles that are liquid at normal temperature and pressure. Some of the characteristic phenomena that are observed experimentally when combustibles are heated in the presence of an oxidizing atmosphere (generally, air or oxygen) under various conditions are described. A description of various methods of measuring ignition temperatures are given in eight chapters. They include: (1) Moore's heated crucible method; (2) Jentzsch's heated crucible method; (3) static heated crucible and furnace methods; (4) bomb methods; (5) adiabatic compression methods; (6) flow methods; (7) heated surface methods; and (8) the Mackey test, diesel engine methods, and other miscellaneous methods. This is followed up by chapters on (1) spontaneous ignition temperature data, (2) effect of fuel additives, (3) factors affecting ignition delay, and (4) the aeronautical applications of spontaneous ignition data (including the spark-ignition engine, the aero-gas turbine, and the rocket and the pulse jets).

CHA. 01:003

[Charyk, J. V., Princeton, N. J.]

INTRODUCTION TO THE STUDY OF CHEMICAL REACTIONS IN FLOW SYSTEMS, by S. S. Penner. London, Butterworths Scientific Publications, 1955, 86p. incl. diagrs. refs. (NATO AGARDograph rept. no. 7) (AF 18(600)972)
Unclassified

This report is intended as an introduction to the study of chemical reactions in moving gas mixtures. The manuscript is divided into four chapters. Chapter 1 contains a résumé of classical chemical kinetics with special reference to the limitations of the steady-state approximation for chain reactions. Chapter 2 contains a brief summary of the conversion laws for reacting fluids and suitable expressions for the determination of transport coefficients. Chapter 3 contains an analysis. A simple example of chemical reactions in flow systems on the problem of chemical reactions during adiabatic flow through a de Laval nozzle which is a flow problem with negligible diffusion is analyzed. Chapter 4 contains a brief discussion of stationary, isothermal gas-solid systems and some of the important features of heterogeneous diffusion flames. Seventy-one references and a subject index are also included.

CDC. 01:001

Chicago Development Corp., Riverdale, Md.

RESEARCH ON A NEW CLASS OF INORGANIC COMPOUNDS CAPABLE OF POLYMERIZING INTO USEFUL STRUCTURAL MATERIALS, by I. Hornstein. Final technical rept. Mar. 1, 1953 - Feb. 28, 1954. Mar. 24, 1954 [18]p. incl. diagrs. [AFOSR-TR-54-12] (AF 18(600)656; continued by AF 18(600)1163)
AD 29764 Unclassified

A series of reactions were developed for converting the reaction products of a polyvalent halide and a Grignard reagent into a new type of thermoplastic material. Laboratory studies established that $FeCl_3$, $VOCl_3$, and ethylmagnesium chloride (C_2H_5MgCl) reacted to form a mixture of $FeVO(C_2H_5)_6$ and $MgCl_2$.

An organo-Fe-V compound was isolated from the mixture by treatment with dimethylformamide and was purified by chromatographic adsorption on an alumina column. The organometallic compound was pyrolyzed under argon to form a polymeric material consisting essentially of Fe, V, and O with 10% or less of C, H, and N. Compression-molded disks of the polymeric material were heated to 700°C in an inert atmosphere without loss in thermal plasticity. Surface oxidation appeared when disks were heated in air to 500°C, but no changes were observed in their dimensional stability or in the clarity of the surface details. The material was leached with H_2O without deletertous effects. A series of reaction mechanisms was postulated to explain the nature and formation of the organo-Fe-V thermoplastic materials. Thermoplastic materials of a similar nature were prepared by using polyvalent halides of B, Fe, Si, Ti, and V with the Grignard reagent ethylmagnesium bromide. (ASTIA abstract)

CDC. 02:001

Chicago Development Corp., Riverdale, Md.

RESEARCH ON A NEW TYPE OF ORGANO-METALLIC THERMOPLASTIC, by I. Hornstein and R. S.

Dean. Final rept. Mar. 1, 1953 – Oct. 4, 1954. Oct. 29, 1954 [40]p. incl. diagrs. (Rept. no. 18) ([AF]OSR-TR-55-5) (AF 18(600)1163; continuation of AF 18(600)656) Unclassified

In this study, a series of reactions has been developed for converting the reaction products of a polyvalent halide and a Grignard reagent into a new type of thermoplastic material. Polymers consisting essentially of Fe, V, O_2 with small amounts (10%) of C, H_2, and N_2 have been prepared which can be heated to 700°C without loss of thermal plasticity. Molded parts of these polymers retain their dimensional stability and detail without distortion even at this temperature. These molded products also maintain their integrity when heated in air for short periods to 500°C. When heated for longer periods at this temperature, surface oxidation appears to take place, but again the molded parts retain their shape, size, and surface details. This material can be leached with water without any deleterious effect effects. Reaction mechanisms have been postulated to explain the nature and formation of these new Fe-V-O thermoplastic materials. In addition, thermoplastic materials of a similar nature have been prepared in which polyvalent halides of the following elements have been used: (a) V, (b) Fe, (c) Ti, (d) Si, and (e) B. Additional studies have been made on the molecular structure of the $VOCl_3$ - $FECl_3$ intermediate in a new type organometallic thermoplastic. Experimental evidence is offered to show that anhydrous $FeCl_3$ and anhydrous $VOCl_3$ can react in dry ether to form a new product. The empirical formula of a product obtained by treating $VOCl_3$ in ether with a large excess of $FeCl_3$ is shown to be $7FeCl_3 \cdot 2VOCl_3$. A description of this study is given in order to gain some understanding of the nature of this and similar $FeCl_3 \cdot VOCl_3$ complexes having different ratios of $FeCl_3$ to $VOCl_3$. (Contractor's abstract, modified)

CHI. 01:001

Chicago U., Ill.

USE OF RANKS IN ONE-CRITERION VARIANCE ANALYSIS, by W. H. Kruskal and W. A. Wallis. Dec. 1952 [39]p. incl. diagrs. tables, refs. [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N6ori-02035] AD 14193 Unclassified

Also published in Jour. Amer. Stat. Assoc., v. 47: 583-621, Dec. 1952.

Given C samples, with n_i observations in the ith sample, a test of the hypothesis that the samples are from the same population may be made by ranking the observations from from 1 to $\sum n_i$ (giving each observation in a group of ties the mean of the ranks tied for), finding the C sums of ranks, and computing a statistic H. Under the stated hypothesis, H is distributed approximately as $\chi^2(C-1)$, unless the samples are too small, in which case special approximations or exact tables are provided. One of the most important applications of the test is in detecting differences among the population means. (Contractor's abstract)

CHI. 01:002

Chicago U., Ill.

THE PRINCIPLES OF EXPERIMENTAL DESIGN, by K. A. Brownlee. [1954] 9p. incl. tables, refs. [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N6ori-02035] AD 139358 Unclassified

Presented at a Colloquium on Statistical Design in Laboratory Experiment, U. S. Naval Ordnance Lab., White Oak, Md., Mar. 24, 1954.

Also published in Indus. Quality Control, v. 13: 1-9, Feb. 1957.

A discussion is presented concerning the theory of experimental design, illustrated by examples of single and multi-factor experiments to show techniques of statistical analysis.

CHI. 01:003

Chicago U., Ill.

THE WAGR SEQUENTIAL t-TEST REACHES A DECISION WITH PROBABILITY ONE, by H. T. David and W. H. Kruskal. [Sept. 1956] [9]p. [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N6ori-02035] AD 139360 Unclassified

Also published in Ann. Math. Stat., v. 27: 797-805, Sept. 1956.

The WAGR test is a sequential procedure for testing the null hypothesis that the proportion of a normal population greater than a given constant is P_0 (given) against the alternative that it is P_1 (given). These are equivalent (after a translation) to hypotheses specifying the value of μ/δ, where μ and δ^2 are the mean and the variance of the normal population under test. We prove that, with probability one, a decision is reached when the WAGR test is applied. This fact is of importance in its own right; it also has indirect interest because, unless it were true, the standard Wald inequalities on probabilities of error at the two hypothesis points could not be applied.

CHI. 02:001

Chicago U. Chicago Midway Labs., Ill.

SOME CONSEQUENCES OF POSSIBLE DEGENERACY BANDS IN Ge, by E. N. Adams, II. [1953] [?] [AF 33(038)25913]

CHI. 02:002 - CHI. 02:006

Published in Phys. Rev., v. 92: 1063-1064, Nov. 15, 1953.

Calculations of Herman (Phys. Rev., v. 88: 1210, 1952) and Herman and Callaway (Phys. Rev., v. 89: 518, 1953) indicate a triple degeneracy for diamond and germanium at the band edge for both the conducting and valence bands, the degeneracy in the conduction band being probably sixfold. Such degeneracies would require a significant modification of the interpretation of certain experimental results on carrier densities. A theoretical consideration indicates that effective masses would have to be smaller than unity, the range of values being such that $a_e a_h \sim 4$-6. The deformation potential as the dominant source of lattice scattering would have to be abandoned. These conclusions also apply to silicon since silicon probably has the same band structure as germanium to the approximation of Herman's calculation. The present harmony between theory and experimental data would disappear when account is taken of the degeneracy. The weak but definite evidence discussed is considered to indicate that the predicted degeneracy in the band structure of germanium and silicon does not occur.

CHI. 02:002

Chicago U. Chicago Midway Labs., Ill.

THE IMAGE INTENSIFIER AS AN AID TO LOW LEVEL VIEWING (Unclassified title), by E. N. Adams, II and J. Burns, III. Dec. 1, 1953 [23]p. incl. diagrs. (Rept. no. CML-R-P-5) (AF 33(038)25913) AD 24987 Confidential

CHI. 02:003

Chicago U. Chicago Midway Labs., Ill.

FURTHER EVIDENCE FOR THE ENERGY GAP OF LEAD SULFIDE, by G. R. Mitchell and A. E. Goldberg. Jan. 29, 1954 [4]p. incl. diagr. ([AF]OSR-TN-54-16) (AF 33(038)25913) Unclassified

Also published in Phys. Rev., v. 93: 1421, Mar. 15, 1954.

The energy gap was measured for a single crystal of PbS which was grown from the vapor phase and which contained a p-n junction that exhibited a small photovoltaic effect. The energy gap is 0.4 ev. (C. A., 1954:74201)

CHI. 02:004

Chicago U. Chicago Midway Labs., Ill.

OCCURRENCE OF NATURAL P-N JUNCTIONS IN LEAD SELENIDE, by A. E. Goldberg and G. R. Mitchell. July 1953 9 p. incl. illus. (Rept. no. CML-R-P1) (AFOSR-TN 54-17) (AF 33(038)25913) AD 15047 Unclassified

Also published in Jour. Chem. Phys., v. 22: 220-221, Feb. 1954.

Single crystals of PbSe were grown from melts in sealed quartz tubes. Except for a very narrow range of initial melt compositions, stoichiometric excesses of Pb or Se in the melt resulted in crystals that were wholly n- or p-type, respectively. Initial compositions within the critical range yielded crystals showing both p- and n-regions. The electrical resistivities were related to crystal compositions permitting the construction of the Pb-Se phase diagram in a narrow region about the compound PbSe. The invariant melting point for the system falls in the Se-rich region. This precludes the possibility of growing a crystal from a melt which is of stoichiometric composition throughout. (Contractor's abstract)

CHI. 02:005

Chicago U. Chicago Midway Labs., Ill.

VAPOR PHASE CRYSTAL GROWTH OF LEAD SULFIDE CRYSTALS, by F. [A.] Pizzarello. Feb. 1954, 3p. ([AF]OSR-TN-54-31) (AF 33(038)25913) Unclassified

Also published in Jour. Appl. Phys., v. 25: 804-805, June 1954.

A method of vapor phase crystal growth which may be generally applicable to a wide variety of materials was devised. With experiments on lead sulfide using this method, complete transfer of material to a growing crystal face was effected. This method also purified the lead sulfide starting material of any nonvolatile impurities.

CHI. 02:006

Chicago U. Chicago Midway Labs., Ill.

PHOTOCONDUCTIVITY AND PHOTOELECTROMAGNETIC EFFECTS IN InSb, by S. W. Kurnick, A. J. Strauss, and R. N. Zitter. [Apr. 1954] [6]p. incl. diagr. (AF [OSR-TN-54-102) (AF 33(038)25913) Unclassified

Published in Phys. Rev., v. 94: 1791, June 15, 1954.

Photoconductive and photoelectromagnetic responses were observed at 300°K and 77°K in p-type samples of InSb which are intrinsic at room temperature. The data reported here was obtained in experiments on rectangular plates measuring 0.028 x .26 x 1.0 cm^3 with an effective impurity concentration of approximately 7×10^{15} acceptors cm^3 (as determined by Hall measurements at 77°K) and with a resistivity of 0.015Ω-cm 300°K and 1.1Ω-cm at 77°K. (Extracted from rept.)

CHI. 02:007

Chicago U. Chicago Midway Labs., Ill.

ELASTORESISTANCE IN p-TYPE Ge and Si, by E. N. Adams, II. [Sept. 1954] 4p. ([AF]OSR-TN-54-241) (AF 33(038)25913) Unclassified

Also published in Phys. Rev., v. 96: 803-804, Nov. 1, 1954.

Elastoresistance in n-type Ge and Si is considered to be brought about by a strain induced transfer of electrons between nonequivalent anistropic energy minima in the conduction band. In p-type specimens, however, it is believed that the great elasloresistance originates in a strain induced mixing of the nearly degenerate bands and a consequent strong warping of the energy surfaces. An experiment was carried out employing a spin orbit coupling model to add validity to this concept.

CHI. 02:008

Chicago U. Chicago Midway Labs., Ill.

PREPARATION OF INDIUM ARSENIDE, by R. H. Harada and A. J. Strauss. [1954] 4p. incl. illus. (AF 33(038)25913) Unclassified

Arsenic purified by a relatively simple method was used to prepare n-type InAs as pure as any previously reported. Reagent grade arsenic trichloride was distilled twice and then reduced with hydrogen at 850°C. The arsenic vapor condensed at 300°C to form a coherent crystalline deposit. This material was further purified by sublimation in argon or helium, using a thermal gradient technique. Ingots of InAs were prepared from the purified arsenic and vacuum-baked indium and then zone refined for ten or more passes. Synthesis and zone refining are carried out in the same apparatus, which utilizes conventional techniques for the processing of decomposing compounds. (Extracted from rept.)

CHI. 02:009

Chicago U. Chicago Midway Labs., Ill.

THE SYSTEM INDIUM ANTIMONIDE-TIN, by R. N. Zitter. 1954 4p. (AF 33(038)25913) Unclassified

Presented at annual meeting of the Amer. Inst. of Mining and Metallurgical Engineers, New York, Feb. 15, 1954.

Because the intermetallic compound InSb is similar to gray tin in its lattice structure and lattice parameter and they are isoelectronic, the vertical section InSb-Sn was investigated in order to ascertain the possibilities of obtaining solid solutions of tin in InSb, and other homogeneous alloys.

CHI. 02:010

Chicago U. Chicago Midway Labs., Ill.

AIR-TO-GROUND INFRARED TARGET AND BACKGROUND MEASUREMENTS (Unclassified title), by G. F. Levy and I. I. Wolken. Feb. 1, 1954, 35p. incl. illus. tables. (Rept. no. CML-R-E1) (AF 33-(038)25913) AD 31427 Confidential

CHI. 02:011

Chicago U. Chicago Midway Labs., Ill.

SOME THEORETICAL ASPECTS OF THERMAL RECONNAISSANCE WITH SINGLE-ELEMENT PHOTODETECTORS (Unclassified title), by J. R. Platt. May 1954, 53p. incl. illus. refs. (Rept. no. CML-R-P7) (AF 33(038)25913) AD 32300 Confidential

CHI. 02:012

Chicago U. Chicago Midway Labs., Ill.

HIGH REPETITION RATE STROBOSCOPIC LIGHT SOURCE, by W. P. Harvey and C. C. Rockwood. June 1954 [13]p. incl. illus. tables. (Rept. no. CML-RM-E12) (AF 33(038)25913) AD 135672 Unclassified

Action stopping with a Fastax camera is improved when a one-microsecond strobe light is used instead of, or as a supplement to, flood lighting. A 5C22 thyratron triggered by the Fastax sprocket teeth discharges a 12 kv pulse-forming network into an Edgerton lamp 5000 times per second. An area 3 feet by 3 feet is adequately illuminated for the photography of objects with good reflection characteristics (painted white or marked with special tape) with ASA 100 film at f/2.7. (Contractor's abstract)

CHI. 02:013

Chicago U. Chicago Midway Labs., Ill.

GENERALIZED DEFORMATION POTENTIAL THEORY FOR N-TYPE Ge (Abstract), by W. P. Dumke. Sept. 23, 1954, 1p. (AF 33(038)25913) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 26-27, 1954.

Published in Phys. Rev., v. 98: 230, Apr. 1, 1955.

The deformation potential theory has been reexamined taking into account the ellipsoidal shape of the surfaces of constant energy in reciprocal lattice space, and the effect of shear wave scattering in n-type Ge. We find that if scattering by compressional waves were the dominant scattering process, a simple relaxation time exists proportional to $E^{-1/2}$, just as for spherical energy surfaces. However, the scattering due to shear waves

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ts strongly anisotroptc and cannot be described by a stmple relaxation time. We have been able to show that when shear wave scattering ts taken tnto account the dtstrtbution function for electrtcal conduction takes the usual form

$$f_1 = -eE \cdot \langle \bar{\tau} \rangle \ddagger \cdot \nabla_p f_o,$$

except that the relaxation time ıs a second rank tensor with components that depend on direction. Prelimtnary calculations indicate that shear wave scattering is the domtnent scattering mechanism for n-type Ge. (Contractor's abstract)

CHI. 02:014

Chtcago U. Chicago Mtdway Labs., Ill.

NOTES ON THE ENERGY BAND OF GERMANIUM AND SILICON, by E. N. Adams, II. Sept. 1954, 57p. tncl. diagrs. refs. (Rept. no. CML-TN-P8) (AF 33(038)-25913) AD 40451 Unclassified

An outline ts given of the current ideas on the band structure of Ge and Si, and the theory of some of the recent important expertments ts worked out. For n-type material, analysts ts given of experiments on Hall mobility and magnetoresistance, electroresistance, and cyclotron resonance, and the information available as a result of these experiments is discussed. For p-type material, the spin-orbit coupling model is described and the shape of the energy surface deduced. The characteristics of the IR absorption curve are discussed following Kahn, and Lax's results showing anisotropy of the cyclotron resonance are cited to further support the two energy surface model. A theory is proposed for the large elastoresistance effects observed in p-type material. The temperature dependence of lattice mobilities is discussed in qualitative terms. Detailed treatments of diverse theoretical points are given in appendices. (Contractor's abstract)

CHI. 02:015

Chicago U. Chicago Midway Labs., Ill.

ELECTRONIC SUSCEPTIBILITY IN CERTAIN ALLOYS, by E. N. Adams, II and R. N. Zitter. Oct. 14, 1954, 7p. incl. diagrs. (AF 33(038)25913) Unclassified

Also published in Phys. Rev., v. 96: 1705-1707, Dec. 15, 1954.

The purpose of this note is to demonstrate that there is a strong effect of band-band interactions on electron susceptibility in certain alloy systems such as $MgCu_2$ - $MgZn_2$.

CHI. 02:016

Chicago U. Chicago Midway Labs., Ill.

MOLECULAR DISTORTION CAUSED BY HINDERED ROTATION (Abstract), by H. T. Minden. Nov. 9, 1954, 1p. (AF 33(038)25913) Unclassified

If there ts a force htndering internal rotation of ethane about its figure axis, there ought to be a force tending to dtstort the hydrogen tetrahedra. The tumbling moment of tnertia should increase as the molecule assumes htgher torsional states. Assuming a cosine hindering potential there ought to be a term proportional to $\langle \frac{1}{2} V_o (1-\cos 3_x) \rangle A_v$ in the expression for the perpendtcular rotational constant. The vartation of this quantity with barrter hetght for the first twelve torstonal states (for K = 0) has been computed and a theoretical mtcrowave spectrum dcduc d for the ethane-like molecule CH_3StF_3. (Contractor s abstract)

CHI. 02:017

Chicago U. Chtcago Mtdway Labs., Ill.

DEPOSITION OF LEAD SULFIDE AND LEAD SELENIDE FILM FROM SOLUTIONS, by S. Whitcher. Dec. 1954, 25p. tncl. tables, refs. (Rept. no. CML-TN-P9) (AF 33(038)25913) AD 53104 Unclassified

The development of detector materials ts a part of a general program which is aimed at improvtng night seeing devices for the Air Force. Lead sulfide films for mirrors and photocells were chemically prepared by mixing a soluble plumbous salt, thiourea and sodium hydroxide. Methods of preparation used in the past by other workers are discussed. The concentrations of the reactants can be varied as well as the order in which the compounds are mixed. Further investigation of these variables is reported in this paper. Impurity cations such as Cu^{++} are known to enhance film deposition. This has been verified in this work by use of highly pure materials. The effect of several ions not previously studied has been investigated. A search was made for other organic sulfur compounds to use in film preparation. None were found to be as good as thiourea, and in general the quality of the film produced was related to the similiarity to thiourea of the molecular structure of the organic sulfide. A method for the preparation of PbSe films is described. Several coordination complex compounds of lead and thiourea have been isolated and analyzed. These do not seem to be intermediates in the deposition mechanism, however. The mechanism which is proposed is based on the slow generation of sulfide ions by the decomposition of thiourea. Evidence is advanced to support this hypothesis. (Contractor's abstract)

CHI. 02:018

Chicago U. Chicago Midway Labs., Ill.

THE FERROELECTRIC THERMAL RADIATION DETECTOR (Unclassified title), by H. L. Berman and J. F. Tribby. Dec. 1954, 32p. i. l. diagrs. tables. (Rept. no. CML-TN-P4) (AF 33(038)25913) Confidential

CHI. 02:019

Chicago U. Chicago Midway Labs., Ill.

INFRARED RECONNAISSANCE TECHNIQUE AND EQUIPMENT (Unclassified title), by S. J. Klapman. Interin final rept. Dec. 1954, 132p. incl. illus. diagrs. refs. (AF 33(038)25913, Task VII) Secret

CHI. 02:020

Chicago U. Chicago Midway Labs., Ill.

EFFECTS OF OXYGEN ON PbS FILMS, by H. T. Minden. Dec. 23, 1954 [33]p. incl. diagrs. refs. (AF 33(033)25913) Unclassified

The conductivity changes produced in lead sulfide films by the sorption of oxygen have been determined. At temperatures less than about 210°C sorption is less than 7×10^{-4} mol of oxygen per mol of PbS. Nonetheless, initial exposure to oxygen at these temperatures produces an abrupt decrease in conductivity; further exposure increases the conductivity slightly. At temperatures higher than about 210°C the conductivity decreases immediately and stays low while sorption of the order of .1 mol oxygen per mol PbS slowly occurs. When the sorption is almost complete the conductivity gradually rises to its initial value. The cycle can be repeated by admitting more oxygen in contact with the same film. These effects are explained by assuming the formation of surface acceptor states by the oxygen. At higher temperatures the oxygen acceptors diffuse inward and reacts chemically with excess lead atoms and with the sulfide ions. (Contractor's abstract)

CHI. 02:021

Chicago U. Chicago Midway Labs., Ill.

PHOTO-EFFECTS IN InSb, by S. W. Kurnick, A. E. Goldberg and others. Jan. 10, 1955 [14]p. incl. diagrs. refs. [AFOSR-TN-55-33] (AF 33(038)25913) Unclassified

Phototransistor, photoelectromagnetic (PEM) and photoconductive effects occur in InSb. P-n junctions have been pulled from the melt; at liquid nitrogen temperatures these junctions show photovoltaic and phototransistor responses. Surface recombination rates and bulk lifetimes have been evaluated from the PEM and photoconductive response at liquid N_2 temperatures using a constant-relaxation-time model for carrier transport. Response is strongly dependent on surface preparation (electro-polished or mechanically polished). The temperature-dependence of the PEM effect is discussed. (Contractor's abstract)

CHI. 02:022

Chicago U. Chicago Midway Labs., Ill.

InSb PHOTODIODES, by G. R. Mitchell, A. E. Goldberg, and S. W. Kurnick. [June 22, 1955] 8p. ([AF]OSR-TN-55-129) (AF 33(038)25913) Unclassified

Presented at the IRE-AIEE Semiconductor Conference, June 20-22, 1955.

The purpose of this paper is to describe the photoproperties of InSb p-n junctions. The photovoltaic response to an equal quantum spectrum was obtained. The characteristic of the junction when exposed to room temperature radiation is described. The noise, signal, and signal-to-noise ratio were measured as a function of reverse bias.

CHI. 02:023

Chicago U. Chicago Midway Labs., Ill.

PHOTOEFFECTS IN InSb, by S. W. Kurnick and R. N. Zitter. [1955] [8]p. incl. diagrs. [AFOSR-TN-55-130] (AF 33(038)25913) AD 113839 Unclassified

Also published in Photoconductivity Conference, p. 531-538, 1956.

Surface conditions in p-type InSb at liquid-nitrogen temperatures influence the magnitude of photoconductive and PEM (photoelectromagnetic) responses and strongly alter the variation of the PEM response with magnetic field. The response of mechanically polished samples exhibits a peak value with increasing magnetic field, whereas the response of electrolytically polished samples reaches a saturation value. A simple theory using the concept of surface-recombination speeds has been developed to analyze these effects. Values of minority-carrier (bulk) liketimes and mobilities obtained from mechanically polished samples are consistent with the values from the same samples after electropolishing. In addition, the theory may be used to estimate surface-recombination speeds. (Contractor's summary)

CHI. 02:024

Chicago U. Chicago Midway Labs., Ill.

SURFACE AREA AND PARTICLE SIZE OF EVAPORATED LEAD SULFIDE FILMS, by R. H. Harada. May 19, 1955 [6]p. incl. diagrs. tables. refs. [AFOSR-TN-55-150] [AF 33(038)25913] AD 94125 Unclassified

Also published in Jour. Chem. Phys., v. 24: 447-452, Feb. 1956.

Physical adsorption isotherms of lead sulfide films evaporated in vacuum and through oxygen were measured in order to determine their surface area and particle size. The surface areas of fresh and of annealed-vacuum evaporated films were found to increase linearly with film thickness. Annealing the films in vacuum decreased the surface area considerably. The average specific surfaces of the fresh and

CHI. 02:025 - CHI. 02:028

annealed films were 63 sq m/g and 6 sq m/g, corresponding to particle sizes of 0.013μ and 0.13μ, respectively. The surface area of fresh films evaporated through oxygen depended upon the rate of evaporation. The average specific surface of the fresh slowly evaporated films was 66 sq m/g; for those evaporated faster, it was 118 sq m/g. The corresponding particle sizes were 0.012μ and 0.0068μ. When these films were annealed in a closed vacuum system, the specific surface became 12 sq m/g and 14 sq m/g, corresponding to particle sizes of 0.067μ and 0.056μ, respectively. For films evaporated through oxygen, the oxygen is chemisorbed on the surface of the film during evaporation. When such a film is annealed sulfur dioxide is evolved and sulfate is formed. (Contractor's abstract)

CHI. 02:025

Chicago U. Chicago Midway Labs., Ill.

EFFECTS OF OXYGEN ON PbS FILMS, by H. T. Minden. Dec. 28, 1954 [8]p. incl. diagrs. table. [AFOSR-TN-55-177] (AF 33(038)25913) AD 94127 Unclassified

Also published in Jour. Chem. Phys., v. 23: 1948-1955, Oct. 1955.

The effect of oxygen on the conductivity of vacuum-evaporated PbS films has been experimentally investigated. When outgassed, these films are n-type semiconductors. If they are exposed to oxygen at temperatures below about 200°C, the conductivity decreases with increasing pressure and then increases again. The thermoelectric power changes from negative to positive, but less than 10^{-3} mole 0_2/mole PbS is sorbed by the film. Above 200°C the conductivity merely decreases when oxygen is admitted, and the thermoelectric power becomes small. The film gradually absorbs all the oxygen in the vacuum system and evolves a good deal of SO_2. When the reaction is complete, the conductivity returns to its initial value, and the thermoelectric power is once again negative. The film can repeatedly absorb large amounts of oxygen without undergoing any permanent change in electrical properties. It is concluded that these films are composed of 2 layers. Next to the substrate there is a conducting layer that chemisorbs oxygen, but does not react with it. The chemisorbed oxygen acceptors are responsible for the observed changes in conductivity. The upper layer of the film is nonconducting and reacts to completion with oxygen, possibly forming $PbSO_3$:PbO, and evolving SO_2. (Contractor's abstract)

CHI. 02:026

Chicago U. Chicago Midway Labs., Ill.

WAVELENGTH DEPENDENCE OF RADIATION-NOISE LIMITS ON SENSITIVITY OF INFRARED PHOTODETECTORS, by J. R. Platt. Aug. 29, 1955 [2]p. incl. diagr. [AFOSR-TN-55-292] (AF 33(038)25913) AD 114585 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 46: 609-610, Aug. 1956.

A theoretical equation is given for the sensitivities or signal-to-noise ratios of infrared photodetectors as functions of area and sensitive time and long-wavelength cutoff λ_0. It is assumed that the materials approach within comparable factors of the fundamental limits set by radiation noise from their surroundings at a given temperature.

CHI. 02:027

Chicago U. Chicago Midway Labs., Ill.

PHOTOCONDUCTIVE AND PHOTOELECTROMAGNETIC EFFECTS IN InSb, by S. W. Kurnick and R. N. Zitter. Sept. 2, 1955 [8]p. incl. diagrs. tables, refs. [AFOSR-TN-55-293] [AF 33(038)-25913] AD 94128 Unclassified

Also published in Jour. Appl. Phys., v. 27: 278-285, Mar. 1956.

Photoconductive (PC) and photoelectromagnetic (PEM) effects have been observed in p-type InSb single crystals of high purity at 77°K (extrinsic range) and 301°K (intrinsic range). Because of the large electron mobilities in InSb, and because the variation of the PEM response with magnetic field was found to be strongly dependent on surface treatment, it was necessary to develop a new theoretical model to describe the PEM effect, permitting the evaluation of bulk lifetime and both electron and hole mobilities. In addition, the model affords an interpretation of Hall and magnetoresistance effects in intrinsic InSb. When the PEM effect is analyzed using impurity- or thermal-scattering, assuming Boltzmann statistics, the result does not fit the data as well as the simple model presented here.

CHI. 02:028

Chicago U. Chicago Midway Labs., Ill.

INFRARED ABSORPTION OF INDIUM ANTIMONIDE, by E. Blount, J. Callaway and others. Sept. 12, 1955 [2]p. incl. diagrs. refs. [AFOSR-TN-55-306] [AF 33(038)25913] AD 94126 Unclassified

Also published in Phys. Rev., v. 101: 563-564, Jan. 15, 1956.

Infrared absorption in InSb near the absorption edge has been interpreted as the superposition of 2 indirect transitions requiring phonons of 100° and 30°, the former transition involving the smaller electronic energy gap. The first transition is consistent with a band scheme having electrons at the center of the zone and holes either at the corner of the zone or about halfway along the [1, 1, 1] line. The other transition may indicate a second hole with an energy gap about 0.025 ev larger than that of the first.

CHI. 02:029

Chicago U. Chicago Midway Labs., Ill.

SPACE-CHARGE FORMATION IN SMALL PbS PARTICLES, by H. T. Minden. Sept. 15, 1955 [8]p. incl. diagrs. refs. [AFOSR-TN-55-322] [AF 33(038) 25913] AD 114587 Unclassified

Also published in Jour. Chem. Phys., v. 25: 241-248, Aug. 1956.

A theoretical model is discussed for the effect of oxygen on the electrical properties of PbS thin films. The films are assumed to be composed of very small n-type microcrystals, on the surface of which oxygen is adsorbed. The adsorbed atoms are singly ionized by electrons from the interior of the microcrystals. The appropriate Potsson-Boltzmann equation is solved for particles of radius 5×10^{-8}m and $5\sqrt{10} \times 10^{-8}$m, and for donor concentrations of 10^{23} m^{-3} and 10^{24} m^{-3}. The potential distribution is given as a function of the surface acceptor concentration required for the conservation of charge. Models for the electron and hole conductivities are given, and the results of calculations based on these models are compared with experiment. This theory is contrasted with the earlier bulk diffusion theory of the effect of oxygen. The free energy of adsorption is roughly calculated. Implications of this theory are discussed on the general character of conduction in PbS films, on the temperature coefficient of conduction, and on the nature of photoconduction. (Contractor's abstract)

CHI. 02:030

Chicago U. Chicago Midway Labs., Ill.

DEFORMATION POTENTIAL THEORY FOR n-TYPE Ge, by W. P. Dumke. June 29, 1955 [6]p. incl. tables, refs. [AFOSR-TN-55-327] [AF 33(038)25913] AD 113840 Unclassified

Also published in Phys. Rev., v. 101. 531-536, Jan. 15, 1956.

The deformation potential theory has been reexamined for electrons in Ge to take into account the ellipsoidal nature of the energy surfaces, and the effect of shear wave scattering. The coupling between shears and the conduction band energy minima is calculated from Smith's piezoresistance data under the assumption that any changes in mobility due to strain may be neglected. The scattering by shears, which is the dominant mechanism, is strongly anistropic and cannot be described by a simple relaxation time. We have shown that the distribution function for electrical conductivity has a tensor dependence on the orientation of the electric field. The mobility is calculated assuming several values of E_{1c}, the shift of the conduction band edge with dilation. The calculated values of the mobility are approximately $3 \times 10^{7} T^{-3/2}$ cm^2 / v-sec. Methods of accounting for discrepancies between the experimental and theoretical values of the mobility and their temperature dependence are discussed. (Contractor's abstract)

CHI. 02:031

Chicago U. Chicago Midway Labs., Ill.

InSb PHOTOVOLTAIC CELL, by G. R. Mitchell, A. E. Goldberg, and S. W. Kurnick. [1955] [2]p. incl. diagr. (AF 33(038)25913) Unclassified

Published in Phys. Rev., v. 97: 239-240, Jan. 1, 1955.

A crystal of InSb containing a photosensitive junction was prepared by the crystal-pulling technique. During crystal growth the melt was doped to produce p-n transition. A specimen 1 cm x 0.1 cm x 0.025 was cut from the crystal so as to include the transition region. This specimen exhibited a dark reststance of 20,000 ohms at 77°K and no noticeable rectification. The photoresponse at 77°K was determined ustng the specimen as a photovoltaic cell. The spectral response extended to about 5.7μ; and the time constant response was less than two microseconds. The noise spectra for the cell at 77°K ts briefly discussed and presented by a diagram.

CHI. 02:032

Chicago U. Chicago Midway Labs., Ill.

HIGH-PRECISION FREQUENCY STANDARDS, by J. Burns, III. Final rept. Jan. 1955, 82p. incl. diagrs. tables, refs. (Rept. no. CML-TN-P10) (AF 33(038)25913) AD 74915 Unclassified

The essential features of phase comparison navigation system and narrow-band secure communtcations systems are examined to determine the frequency stability required of radiofrequency oscillators to be used with them. It is estimated that the ultimate accuracy of a phase compartson navigation system ts limited to several hundred feet by radio propagation uncertainties. For a system operating at 100 kc these propagation errors amount to a few hundred feet until the range exceeds several hundred miles beyond which the accuracy deteriorates rapidly due to sky-wave interference. Accordingly, the oscillator stability requirements were established with these accuracy limitations in mind so errors arising from frequency instability should be somewhat smaller than the propagation errors. It is shown that frequency stabilities of one part in 10^6 averaging over one second and one part in 10^{11} over three hr are necessary to give the desired accuracy in position fixes. Oscillators for narrow-band voice communtcations systems operating in the VHF frequency band must be stable to one part in 10^7 averaging over one second and must have a long-time stability of about the same order. Several methods of generating radiofrequencies with these stabilities are examined and the results are summarized in a table.

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All of these except the first and last serve the purpose of synchronizing an external oscillator. The crystal and molecular oscillators are self-excited. The essential features of a suitable technique for performing this synchronization are analyzed to show how the precision of synchronization depends upon the properties of the particular atomic or molecular resonance phenomena with which it is achieved. (Contractor's abstract)

CHI. 02:033

Chicago U. Chicago Midway Labs., Ill.

FEASIBILITY OF DETECTING 7μ RADIATION WITH AN UNCOOLED DETECTOR (Unclassified title), by F. F. Rieke. [Jan. 26, 1955] 7p. incl. diagr. (Rept. no. CML-P9-1/55) (AF 33(038)25913) Confidential

CHI. 02:034

Chicago U. Chicago Midway Labs., Ill.

A SURVEY OF FILTER THEORY AND ITS APPLICABILITY TO INSTRUMENTATION, by R. N. Lewis. Phase rept. July 1955, 66p. incl. diagrs. refs. (Rept. no. CML-TN-55-F. 2-6) (AF 33(038)25913) AD 69815 Unclassified

This report gives an elementary review of the factors and the philosophy upon which fire control filter theory is based. A close analogy between fire control system sensors and classes of measuring instruments is maintained so that, while the theory of random noise filtering is developed, the difficulties of the measurement and evaluation of such filtering are indicated. The first section indicates the necessity for filtering of noisy signals, the second section develops the required theory, and the third section applies the theory to fire control system sensors and computers and to measuring instruments. The final section contains preliminary conclusions and recommendations for applying filter theory concepts in the selection of instrumentation for evaluating airborne fire control systems. (Contractor's abstract)

CHI. 02:035

Chicago U. Chicago Midway Labs., Ill.

INFRARED RECONNAISSANCE TECHNIQUES AND EQUIPMENT (Unclassified title), by [H. L. Berman] Final rept. Jan. 1-Sept. 1, 1955 [61] p. incl. illus. tables. (Rept. no. CML-TR-55-H-9) (AF 33(038)-25913) AD 112702 Confidential

CHI. 02:036

Chicago U. Chicago Midway Labs., Ill.

DETECTOR DEVELOPMENT AT CHICAGO MIDWAY LABORATORIES (Abstract), by F. F. Rieke. Oct. 18, 1955, 1p. (AF 33(038)25913) Unclassified

Presented at the Symposium on Military Applications of Infrared Physics, Johns Hopkins U. Radiation Lab., Baltimore, Md., Jan. 25-26, 1956.

A photovoltaic cell, based on a p-n junction of indium antimonide operated at liquid nitrogen temperature, has been developed within the last year. Such detectors have a sensitive area of 0.2 sq mm, a noise equivalent power of 2×10^{-11} watts at 5.5 microns, and a response-time of 10 microseconds or less, the internal impedance is approximately 50,000 ohms. Indium antimonide at room temperature may also be used as a photodetector, employing either the photoconductive or the photoelectromagnetic effect to generate an electric response. The peak sensitivity occurs at 7.5 microns, but the NEP is approximately 100 times greater than for the cooled detector discussed above. Performance can be somewhat improved by cooling to -20°C. Response-times are very short and internal impedances are of the order of 1 ohm. Recent improvements in a dielectric thermal detector, developed some time ago, will be discussed briefly. (Contractor's abstract)

CHI. 02:037

Chicago U. Chicago Midway Labs., Ill.

INFRARED ABSORPTION AND THE BAND STRUCTURE OF INDIUM ANTIMONIDE, by J. Callaway. Dec. 1955, 38p. incl. diagrs. tables, refs. (Rept. no. CML-TN-55-A. 2-13) (AF 33(038)25913) AD 83637 Unclassified

The experimental data on infrared absorption in InSb are studied in the light of current theories of absorption, considering both direct and indirect transition mechanisms. It is shown that direct transition theory is not compatible with the data, while a satisfactory agreement can be obtained with the indirect theory. In particular, there are indications of two indirect transitions, requiring 100° phonons and 30° phonons. These results are related to current ideas on the band structure of InSb by use of simple theoretical considerations on lattice vibrations in InSb. We conclude that further evidence from magneto- and elasto-resistance is highly desirable at this time, and a summary of considerations relevant to these phenomena closes this report. A bibliography of the literature on InSb is appended. (Contractor's abstract)

CHI. 02:038

Chicago U. Chicago Midway Labs., Ill.

PHOTOSENSITIZATION OF PbS FILMS, by R. H. Harada and H. T. Minden. [Jan. 12, 1956] 22p. incl. refs. (AF 33(038)25913; continued by AF 18(603)9) Unclassified

Also published in Phys. Rev., v. 102: 1258-1262, June 1, 1956.

The effect of O_2 on the photoconductive response of evaporated PbS films has been experimentally investigated. The dark conductance g, the photoconductance Δg, and the time constant τ for the photoconductive response of PbS evaporated films vary when the films are exposed to oxygen. The g initially decreases several orders of magnitude when an outgassed film is exposed to oxygen; it reaches a minimum and then increases. The thermoelectric power changes from negative to positive at the minimum in conductance. Δg and τ are given as a function of g. Δg decreases with increasing oxygenation, reaches a minimum near the minimum in g and then increases as g increases; after the film becomes p-type; $\Delta g/g$ is a maximum however, near the minimum in g. On the other hand, τ increases steadily as the film changes from n- to p-type. These results are attributed to the effect of two oxygen surface states. A low lying O^- state alters the Fermi level of the originally n-type film. The surface charge thus formed lowers the effective carrier mobility. A higher energy O^{--} state, when empty, traps photoelectrons and, hence, enhances the hole photoconductivity. (Contractor's abstract)

CHI. 03:001

Chicago U. Chicago Midway Labs., Ill.

ELASTIC CONSTANTS OF INDIUM ANTIMONIDE, by L. H. DeVaux and F. A. Pizzarello. Oct. 13, 1955 [1]p. incl. table. [AFOSR-TN-55-359] [AF 18(603)9; continuation of AF 33(38)25913] AD 113931 Unclassified

Also published in Phys. Rev., v. 102: 85, Apr. 1, 1956.

By means of an acoustical method, the elastic constants InSb (indium antimonide) were measured. At room temperature they are: $C_{11} = (6.6 \pm 0.3) \times 10^{11}$, $C_{12} = (3.8 \pm 0.2) \times 10^{11}$, $C_{44} = (3.0 \pm 0.1) \times 10^{11}$ dynes/sq cm. (Contractor's abstract)

CHI. 03:002

Chicago U. Chicago Midway Labs., Ill.

THE VARIATION WITH OXYGEN TREATMENT OF PHOTOCURRENT IN PbS FILMS (Abstract), by R. H. Harada and H. T. Minden. Dec. 1955, 1p. ([AF]OSR-TN-55-478) [AF 18(603)9] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 31, 1956.

Freshly evaporated PbS films are n-type and highly conducting. When a film is exposed to oxygen the conductance g decreases 3 to 5 orders of magnitude, reaches a minimum and then increases. The sign of the thermoelectric power changes at the minimum in conductance. The photoconductance g also decreases with initial oxygen treatment, but as the oxygen pressure is raised and g begins to increase, g also increases. This anomalous effect is explained by the following theory. Oxygen acceptors adsorbed on PbS films reduce the photocurrent by lowering the free carrier mobility. If enough oxygen is present, however, the Fermi level is lowered sufficiently, so that some of the oxygen surface states are emptied. These states can act as special electron traps, from which recombination does not take place. The lifetime photoholes becomes essentially the dwell time of the photoelectrons in the traps, and the photocurrent is enhanced. (Contractor's abstract)

CHI. 03:003

Chicago U. Chicago Midway Labs., Ill.

SPONTANEOUS RADIATIVE RECOMBINATION IN SEMICONDUCTORS, by W. P. Dumke. Sept. 20, 1956 [6]p. incl. diagrs. refs. ([AF]OSR-TN-56-438) (AF 18(603)9) AD 96781 Unclassified

Also published in Phys. Rev., v. 105: 139-144, Jan. 1, 1957.

The mechanisms by which electrons and holes recombine with the emission of radiation are examined. Expressions are derived for the radiative recombination lifetimes due to direct and indirect transitions, and these are applied to Ge and Si. Matrix elements in the transition probability for direct and indirect transitions are obtained from analyses of the cyclotron resonance effective mass data, and the optical absorption data close to the band edge, respectively. For indirect transitions, the calculated lifetimes were of the order of seconds, and agreed within a factor of 3 with lifetimes calculated by the method of Van Roosbroeck and Shockley. It is shown that in Ge at room temperature, while the density of filled states in the conduction band at k = 0 is very low, the rate of recombination by direct transitions is nevertheless somewhat greater than that by indirect transitions. This is consistent with the findings of Haynes. The role of radiative recombination in the observed lifetimes of excess carriers is questioned. It is concluded that for those semiconductors which have a rather high absorption constant close to the band edge (InSb), an emitted photon is usually reabsorbed before it can escape from the crystal, producing another hole-electron pair, without contributing to the macroscopically observed lifetime. In the limit of a very high absorption constant, this emission and absorption of photons acts as an additional mechanism for the diffusion of hole-electron pairs. (Contractor's abstract)

CHI. 03:004

Chicago U. Chicago Midway Labs., Ill.

QUALITATIVE STUDY OF ENERGY BANDS IN GALLIUM ARSENIDE, by J. Callaway. Sept. 1956, 17p. incl. diagrs. table, refs. (Rept. no. CML-56-TN-P108-5) (AFOSR-TN-56-414) (AF 18(603)9) AD 96223 Unclassified

CHI. 03:005 - CHI. 03:007

Also published in Jour. Electrontcs (Sertes t), v. 2: 330-340, Jan. t957.

In thts study, an attempt ts made to relate energy bands in GaAs to those tn germanium through the use of second-order perturbation theory. The perturbtng potential is obtained from self-consistent fteld calculations for neutral Ga, Ge, and As atoms. The effect of a posstble partially tonic nature of GaAs ts also considered. Spin-orbit coupling ts neglected. A group theoretic study is made to determine whtch matrtx etements of the perturbing potential exist at symmetry points of the Brtllouin zone, and an attempt is made to estimate them. It is found that tn going from Ge to GaAs, the valence band is pushed down with respect to the conduction band. The minimum of the conduction band may shift from the t11 axis to the center of the zone. An increase tn the energy gap of the rtght order of magnitude is obtained. (Contractor's abstract)

CHI. 03:005

Chicago U. Chicago Midway Labs., Ill.

THERMAL IMAGE TUBE, by J. Burns, III. First interim rept. June 1956 [56]p. incl. diagrs. (Rept. no. CML-56-TN-P108-2) (AFOSR-TN-56-460) (AF t8(600)9) AD 106094 Unclassified

The ferroelectric thermal image tube was developed in the form of a very thin wafer an inch or more in diameter. Three methods were considered for measurtng the thermally induced surface potential variations of the ferroelectric. The first method is deflection modulation in which surface potentiats deftect an electron beam, causing proportional amounts to pass the edges of a suitably placed grid structure. The second method is aberration modulation which is structurally similar to the first except that the grid structure is operated at such a potential that a repulsive electric field is established close to the ferroelectric surface. The large electron-optical aberrations of the field produce a strong defocusing of the reading beam as it is reflected back from the vicinity of the ferroelectric surface. The third method is absorption modutation which is a capacitor-discharge reading method in which the beam is allowed to charge up the detector surface, after which the beam is repelled by the charged surface. The amount of charge abstracted from the beam to perform this charging operation depends upon the initial surface potential. The deflection and absorption modulation methods are capable of linear response to a wide range of surface-potential differences, although linearity can be achieved in deflection modulation only by employing a very nearly monoenergetic scanning beam. The absorption modulation method is more conventional, and resembles the techniques used in several types of TV pickup tubes. Its sensitivity is not as good as deflection modulation for small signals although its response is linear over a wide range. The feasibility was apparently established in principle of a ferroelectric thermal-image tube capable of giving at least a 200-line picture and of detecting objects differing in temperature by about 1° from the background.

CHI. 03:006

Chtcago U. Chtcago Mtdway Labs., Itl.

MAGNETICALLY FOCUSED SECONDARY EMISSION SCREEN-TYPE IMAGE INTENSIFIER, by F. F. Rteke. Final rept. Aug. t956, 38p. tncl. ttlus. diagrs. (Rept. no. CML-56-TN-Pt08-4) (AFOSR-TN-56-603) (AF 18(603)9) AD 108437; PB 124263 Unclassifted

Development of an tmage tntensifier is descrtbed which makes use of cascaded ftne mesh screens coated with an efficient secondary emttter, cesium-anttmony, to achteve muttiplication of weak photoelectron tmages from a cesium-antimony photocathode. An axial magnetic field is used together with appropriate potentials and spacings of the screens to keep the electron image in focus. Defocusing caused by the spread in vetocities of electrons from each multiplier screen is minimized but not eliminated by varying the spacings and potential differences between screens in such a way that electrons having two different initial velocities can be brought to focus in the same plane. The residual focusing errors, arising chiefly from the incomplete correction of chromatic aberration from the initial velocity spread, holds the resolution of a nine-stage tube to two or three line pairs per mitlimeter. Production of htgh yield cestum-anttmony secondary emission surfaces cotncidentally with high sensitivity photocathodes of the same material in a common tube envelope has not proved feasible. Maximum secondary ytetd and peak photosensitivity have been shown to occur in thts compound for such widety different concentrations of cesium that it does not seem possibte to achieve a satisfactory compromise. Forty-five image tubes were produced under this contract, and the methods of production together with the results of tests and experiments on these tubes are descrtbed. Recommendattons for the course to be followed tn the further development of the screen-type intensifier to overcome the drawbacks of the present design are discussed. (Contractor's abstract)

CHI. 03:007

Chicago U. Chicago Midway Labs., III.

THE EFFECTIVE MASS APPROXIMATION FOR EXCITONS, by G. Dresselhaus. [1956] [13]p. incl. diagrs. refs. (Bound with the Forty-First Quarterly rept. to Sponsors of Chicago U. Inst. for the Study of Metals, June 1956, p. 149-161; AD 103589) (AF 18-(603)9) Unclassified

Also published in Phys. and Chem. of Solids, v. 1: 14-22, Sept.-Oct. 1956.

The effective mass approximation for degenerate electronic energy bands is applied to the interaction of electrons and holes in an insulator. It is shown that bound exciton states result from this treatment. The exciton Hamiltonian is of the form derived previously for impurity state problems. The criterion for the validity of the effective mass approximation is that the

lowest state be bound with an energy < 0.2 ev. Corrections to the approximation to account for the effective magnetic moments of the electron and hole are indicated. Selection rules and line widths for optical excitation of excitons are discussed. The question of the existence of positronium in crystalline solids is also considered. (Contractor's abstract)

CHI. 03:008

Chicago U. Chicago Midway Labs., Ill.

INFRARED ABSORPTION EDGE, BAND STRUCTURE, AND ELECTRON MOBILITY IN InSb, by W. P. Dumke. [Oct. 1956] 6p. incl. diagr. refs. [AF 18(603)9] Unclassified

The absorption edge tail for InSb was fitted by the following indirect transition model: The valence and conduction band edges are at the center of the Brillouin Zone. Below the threshold for direct transitions, electrons may make a second order transition involving, first, a vertical optical transition to an intermediate virtual state in the conduction band from which they may be scattered to a real state in the conduction band by absorption of an optical mode phonon of essentially reststrahlen energy (.024 ev). Transitions through intermediate states in higher conduction bands are infrequent because of the large energy denominators for such processes. This model is simple and consistent with the various experiments on InSb.

CHI. 04:001

Chicago U. Committee on Math. Biology, Ill.

MATHEMATICAL BIOPHYSICS OF COLOR VISION. II. THEORY OF COLOR CHANGES INDUCED BY THE ALTERNATION OF COLORS AT VARIOUS FREQUENCIES, by H. D. Landahl. Feb. 10, 1956, 14p. incl. diagrs. (AFOSR-TN-56-267) (AF 18(600)1454) AD 88987 Unclassified

Also published in Bull. Math. Biophysics, v. 18: 137-149, 1956.

A model previously introduced to account for a number of phenomena of color vision is studied for the conditions in which the alternation of colors is periodic. The case of three primary receptors having no differences in their time constants is considered for the situations such as the temporal alternation of two primaries, a primary and a neighboring binary, a primary and white, a binary and white, etc. Using the same mathematical model which was used to account for the enhancement effect of interrupted illumination, it is found possible to account for observed changes in hue in a qualitative manner. A method is suggested for measuring the color changes quantitatively. This method is readily adapted for demonstration purposes. The model shows that there should be differences between "primaries" and "binaries" with respect to change in hue. In principle, therefore, comparison between theory and experiment should yield information regarding the physiological primaries. (Contractor's abstract)

CHI. 04:002

Chicago U. Committee on Math. Biology, Ill.

CONTRIBUTIONS TO THE THEORY OF ACTIVE TRANSPORT, by C. S. Patlak. May 15, 1956 [45]p. refs. (AFOSR-TN-56-411) (AF 18(600)1454) AD 96220 Unclassified

Also published in Bull. Math. Biophysics, v. 18: 271-315, 1956.

In many biological situations, the net transport of material from one region to another cannot be explained by a passive movement following thermodynamic laws. The term "active transport" has been applied to such cases, and is discussed in this study. It is pointed out that a system consisting of 2 solutions separated by a membrane may be in one of four possible states: (1) transient; (2) steady; (3) equilibrium; or (4) pseudo-equilibrium. The latter state denotes that in the solutions the net flow of all components is zero, but at least one of the components is not in thermodynamic equilibrium. Transient and steady-state systems may or may not have active transport; thus only systems in either equilibrium or pseudoequilibrium are considered here, since the former indicates that there is no active transport, whereas, in the latter case there always is active transport. This simplifies the problem of finding whether a system does or does not have an active transport mechanism, since it is frequently fairly easy to determine experimentally whether a system is in equilibrium or pseudoequilibrium. The assumption that electric neutrality exists within very thin membranes is shown not be be valid; however, electric neutrality does exist in the solutions in a system in a pseudo-equilibrium state with fixed charges and impermeative ions. It is then shown how the presence and sign of an electric potential may be found by use of electroneutrality. The mechanism of active transport may result from a general force acting on all particles of a particular component or to an individual force acting on the individual particles of a particular component. A general solvent flow or a diffusion drag force illustrates the first mechanism, while the second is accomplished by either a carrier or a Maxwell Demon. The Maxwell Demon is a hypothetical mechanism which allows each particle of A to cross a potential barrier by itself more readily in one direction than in the other. It differs from a carrier in that no part of it in contact with A moves while A is crossing the barrier. The Demon operates either by lowering the potential barrier height for A, by increasing A's speed of crossing the barrier, or by modifying A so that it can cross the potential barrier more readily. The general type of active transport has been extensively treated in the literature, while the individual type has not been treated in a generalized form. Therefore, the individual type of active transport is discussed at length, and a simple illustrative model is intensively analyzed. Following this, there is a discussion of the Maxwell

Demon, and some models of it are presented. (Contractor's abstract, modified)

CHI. 05:001

Chicago U. [Dept. of Mathematics] Ill.

PROBLEMS RELATED TO CHARACTERISTIC SURFACES, by M. Riesz. Technical rept. June 15, 1954, 26p. [AFOSR-TN-54-186] (AF 18(600)659) AD 49912 Unclassified

Also published in Proc. of the Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 57-71.

Multiple integrals of the Riemann-Liouville type are introduced which depend on a parameter α and which converge for sufficiently large values of α. The Cauchy problem for the wave equation with a space-like boundary is given by a unique formula which is the same for odd or even dimensional space-time; the formula implies an analytic continuation with respect to α. After the analytic continuation is carried out, quite different formulas are obtained for odd or even dimensions; the one relative to even dimensions is ruled by the Huygens principle. A geometric interpretation of the solution is given relative to ordinary 4-dimensional space-time. A solution of the wave equation is given for a very general class of characteristic boundaries in which the restrictions are of a topological nature. In the 3-dimensional case, a specialization of the solution formula leads to a case of curvatura integra for twisted curves. A sequence of special functions is constructed whose members are related to a given characteristic surface in the same way as different powers of the Lorentz distance are related to a characteristic cone. An explicit solution is given of the homogeneous wave equation which becomes infinite on the characteristic surface in the same way as the classical elementary solution does on a characteristic cone. This provides a complement to Delassus theorem. One of the special functions furnishes a formula of curvatura integra in the even-dimensional case.

CHI. 05:002

Chicago U. [Dept. of Mathematics] Ill.

ON CONSERVATION LAWS, by I. Osborn. June 15, 1954, 5p. (AF 18(600)659) ([AF]OSR-TN-54-262) AD 49911 Unclassified

A first order quasi-steady homogeneous partial differential equation in the independent variables x^i, $i = 1, \ldots, n$, and dependent variables u^j, $j = 1, \ldots, p$ is a conservation law if it is of the form

$$\sum_{i=1}^{n} \frac{\partial}{\partial x^i} \phi^i = 0$$

Since it is of interest to know when conservation laws can be formed by linear combination of the members of a given system of partial differential equations, some examples are given.

CHI. 05:003

Chicago U. [Dept. of Mathematics] Ill.

JORDAN ALGEBRAS OF CHARACTERISTIC TWO, by E. C. Paige, Jr. June 15, 1954, 1p. [AFOSR-TN-54-263] (AF 18(600)659) Unclassified

The author has concluded his investigations of Jordan algebras of characteristic two, and has deduced a partial structure theory for a special class of simple algebras which are designated as single string connected algebras. The dimensions and partial multiplication tables for these algebras were obtained. Moreover, special examples of these algebras were derived consisting of several infinite classes of simple Jordan algebras. Finally, in finding these special examples, the author was able to develop a new proof for the multilinear Jordan identity. This method may also be applied to the proof of other multilinear identities, and it is hoped that the author will be able to use it very soon in the study of simple Lie algebras of characteristic p. (Contractor's summary)

CHI. 05:004

Chicago U. Dept. of Mathematics, Ill.

THE EXISTENCE OF CONSERVATION LAWS, by H. Osborn. Oct. 28, 1954, 70p. (Technical rept. no. 27) (Sponsored jointly by Office of Naval Research under Nonr-22511 and [Air Force Office of Scientific Research] under AF 18(600)659) AD 46283 Unclassified

A first-order quasi-linear homogeneous partial differential equation in the independent variables x^i, $i = 1, \ldots, n$ and the dependent variables u^j, $j = 1, \ldots, p$ is said to be a conservation law if it is of the form

$$\frac{\partial \phi^1}{\partial x^1} + \ldots + \frac{\partial \phi^n}{\partial x^n} = 0$$

for some ϕ^i which are functions of $x = \{x^i\}$ and $u = \{u^j\}$. If a given system is equivalent to a system, one of whose equations is a conservation law, the original system is said to contain the conservation law. The problem is that of determining the number of conservation laws contained in a given system. The problem of when a system is equivalent to another system consisting entirely of conservation laws and in how many ways such a representation can be found is also treated. One result is that even if those representations which can be obtained from one another by linear combination with constant coefficients are included in the same equivalence class, there is still a wide variety of systems which can be represented by infinitely many equivalence classes. The problem is first reduced to that of solving an over-determined system of linear homogeneous partial-differential

equations. An existence theorem ts given for thts system under certain integrabtlity-condition restrtctions. The more general problem ts then stated in therms of extertor differential forms in order to utilize the existence theorem of E. Cartan (Les systèmes différentiels extérieurs et leurs applications géométrtques, Paris, 1945) and E. Kähler (Einführung in die Theorie der Systeme von Differentialgletchungen, Letpztg, 1934). (ASTIA abstract)

CHI. 06:001

Chicago U. Dept. of Mathematics, Ill.

RESEARCH ON THE HILBERT TRANSFORMS AND RELATED TOPICS, by A. P. Calderón and A. Zygmund. Jan. 1956 [54]p. tncl. refs. (AFOSR-TN-56-470) (AF 18(600)1111) AD 97354 Unclassified

Thts paper consists of three technical reports: (1) A Note on the Interpolation of Sublinear Operations. This is abstracted as item CHI. 06:002; (2) Algebras of Certain Singular Operators. Thts is abstracted as item no. CHI. 06:003; (3) On Stngular Integrals. This is abstracted as ttem no. CHI. 06:004.

CHI. 06:002

Chicago U. Dept. of Mathematics, Ill.

A NOTE ON THE INTERPOLATION OF SUBLINEAR OPERATIONS, by A. P. Calderón and A. Zygmund. Jan. 1956, 8p. (Technical rept. no. 1) (AFOSR-TN-56-470, Pt. 1) (AF 18(600)1111) AD 97354 Unclassified

Also published in Amer. Jour. Math., v. 78: 282-288, Apr. 1956.

Let (α_1, β_1), (α_2, β_2) be two points of the square $0 \leq \alpha \leq 1$, $0 \leq \beta \leq 1$. Let R be a measure space and let T be simultaneously a bounded operator from $L^{1/\alpha}1$ to $L^{1/\beta}1$ and from $L^{1/\alpha}2$ to $L^{1/\beta}2$ defined on R and having the following properties, (a) if $f = f_1 + f_2$ and Tf_1, Tf_2 are defined, then Tf is defined, (b) if Tf is defined T(kf) is defined for any scalar k, (c) $\|Tf_1 + Tf_2\| \leq \|Tf_1\| + \|Tf_2\|$, (d) $\|T(kf)\| = |k| \cdot \|Tf\|$. Let $\|T\|_1 = M_1$ for T considered as an operator from $L^{1/\alpha}1$ to $L^{1/\beta}1$, and $\|T\|_2 = M_2$ for T considered as an operator from $L^{1/\alpha}2$ to $L^{1/\beta}2$. Then if $0 \leq t \leq 1$, $\alpha = (1-t)\alpha_1 + t\alpha_2$, $\beta = (1-t)\beta_1 + t\beta_2$, T is also a bounded operator from $L^{1/\alpha}$ to $L^{1/\beta}$ with norm $M \leq M_1^{(1-t)}M_2^{t}$. Tnis is a generalization of a theorem of M. Riesz (Acta Math., v. 49: 465-497, 1927) who proved the result for bounded linear operators. (Math. Rev. abstract)

CHI. 06:003

Chicago U. Dept. of Mathematics, Ill.

ALGEBRAS OF CERTAIN SINGULAR OPERATORS, by A. P. Calderón and A. Zygmund. Jan. 1956, 17p. (Technical rept. no. 2) (Also bound with its Technical rept. no. 1; AFOSR-TN-56-470, Pt. I) (AFOSR-TN-56-470, Pt. II) (AF 18(600)1111) AD 97354(a) Unclassified

Also published in Amer. Jour. Math., v. 78: 310-320, Apr. 1956.

Let $x = (\zeta_1, \cdots, \zeta_n)$ be an element of Euclidean n-space, and $|x| = (\zeta_1^2 + \cdots + \zeta_n^2)^{1/2}$. Let K(x) be a homogeneous function of degree $-n$, such that $K(\lambda x) = \lambda^{-n}K(x)$ for every x and every $\lambda > 0$, and let $\int K(x)d\sigma = 0$, $\int |K(x)|^p d\sigma < \infty$, $p > 1$, where the integrals are taken over the unit sphere $|x| = 1$, and $d\sigma$ denotes the area-element. Then, according to the previous work of the authors (Acta Math., v. 88: 85-139, 1952; Amer. Jour. Math., v. 78: 289-309, 1956) for $f \in L^r$ one can consider

$$\tilde{f}_\varepsilon(x) = \int_{|x-y|>\varepsilon} K(x-y)f(y)dy,$$

and show that tt converges pointwtse almost everywhere, and in the mean of order r, as $\varepsilon \to 0$. Let the limit be denoted by $\tilde{f}$. The authors consider operators K(f) of the form $K(f) = af + \tilde{f}$, a being a complex constant. Let A be the class of operators K with K(x) in C^∞ for $|x| > 0$, and A_p $(p>1)$ the class of operators K for which

$$(*) \quad \|K\|_p = |a| + \left[\int_{|x|=1} |K(x)|^p d\sigma\right]^{1/p} < \infty.$$

It is proved that A is closed under addition and operator multiplication, while A_p, with the norm (*), is a commutative, semi-simple Banach algebra, under operator multiplication. A Fourier transform of the operator K is defined, and some of its properties established. An operator in A (or A_p) has an inverse in A (or A_p) if and only if its Fourier transform does not vanish. The space of maximal ideals of A_p is homeomorphic to the sphere $|x| = 1$. (Math. Rev. abstract)

CHI. 06:004

Chicago U. Dept. of Mathematics, Ill.

ON SINGULAR INTEGRALS, by A. P. Calderón and A. Zygmund. Jan. 1956, 28p. (Technical rept. no. 3) (Also bound with its Technical rept. no. 1: AFOSR-TN-56-470, Pt. 1) (AFOSR-TN-56-470, Pt. III) (AF 18-(600)1111) AD 97354(b) Unclassified

Also published in Amer. Jour. Math., v. 78: 289-309, Apr. 1956.

CHI. 06:005 - CHI. 06:006

As in a previous paper (Acta Math., v. 88: 85-139, 1952) the authors deal with extensions of Hilbert transforms to the n-dimensional space E_n. Let $x, y, x, \cdots$ be vectors in E_n $|x|$ the length of x, and

$$\tilde{f}_\varepsilon(x) = \int_{|x-y|>\varepsilon} K(x,y)f(y)dy,$$

where dy is the element of volume in E_n. The method which the authors use to deduce properties of $\tilde{f}_\varepsilon$ is entirely different from their previous procedure. It is based on the classical theory of Hilbert transforms in E_1 (where the kernel $K(x,y)$ is $\pi^{-1}(x-y)^{-1}$); and it yields, except for some cases including $f \in L$, their previous results under far less restrictive assumptions. In Theorem 1, the kernel is $K(x,y) = N(x-y)$, where $N(x)$ is homogeneous of degree $-n$; in Theorem 2, $K(x,y) = N(x, x-y)$, where $N(x,y)$ is homogeneous in y; in Theorems 3 and 4, $K = N(x, x-y)\psi(|x-y|)$, where $\psi(t)$ is an even or odd Fourier-Stieltjes transform, while $N(x,y)$ is odd or even, respectively, and homogeneous in y and its modulus is majorised by a homogeneous function $F(y)$. In each case, $f(x) \in L^p$, and N satisfies some conditions of integrability. Then, as in the classical case, $\tilde{f}_\varepsilon(x)$ tends to a function $\tilde{f}(x)$ both in the mean of order p, and pointwise almost everywhere, as $\varepsilon \to 0$, provided that p exceeds 1 and is subject to some further restrictions in Theorems 2 and 4. Again

$$\int_{-\infty}^{\infty} (\sup_\varepsilon |\tilde{f}_\varepsilon(x)|)^p dx \leq A^p \int_{-\infty}^{\infty} |f(x)|^p dx,$$

where A is independent of $f(x)$. Two other kernels are dealt with in Theorems 6 and 7, while in Theorem 5 the convergence to f, in the mean of order p, of the spherical means of order $\frac{1}{2}n(n-1)$ of the Fourier integral representation of $f \in L^p$ (n variables, n odd; $1 < p \leq 2$) is stated, which is proved at the end of the paper. First the Theorems 3, 4, 6 and 7 are deduced from the classical case and by interesting technique; while the proofs of 1 and 2 are more complicated: they depend on vector valued functions and are based on theorems 3 and 4 and on the transforms

$$\int_{|x-y|>\varepsilon} R(x-y)F(y)dy, \quad \int_{|x-y|>\varepsilon} R(x-y)F(y)\phi(|y|)dy,$$

where $R(x)$ is the (vector valued and odd) Riesz kernel $R(x) = \pi^{-\frac{1}{2}(n+1)}\Gamma(\frac{1}{2}n+\frac{1}{2})x|x|^{-n-1}$, $F(x)$ is even, homogeneous and satisfies some condition of integrability, and where $\phi(t)$ $(0 \leq t < \infty)$ is some continuously differentiable function. (Math. Rev. abstract)

CHI. 06:005

Chicago U. Dept. of Mathematics, Ill.

PRIMITIVE OPERATORS OF DEFICIENCY (m, m), by H. L. Hamburger, A. Brown, and S. Sternberg. Technical rept. July 1956, 59p. (AFOSR-TN-56-500) (AF 18(600)1111) AD 110315 Unclassified

The following topics are discussed. Notations; Preliminaries; linear transformations and their graphs; elementary combinations; inverse of linear transformations; matrix representation of a closed operator; an example; spectrum and resolvent; deficiency indices of a Hermitian transformation; extensions of Hermitian operators and the Cayley transform; the spectral theorem. Problem; when a given self-adjoint extension of a closed Hermitian transformation with deficiency indices (m, m) has a spectrum consisting only of isolated eigenvalues; some fundamental relations; Hermitian contractions; necessity; sufficiency; a supplementary theorem; on prescribing the eigenvalues of a self-adjoint Hermitian operator, H.

CHI. 06:006

Chicago U. [Dept. of Mathematics] Ill.

ON A THEOREM OF MARCINKIEWICZ CONCERNING INTERPOLATION OF OPERATIONS, by A. Zygmund. [1956] [26]p. incl. refs. [AF 18(600)1111] Unclassified

Published in Jour. Math. Pures Appl., v. 35: 223-248, 1956.

To M. Riesz and G. O. Thorin (Thorin, Kungl. Fysiogr. Sällsk. i. Lund Förh., v. 8: 166-170, 1938) is due the following theorem. Let T be a linear bounded operator from $L^a(\mu)$ to $L^b(\nu)$, $\|f\|_{a,\mu} = \left[\int_R |f|^a d\mu\right]^{1/a}$ and $M_{a,b}$ its bound. Then the assertion is that if T is a bounded operator for a_1, b_1 and a_2, b_2, then it is a bounded operator for a_3, b_3, where

$$\frac{1}{a_3} = \frac{t}{a_1} + \frac{1-t}{a_2}, \quad \frac{1}{b_3} = \frac{t}{b_1} + \frac{1-t}{b_2};$$

$$M_{a_3b_3} \leq M_{a_1b_1}^{t} M_{a_2b_2}^{1-t}.$$

Below is given the definition of "weak boundedness" (reviewer's term) which is such that if T is weakly bounded for a_1, b_1 and for a_2, b_2, then T is bounded for a_3, b_3 given as above. In this case T may not even be linear, but satisfy only $\|T(f_1+f_2)\| \leq k(\|Tf_1\| + \|Tf_2\|)$, k independent of f_1. Also

$M_{a_3b_3} \leq KM_{a_1b_1}^{t} M_{a_2h_2}^{1-t}$, where K depends only on a_1, b_1, k and stays bounded, if t stays away from 0 and 1. This is the theorem of Marcinkiewicz in a form given and proved in this paper. It remains to give the definition of weak boundedness. T will be called weakly bounded with respect to a, b, if there exists an M_{ab} such that

$$\nu\{t \mid |Tf(t)| > y\} \leq (M_{ab}\|f\|_{a,\dots}/y)^b.$$

Numerous corollaries are given, especially some to spaces whose norm is of the form $\int \varphi(|f|)dx$, and to Fourier expansions into orthonormal series. If T is a Hilbert transform, then it is well-known, that it is bounded p, p for all $p > 1$. It is interesting to note that it is weak bounded 1, 1. (Math. Rev. abstract)

CHI. 06:007

Chicago U. [Dept. of Mathematics] Ill.

ON THE LITTLEWOOD-PALEY FUNCTION $g^*(\theta)$, by A. Zygmund. [Feb. 1956] [5]p. (AF 18(600)1111) Unclassified

Published in Proc. Nat'l. Academy Sciences, v. 42: 208-212, Apr. 1956.

Let $\Phi(z) = \Sigma_0^\infty c_n z^n$ be regular for $|z| < 1$ and of class H^λ, $0 < \lambda$, and $\Phi(e^{i\theta}) = \lim_{r \to 1} \Phi(re^{i\theta})$. Let $\sigma_n^\alpha(\theta)$ be the nth (C, α) mean of the series $\Sigma_0^\infty c_n e^{in\theta}$ and let

$$M_a(f) = M_a(f(\theta)) = \left\{ (2\pi)^{-1} \int_0^{2\pi} |f(\theta)|^a d\theta \right\}^{1/a}.$$

Among the functions concerning which integral inequalities are obtained are the following:

$$g^*(\theta) = \left\{ \int_0^1 (1-\rho)\, X^2(\rho, \theta) d\rho \right\}^{1/2},$$

where

$$X(\rho, \theta) = \left\{ \frac{1}{2\pi} \int_0^1 \frac{(1-\rho^2)\,|\Phi'(\rho e^{i(\theta+t)})|^2}{(1-2\rho\cos t+t^2)} dt \right\}^{1/2}$$

Among the new inequalities obtained are

$$M_\mu(g^*) \leq A_\mu M_1(\Phi(e^{i\theta})) \quad (0 < \mu < 1),$$

$$M_1(g^*) \leq A \int_0^{2\pi} \Phi(e^{i\vartheta}) |\log^+ |\Phi(e^{i\theta})| \, d\theta + B,$$

where in the last relation it is assumed that Φ belongs to H $\log^+$ H. Also obtained are the inequalities

$$M_{\lambda,\eta}[\gamma] \leq C_{\lambda,\eta}(\Phi), \quad \alpha = \lambda^{-1} - 1 \quad (0 < \lambda \leq 1),$$

$$M\lambda[\gamma] \leq C_\lambda \left\{ \int_0^{2\pi} |\Phi(e^{i\theta})| \log^+ |\Phi(e^{i\theta})| \, d\theta + 1 \right\}^{1/\lambda}$$

for $\Phi \in H_\lambda \log^+ H$, which have also been observed by

Sunouchi (Tôhoku Math. Jour., v. 7: 96-109, 1955). These are applied to partially settle the conjecture of the author (Proc. London Math. Soc., v. 47: 326-350, 1942) that $\sup_r |\sigma_r^\alpha(\theta)|$ is in L^λ for $0 < \lambda \leq \frac{1}{2}$ for Φ in $H^\lambda \log^+ H$. The case $\frac{1}{2} < \lambda < 1$ remains open. (Math. Rev. abstract)

CHI. 06:008

Chicago U. Dept. of Mathematics, Ill.

FOURIER SERIES AND POWER SERIES IN SEVERAL VARIABLES, by A. Zygmund. July 1956, 13p. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume II; AF 18(600)12)) (AF 18(600)1111) Unclassified

Theoretical applications of rectangular and Abel methods of summation are considered with respect to multiple Fourier series and power series.

CHI. 07:001

Chicago U. Dept. of Mathematics, Ill.

SOME ALGEBRAIC ASPECTS OF LOGIC, by M. H. Stone. Technical rept. July 1, 1955-June 30, 1956. Sept. 1956, 78p. refs. (AFOSR-TN-56-434) (AF 18-(600)1125) AD 96517 Unclassified

An analysis is made of those algebraic aspects of logic which may conveniently be studied in terms of certain free algebras, with emphasis on the algebraic treatment of the predicate calculus. The symbolism employed is essentially that introduced by E. L. Post (Amer. Jour. Math., v. 65: 197-215, 1943). A method is given for constructing algebras of arbitrary type generated by an arbitrary number of elements. Each algebra is obtained as a homomorph of a free algebra of the same nature. The analysis is completed by an isomorphism theorem which shows that any algebra whatever is isomorphic to such a canonical algebra.

CHI. 08:001

Chicago U. Dept. of Mathematics, Ill.

SLIDE AND TORSION PRODUCTS FOR MODULES, by S. MacLane. Oct. 1956 [29]p. (AFOSR-TN-56-488) (AF 18(600)1383) AD 110303 Unclassified

Also published in Univ. e Politec. Torino. Rend. Sem. Mat., v. 15: 281-309, 1955-56.

A direct definition of the functor $\mathrm{Tor}_n(C, G)$ by generators and relations is compared with that introduced by Cartan-Eilenberg who defined $\mathrm{Tor}_n(C, G)$ as the nth homology group with coefficients in G of an arbitrary free resolution of the module C. This invariant definition is an application of the method used in finding generators for the group Tor (C, G) which repairs an inexact sequence by describing the sources of inexactitude by generators and relations. With the aid of new slide products, a functor is defined which satisfies an exact sequence theorem and coincides with the nth torsion product of C and G. Some examples and problems were formulated concerning the possible independent interest related to the slide products themselves.

CHI. 08:002

Chicago U. Dept. of Mathematics, Ill.

[SOME THEOREMS AND PROBLEMS ON EXTENSIONS OF ABELIAN GROUPS] Quelques théorèmes et problèmes sur le groupe des extensions des groupes abéliens, by S. MacLane. May 7, 1956, 12p. [AF 18(600)1383] Unclassified

CHI. 08:003 - CHI. 10:001

Presented at the Algebra Seminar of the Sorbonne, Paris (France), May 7, 1956.

A number of theorems and problems on extensions of abelian groups are presented. The following are considered: (1) construction of the extensions; (2) the group of extensions; (3) the series; (4) the theorem of Nunke; (5) locally common extensions; (6) double series of groups; and (7) the structure of extensions for primary groups.

CHI. 08:003

Chicago U. Dept. of Mathematics, Ill.

[HOMOLOGY OF RINGS AND MODULES] Homologie des anneaux et des modules, by S. MacLane. June 1956, 26p. incl. refs. [AF 18(600)1383] Unclassified

Published in Colloque de Topologie Algébrique, 55-60, June 11-13, 1956.

Study is made of the extensions of various algebraic structures for which there exists a theory of homology and cohomology. Attention is focused on rings and modules. Several theorems are discussed and a number of problems are analyzed.

CHI. 09:001

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

NEGATIVE PION ACTIVATION OF BROMINE, by T. T. Sugihara and W. F. Libby. [1952] [2]p. incl. tables. [AF 33(038)18013] Unclassified

Published in Phys. Rev., v. 88: 587-586, Nov. 1, 1952.

Radiochemical studies of the reactions of π^- mesons with bromine, silver, and the light elements present in photographic emulsions should assist considerably in the interpretation of data obtained with photographic plates. The results for bromine with 122-Mev negative pions expending their full range in the element include: Peak yield of about 7 percent for As^{76} (ejection of 1 proton and 2 or 4 neutrons depending on which Br isotope absorbs the pion); the ratio of number of neutrons to the number of protons ejected was three to four in the most probable cases, the distribution of radioactivities appears to be reconcilable with photographic plate data if one guesses that the silver data will resemble those for bromine. (Contractor's abstract)

CHI. 09:002

Chicago U. [Enrico Fermi Inst. for Nuclear Studies] Ill.

NATURAL TRITIUM ASSAY. ROUTINE METHOD FOR ABSOLUTE ASSAY OF BETA RADIOACTIVITY, AND THE REACTIONS OF NEGATIVE PI MESONS WITH ELEMENTARY BROMINE, by W. F. Libby. Final repl. Dec. 1, 1952, 107p. incl. diagrs. tables, refs. (AF 33(038)18013; continued by AF 18(600)564)
AD 13760 Unclassified

In this study, the abundance of H^3 (tritium) in natural waters is determined. It is pointed out that about 200 g of H^3 appear to be present in the atmosphere at any given time. Some 15 kg are estimated to make up the total world assay. It is suggested that the H^3 in the atmosphere offers a means of dating organic materials on a 12.5-yr halflife basis. A routine method is described for obtaining an absolute assay of β "radioactivities", which are pure β emitters and do not emit γ radiations or possess complicated decay spectra. An error of not more than 5 - 10% is expected. Reactions involving the emission of neutrons are measured to elucidate the reactions of π mesons with photographic plate materials. Br is irradiated, and radioactivities are produced for Se, As, Ge, Ga, and Zn. Absolute yields of the elements are determined by γ assays, and an absolute measurement of the number of mesons entering the Br target is made. Measurements indicate that neutron emission is more probable than charged-particle emission. For Br, the most probable occurrence is the emission of about 3 neutrons and 1 proton which corresponds to a mountain peak on the yield map at a height of about 8%. The slope of the yield peak is steep in all directions from the peak. The lowest slope corresponds to about 3 neutrons for each proton. (ASTIA abstract, modified)

CHI. 10:001

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

THE POTENTIAL USEFULNESS OF NATURAL TRITIUM, by W. F. Libby. [1953] 5p. refs. (AF 18(600)564; continuation of AF 33(038)18013)
Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 39: 245, 1953.

It has been established that rainwater contains tritium (T) in amounts corresponding to values ranging from 5×10^{-18} up to 40×10^{-18} T atoms/H atom. In this study, the possible applications of natural T measurements are considered. They include: (1) age estimation of rain and agricultural products; (2) hydrology and identification of water sources; (3) meterology and test of vertical mixing in air masses and source of the moisture in air masses; and (4) rate of escape of He^3 (the isotope formed by T during its radioactive decay) from the earth's atmosphere. An equation is presented for determining the residence time of sea moisture air masses. It is expressed as: , (T,) = 470 Qt, where , is the moisture content of the air masses (a sq cm), T, is the tritium content of the rain (10^{-18} T atoms H atom), Q is the tritium production rate (T atoms sq cm sec), and t is the time (yr) spent by the moisture in the air mass since it left the ocean.

CHI. 10:002

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

RESEARCH TO ASSAY RAIN AND SURFACE WATER FOR NATURAL TRITIUM CONTENT, by W. F. Libby. Final rept. June 1, 1954, 26p. incl. tables, refs. ([AF]OSR-TN-54-142) (AF 18(600)564) AD 34458 Unclassified

The method used for the quantitative measurement of tritium in natural waters consisted of: (1) electrolytic concentration of water samples; (2) measurement of the deuterium concentration in the final product; and (3) determination of the tritium content of the concentrate by placing it as gaseous H in a Geiger counter. The results obtained are expressed as units of the number of tritium atoms/10^{18} H atoms present in the original sample. The data obtained were in accord with an average cosmic-ray production rate of about 0.14 tritium/sq cm/sec. Essentially, all of this tritium is passing into water without decaying into He, and the tritiated water is rained out and goes into the sea. The average tritium content of oceanic rain appeared to be about 1; the continental rains have higher assays. The Mississippi Valley shows about 6, and the western coast of Europe shows about 2.5. Changes in the natural tritium manufacturing rate are discussed in relation to old-water examination. Accumulation of He^3 in the atmosphere from the decay of cosmic-ray tritium indicated that He must leave the earth in a time not in excess of about 50,000,000 yr.

CHI. 10:003

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

NATURAL DISTRIBUTION OF COSMIC-RAY-PRODUCED TRITIUM II, by H. von Buttlar and W. F. Libby. Nov. 1954, 33p. incl. tables. ([AF]OSR-TN-54-338) (AF 18(600)564) AD 50983 Unclassified

Also published in Jour. Inorg. and Nuclear Chem., v. 1: 75-91, Mar. 1955.

The measurement of the abundance of tritium in natural waters has been continued during the last eighteen months. The method used consists of the electrolytic concentration of the water samples, the measurement of the deuterium concentration in the final product from which the enrichment factor for any tritium present in the original sample can be calculated, followed by the determination of the tritium content of the concentrate by placing it as gaseous hydrogen in a Geiger counter. It is shown that the data are in agreement with an average cosmic ray production rate of about 0.14 tritium atoms/cm^2/sec of the earth's surface on the assumption that essentially all of this tritium passes into water without decaying into helium, and the titrated water is precipitated out and goes into the sea. The average tritium content of oceanic rain appears to be about 1 tritium atom per 10^{18} hydrogen atoms, whereas the continental rains have higher assays. The great Mississippi Valley shows about 6. The western coast of Europe runs about 2.5. Several hot springs have been tested and most found to be rain water. Tests on wells agreed with expectations. As yet there is no significant meterological understanding of the erratic fluctuations in the tritium assays for rain in a given location. It probably is due to variation in air mass trajectories, origins, and water contents. (Contractor's abstract)

CHI. 10:004

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

THE NATURAL DISTRIBUTION OF TRITIUM, by S. Kaufman and W. F. Libby. [1954] 8p. incl. diagr. tables. [AF 18(600)564] Unclassified

Published in Phys. Rev., v. 93: 1337-1344, Mar. 15, 1954.

The abundance of cosmic-ray-produced tritium has been measured in a variety of natural waters in the Mississippi Valley, the Chicago, Ill. area, and in a few places elsewhere in the northern hemisphere. Contents ranging between 0.5 and 67 tritium atoms per 10^{18} hydrogen atoms have been found. These correspond to an average cosmic-ray production rate of about 0.12 tritium atoms/cm^2/sec if the total rate of transfer of tritium into the oceans by oceanic rain and snow and by rivers carrying continental water is taken as being equal to the total production rate. This is equivalent to assuming short land storage time in terms of eighteen years, the tritium average life. This production rate corresponds to an inventory of about 1800 g, with only about one percent of this in the atmosphere. The tritium contents of vintage wines appear to agree with the time elapsed since bottling, indicating the tritium abundances over the last eighteen years to have been essentially equal to the present ones. Some of the possible applications of natural tritium to problems of hydrology and meterology are discussed. The present production rate for tritium corresponds to an He^3 escape rate from the earth of about 5 x 10 years or less. (Contractor's abstract)

CHI. 10:005

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

CONTINENTAL WATER BALANCE, GROUND WATER INVENTORY AND STORAGE TIMES, SURFACE OCEAN MIXING RATES AND WORLD-WIDE WATER CIRCULATION PATTERNS FROM COSMIC RAY AND BOMB TRITIUM, by E. Begemann and W. F. Libby. Nov. 15, 1956 [33]p. incl. diagrs. tables, refs. (AFOSR-TN-56-561) (AF 18(600)564) AD 110381 Unclassified

Also published in Geochimica et Cosmochimica Acta, v. 12: 277-296, 1957.

The tritium (T) produced during the Castel Operation in the spring of 1954 was used to study the circulatory

CHI. 10:006 - CHI. 11:002

rates of waters in the Northern Hemisphere, particularly in the northern Mississippi Valley. Observations indicated that rains following the Castle Operation were lower in T content than the ground water, and this difference revealed that about 67% of the rain in the Mississippi Valley is ocean water and about 33% re-evaporated ground water. The total inward transport of ocean water was calculated as about 1.00 m/yr. The average T residence half-life was determined as 6 yr on continental North America. Water from the oceans stays an average of 15 yr in the northern Mississippi Valley. Data on the northern Mississippi Valley indicated that about 8 m of ground water are available for mixing with the rainfall, about 0.28 m of water runs off annually in rivers, and 0.24 m/yr is carried back to the oceans by winds. The atmospheric residence time for the Castle T was about 40 days. Evidence suggests that the residence time for mixing of water above and below the thermocline may be as short as 5 yr. The direct measurement of T production cross sections and calculation of $\bar{Q}$ from cosmic ray intensities predict that the average cosmic-ray production rate for T is 0.7 T-atoms/sq cm/sec averaged over the whole world, the intensity varying strongly as the cosine of the latitude with a factor of 4 in intensity between the equator and the poles. Studies of the circulatory pattern of hot springs showed that the spring water is mainly rainwater which was stored for brief periods. (ASTIA abstract)

CHI. 10:006

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

DISTRIBUTION OF ARTIFICIALLY PRODUCED TRITIUM IN NATURE, by F. Begemann. [1956] [6]p. incl. diagrs. table. [AF 18(600)564] Unclassified

Published in Proc. Second Conference on Nuclear Processes in Geologic Settings, July 31, 1956, p. 166-171.

Previous detailed measurements on the occurrence of tritium in nature had shown that there was an equilibrium amount of about 1800 g of cosmic ray-produced tritium present on the earth. As a consequence of the test of thermonuclear weapons in the Pacific in Spring 1954, the situation has changed completely. Now the equilibrium amount of tritium produced by cosmic radiation is only about 10% of the total tritium present on the earth. In the basic nuclear reactions leading to the production of this "excess tritium," it is produced as atomic tritium. Immediately following in the more moderate temperature zones of the fireball of the explosion, it is burned completely to HTO. The further history of the tritium is that of the water vapor in the atmosphere. It will be carried around the earth, distributed more or less homogeneously in the northern hemisphere, and finally rained out of the atmosphere and carried into the oceans.

CHI. 11:001

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

DIRECT PRODUCTION OF RADIOACTIVE ALIPHATIC HYDROCARBONS BY PILE IRRADIATION, by A. G. Schrodt and W. F. Libby. May 5, 1954, 3p. incl. table. (Technical note no. 1) ([AF]OSR-TN-54-121) (AF 18(600)663) AD 106914 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 3100, June 5, 1954.

A 5-mole solution of aniline in normal pentane was enclosed in a quartz tube and irradiated in the heavy-water pile at the Argonne National Lab. for one week at a flux of 10^{11} neutrons/cm^2/sec. The irradiation yielded radiocarbon in the form of normal pentane (25%), isopentane (less than 1%), hexane (15%), and heavier hydrocarbons (remainder). Similarly, radioactive hydrocarbons were produced by irradiation of ethyl amine in pentane. It is concluded that a high-velocity C^{14} on colliding with the liquid aliphatic hydrocarbon has a good chance of entering the chain. The possibility is mentioned that this process could also serve to introduce hydrocarbons into heavy lubricating oils.

CHI. 11:002

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

HOT ATOM CHEMISTRY OF CARBON, by A. G. Schrodt and W. F. Libby. Dec. 1954 [36]p. incl. diagrs. tables, refs. ([AF]OSR-TN-54-368) (AF 18(600)663) AD 53028 Unclassified

The reactions of radioactive C^{14} atoms moving with the high velocities corresponding to energies up to 40,000 ev were studied in $PhNH_2$, C_6H_6, C_5H_{12}, MeOH, Ph_3N, $PhNH_2$, HF, $EtNH_2$, and $MeNH_2$.HF, all at room temperature. The hot C^{14} atoms were generated by the reaction of thermal neutrons with N^{14} and $N^{14}(n,p)C^{14}$. For hydrocarbons not containing N, about 5 mol-% of a nitrogenous material, such as $PhNH_2$, was dissolved in the hydrocarbon and the solution irradiated and studied. The nature of the C hot atom reactions was essentially independent of the choice of nitrogenous solute. The radioactive C atoms were incorporated into the solvent molecule in high yields in the case of saturated compounds, such as C_5H_{12} for which about 25% of the radiocarbon appeared as C_5H_{12}; while the aromatic compounds, such as C_6H_6 and $PhNH_2$, gave low yields of 1 or 2%. In all cases a variety of products differing from the molecules struck by the high-velocity C atom were produced, ranging from light gases to heavy molecules, with a tendency to yield heavy materials in the case of aromatic compounds and solid phases. In the case of aliphatic hydrocarbons, the radical produced by the collision stopping the C^{14} atom is not so reactive and merely combines with the neighboring C^{14} atom resulting from the collision and reforms the original molecule with high yield. Other processes also occur in lower yield, resulting in a wide distribution in molecular weights peaked at the parent molecule.

CHI. 11:003

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

NATURAL RADIOACTIVITY OF RHENIUM, by A. D. Suttle, Jr. and W. F. Libby. Aug. 1, t954 [2]p. [AF 18(600)663] Unclassified

Published in Phys. Rev., v. 95: 866-867, Aug. t, t954.

Gaseous compounds of rhentum such as rhenium oxychloride and rhenium hexafluoride are considered useful in proportional counters to determine the half-life and the energy of radiation of rhenium. Reference is made to the shell model and beta decay systematics which imply that R_n^{187} should have an ft value of about 10^{t0} and be only first-forbidden with a spin change of 2. This indicates that a one-kev transition could correspond to a half-life of about $t0^{-tt}$ years.

CHI. tt:004

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

ABSOLUTE ASSAY OF BETA RADIOACTIVITY tN THICK SOLIDS. APPLICATION TO NATURALLY RADIOACTIVE POTASSIUM, by A. D. Suttle, Jr. and W. F. Libby. June t955 [8]p. incl. diagrs. tables, refs. [AF t8(600)663] Unclassified

Published in Anal. Chem., v. 27: 921-927, June 1955.

The method of absolute measurement of beta radioactivity in solids has been found reliable within about 5%. The simplicity of this method and the scarcity of other practical absolute assay techniques led to this study. A wide variety of simple beta emitters display exponential absorption curves when the sample, absorber, and counter are placed close in cylindrical geometry. The absorption coefficient for the material constituting the sample can be used to calculate the absolute specific radioactivity of the solid sample. The absorption coefficients for a given absorbing material vary smoothly with the energy of the beta radioactivity transition, so that reliable values of the energies of such radioactivities can be obtained form the absorption coefficients. The coefficients vary with the atomic weight of the absorber. This effect is only partially elucidated. (Contractor's abstract)

CHI. 11:005

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

ABSOLUTE CROSS SECTIONS FOR DEUTERONS ON BERYLLIUM, by R. E. Heft and W. F. Libby. Mar. 1, 1955 [t5]p. incl. diagrs. tables, refs. (AFOSR-TN-56-55) (AF 18(600)663) AD 81047 Unclassified

Also published in Phys. Rev., v. 100: 799-813, Nov. 1, 1955.

The absolute cross section for the reactions of deuterons on Be which produce tritium and Be^{10} have been measured up to energies of t7 to 20 mev. Data of Dejong, Endt, and Simons show no threshold which is as expected for exothermic (d, p) and (d, t) processes. For the reaction producing Be^{10}, which is equivalent to the introduction of a neutron into the Be nucleus by the bombarding deuteron, the cross section rises to a peak value of about 0.34 barn, at about 4 mev. It then falls almost linearly to the low value of 0.08 barn at 20 mev. There are evidences of fine structure in the curve, but it is possible that these are not really significant. The reaction producing tritium rises to a peak value of about 0.23 barn at about 5 mev, and then falls to a low value of about 0.03 barn at 13 mev. The reaction cross section appears to remain essentially constant at this low value, although it may rise slightly as the energy is raised to about 20 mev. A new reaction producing tritium begins at t7.47 mev, namely one which produces both tritium and Be^7 simultaneously. This corresponds to the ejection of both a triton and a neutron as a result of the deuteron Be^9 collision. This cross section rises from zero at the threshold linearly to a value of 8×10^{-5} barn at 21.5 mev. (Contractor's abstract)

CHI. 1t:006

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

TRITIUM PRODUCTION BY HIGH ENERGY PROTONS, by L. A. Currie, W. F. Libby, and R. L. Wolfgang. Nov. 1955 [29]p. incl. diagrs. tables, refs. (AFOSR-TN-56-56) (AF t8(600)663) AD 81048 Unclassified

Also published in Phys. Rev., v. 10t: 1557-t563, Mar. 1, 1956.

The cross sections for tritium production in various substances by 450 mev and 2.05 bev protons have been measured and the data tabulated. The N_2 and O_2 cross sections 25 ± 4 mb and 30 ± 4 mb, respectively, at 2.05 bev lead to a world-wide average tritium production rate by cosmic rays of $0.14 \pm {}^{0.10}_{0.03}$ tritons/sq cm/sec in good agreement with the observed value. The Fe cross section 53 ± 8 mb at 2.05 bev suggests a rate of production of 8.8×10^{-4} tritons/gm/sec near the surface of a large meteorite in outer space. For the small Mt. Ayliff Fe meteorite an age of $1.4 \times t0^9$ yr was calculated from the observed He^3 content. Finally, the results for tritium production have been compared to those for other light particles. (Contractor's abstract)

CHI. 11:007

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

HOT ATOM CHEMISTRY OF CARBON; PARTICULARLY IN AROMATIC SYSTEMS, by A. G. Schrodt and W. F. Libby. Dec. 16, t954 [7]p. incl. diagr. tables, refs. (AFOSR-TN-56-216) (AF 18(600)663) AD 86022 Unclassified

CHI.11:008 - CHI. 12:001

Also published in Jour. Amer. Chem. Soc., v. 78: 1267-1273, Apr. 5, 1956.

The reactions of radtoactive C^{14} carbon atoms movtng with the hlgh velocttles correspondtng to energies up to 40,000 ev have been studted tn anlline, benzene, methanol, trtphenylamtne, anlline hydrofluoride, ethylamtne and methylamine hydrofluorlde at about room lemperalure. The hot C^{14} atoms were generated by the reaction of thermal neutrons wlth nitrogen 14, $N^{14}(n,p)C^{14}$. For those substances, such as hydrocarbons, whtch do nol contain N to serve as a source of C^{14}, about 5 mol % of a nlirogenous malerial such as anlltne was dissolved in the subslance and lhe solution irradiated and studted. It was demonstraled thal the nature of the C^{14} hot atom reactions ts essentially independent of the chotce of nlirogenous solute and lherefore mosl probably ts characleristic of the solvenl hydrocarbon. The irradtations were performed in the reaclors al the Argonne National Laboratory. In all cases, a variety of products differing from the molecules slruck by the high velocity C^{14} atom was produced rangirg from lighl gases to heavy molecules, with a marked lendency lo yield heavy malertals in the case of aromatic compounds and solid phases. It is supposed that in the case of aromalic compounds, the opened ring formed by the collision of the recoiling C^{14} atom with one of the ring CH groups is so reaclive thal il combines nol only with the C^{14} atom which slruck bul avidly with lhe surrourding molecules of the syslem producting a highly aromalic substituled derivative of hexane. (Con-lractor's abstracl)

CHI. 11:008

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

NEGATIVE PION ACTIVATION OF SILVER, by W. Goishi and W. F. Libby. Aug. 1, 1956 [5]p. incl. table. (AFOSR-TN-56-350) (AF 18(600)663) AD 95436 Unclassified

Also published in Phys. Rev., v. 104: 1717, Dec. 15, 1956.

A sludy was made of lhe reaction with Ag of π-mesons, using a collimaled 5 sq cm beam of 122 mev negative pions on 2 to 4 kg of powdered Ag largels thicker than the pion range. Irradiation was conducled for 7-12 hr at intensities of about 5000 mesons sec. The % yields of some isotopes of Pd, Rh, and Ru, determined radiochemically on tne basis of their half-lives were: Pd^{103}, 4.9 ± 0.8; Pd^{101}, 6.8 ± 0.6; Pd^{100}, 1.9 ± 0.3; Rh^{105}, 0.9 ± 0.1; Rh^{102}, 3.8 ± 0.4; Rh^{101}, -0.2 ± 1.2; Rh^{100}, 1.8 ± 0.3; Ru^{103}, 1.1 ± 0.2; and Ru^{97}, 0.8 ± 0.2. The % yields signify the fraction of the incident mesons which produced the given nuclide. The yield of Pd^{101} appeared to be too high, that of Rh^{101} too low, possibly because some activity should be assigned to Pd^{109}. The total elemental yields were estimated at 22% for Pd, 16% for Rh, and 22% for Ru. Considering the rather large uncertainties in the present work, rough agreement was found wtth published data.

CHI. 11:009

Chtcago U. Enrico Fermt Inst. for Nuclear Studies, Ill.

RADIOCHEMICAL RESEARCHES, by E. A. Martell. Ftnal rept. Aug. 31, 1956, 29p. Incl. tables, refs. [AFOSR-TR-56-35] (AF 18(600)663) AD 96501 Unclassifted

Studies were made of (1) reaction rates of slow reactions, (2) hol atom chemisiry of radiocarbon, and (3) negative π-meson activation of Ag. Under study 1, a general method was developed for measuring the rales of very slow rate reactions. A study of the HT-HTO reaction indicaled that the reaclton is 0 order with respecl lo O pressure and ftrst order with respect lo H pressure and the amounl of surface present. From 373 to 569°K, the reaction rale ls independent of the nature of the surface of the reaction vessel. The decarboxylation of dl-α-alanine was sludied. Resulls showed about the same activation energy between 154 and 118°C as Abelson obtained (~40 kcal compared with 41 kcal) with a factor of ~4 difference tn half-life. Below 118°C, a side reaction apparently occurs which resulls in considerable variations between expertmenial results and the extrapolated values of Abelson (Science, v. 119: 576, 1954). Sludy 2 resulled ln the direct-pile-trradiation production of a wide variety of useful alkyl radioactive compounds. The method used was thal of irradiating nonnitrogenous aliphatic compounds in the presence of amines with the purpose of lagging the aliphatic compound by the $N^{14}(n,p)C^{14}$ reaction. In lhe hol range, any C of the bombarded compound can slop a recoiling C^{14}. Only those producls are formed which can be formed by dtrecl H subslitution. Under study 3, the absolule yields are presenled for Pd, Rh, and Ru lsotopes which resulled from 122-mev negative π-meson bombardment of Ag. The 4.5-hr Ru^{105} was nol observed. Plols of smooth single-reaclion yield curves show the strong preference for the emission of 5 lo 6 neulrons. A comparison is made belween a combination of the resulls for Br research by Sugihara and Libby (Phys. Rev., v. 88: 587, 1952) and for Ag with the heavy slar-prong distribution deduced by Menon, Mulrhead, and Rochat (Phil Mag., v. 41: 583, 1950).

CHI. 12:001

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

RECURRING DAILY CYCLES OF NUCLEONIC COMPONENT INTENSITY (Abstract), by W. H. Fonger, J. W. Firor, and J. A. Simpson. Nov. 28, 1952 [1]p. [AF 18(600)666] Unclassified

Presented at meeting of the Amer. Phys. Soc., St. Louis, Mo., Nov. 28-29, 1952.

Published in Phys. Rev., v. 89: 891, Feb. 15, 1953.

A variation of neutron tntensity wtth a period of one sotar day was found by averaging data over a pertod of ~65 days. The detectors were tead-paraffin piles containing BF_3 proportional counters to measure the local neutron production from the nucteonic component. Measurements were obtained at geomagnetic latttudes 48°N 0.5°S at an atmospheric depth of 680 g-cm^{-2}. The mean counting rates at 48°N and 0.5°S were 620 and 380 counts per min,respectivety. After pressure correction the averaged cyctes were simitar to stne functions with peak to peak ampttude ~1 percent and wlth maxima near local noon. Ustng the data at 48° N, significant departures from the average cycle were found for individual days. It was also found that these departures persist for intervals of 2-3 days and reoccur. The results are insensitive to choice of barometric coefficient. (Contractor's abstract)

CHI. 12:002

Chicago U. Enrico Fermi Inst. for Nuctear Studies, Itt.

COSMIC RADIATION tNTENSITY-TIME VARIATIONS AND THEIR ORIGIN. t. NEUTRON tNTENSITY VARIATION METHOD AND METEROLOGtCAL FACTORS, by J. A. Simpson, W. H. Fonger, and S. B. Treiman. Dec. 1952, 66p. Inct. diagrs. tabtes, refs. [AF t8-(600)666] Unctassified

Also published in Phys. Rev., v. 90: 934-950, June t, 1953.

tn thls cosmic-radiation study, the fottowing probtems are considered: (1) the use of the nucteonic component for intenstty-variation determinations; (2) the examinatton of the quantitative probtem of relating secondary component intensity measurements deep in the atmosphere to the primary variations; (3) the determtnation of the influence of the terrestriat atmosphere upon intensity vartations; and (4) the design and operation of a serles of detectors at setected geomagnetic tatitudes for experimentat purposes.

CHI. 12:003

Chicago U. Enrico Fermi Inct. for Nuclear Studies, ttt.

COSMIC RADIATION INTENSITY-TIME VARIATtONS AND THEIR ORIGIN. tt. ENERGY DEtENDENCE OF 27-DAY VARIATIONS, by W. H. Fonger. Mar. 1953, 40p. incl. diagrs. refs. [AF 18(600)666] Unclassified

Also published in Phys Rev., v. 91: 351-361, July 15, 1953.

In this study, cosmic ray intensity-time variations, recorded in the lower atmosphere by 1 neutron detector (D-1, Climax, Colorado) and 3 ionization detectors (Freiburg, Germany; Cheltenham, Marytand; and Huancay Peru) are compared. Irregular intensity variations, characterized by time parameters of 27 days and 24 hr, are shown to occur coincidentally in the records of both types of detectors. Therefore, tt seems reasonabte to ascribe correlated neutron and lontzation intensity variations to a common origin. tt has been shown that 27-day neutron intenstty variations are produced by primary tntensity vartations. The magnitude of these vartations must be greater for low energy prtmartes as 27-day neutron intensity vartations at Climax are ≈5 times targer than correspondtng tonization intenstty variations at Fretburg, Cheltenham, and Huancayo. These vartations must extend, however, to high energy primartes as thetr effects are observed at the geomagnetic equator. From the ≈3.1 relative response (Climax neutron. northern sea level lonization detector) 1 parameter describing the energy dependence of 27-day primary intensity vartations can be evaluated empirically. Assuming a power taw stmttar to that descrtbtng the energy dependence of the time average prtmary intensity spectrum, tt is found that the amplitude of 27-day primary intensity vartations is required to decrease with increasing primary energy approximately 1 power of energy more rapidly than the time average prtmary spectrum itself. The etectric ftetd acceteration process hypothests predtcts primary intensity variations with approximately this energy dependence. 24-hr neutron (Climax) and ionization (Freiburg) intensity variations are corretated in tocal time. It is not certain that these variations are produced by primary intensity variations. Even if this were the case, the retative response (Climax: Freiburg) to such primary intensity variations cannot be determined accurately from the data studied here. (Contractor's abstract)

CHI. t2:004

Chicago U. Enrico Fermi Inst. for Nuctear Studies, Ill.

COSMIC-RAY NEUTRON PRODUCTION IN ELEMENTS AS A FUNCTION OF LATITUDE AND ALTITUDE, by J. A. Simpson and R. H. Uretz. Apr. 1, 1953 [7]p. incl. diagrs. tabtes, refs. (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under [AF t8(600)666]) Unclassified

Published in Phys. Rev., v. 90: 44-50, Apr. 1, t953.

The relattve rates of tocat neutron production in Al, Cu, Sn, and Pb were obtained at geomagnetic lattitudes λ = 40° and 54° at atmospheric depth 312 g-cm^{-2} (30,000 ft pressure altitude). The tatitude and altitude dependence of local neutron production in carbon and lead were measured in the latitude intervat 0° - 54° with pile geometries containing BF_3 proportional counters. From these observattons several resutts were obtained: (1) the relative neutron muttipttcittes in etements were measured and found to be in good agreement with reported low attitude observations; (2) a neutron transition maximum in tead at ~20 g-cm^{-2} Pb was obtained at 23,000 ft pressure attitude; (3) the absorption mean free path for the neutron producing radiation in lead was 350 g-cm^{-2}; (4) an anomatous air absorption mean free path for the nucleonic component has been found for measurements derived from local

CHI. 12:005 - CHI. 12:008

neutron production in lead at $\lambda \gtrsim 40°$; (5) aside from the absorption anomaly in elements of htgh atomtc wetght A, local neutron production in elements of high A as a function of λ is in fair agreement with the free air neutron latitude effect; and (6) local production in carbon as a function of λ and altitude is tn agreement with corresponding free air neutron measurements. (Contractor's abstract)

CHI. 12:005

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

PROPERTIES OF THE LOW ENERGY NUCLEONIC COMPONENT AT LARGE ATMOSPHERIC DEPTHS, by J. A. Simpson and W. C. Fagot. [1953] [5]p. incl. diagrs. tables. [AF 18(600)666] Unclassified

Published in Phys. Rev., v. 90: 1068-1072, June 15, 1953.

This is a report on the absorption properties of the cosmic radiation low energy nucleonic component measured by detectors of disintegration product neutrons as the nucleonic cascade develops deep within the atmosphere. The air absorption mean free path L of the star- or neutron-producing radiation was measured as a function of atmospheric depth x (in g-cm^{-2} atmosphere) at the geomagnetic latitudes $\lambda = 0°, 41°, 52°$. $L(x, \lambda)$ was obtained for carbon or free atmosphere and for a lead plus carbon pile geometry. As reported earlier, for small x the absorption mfp, L, is dependent upon λ (L is a function of the average energy of the primary nucleons whtch tntttate the nucleonic chain or cascade. However, it is shown by the present measurements that, for $x > 600$ g-cm^{-2}, $L \rightarrow \sim 140$ g-cm^{-2} independent of latitude λ. The latitude dependence of neutron component intensity was measured at $x = 680$ g-cm^{-2} (11,200 ft) between $\lambda = 0°$ and 58°N. The latitude factor of intenstty increase is 2.55. In view of the independence of $L(x)$ on λ at large atmospheric depths thts latttude effect is nearly constant down to sea level ($x = 1030$). It is shown that at large atmospheric depths neutron production ts observed from primary protons with energies as low as ~1 bev. The specific yield of neutrons at t1,200 ft has been computed by taking into account protons, alpha-particles, and heavter primary nuclei. These measurements resolve discrepancies reported in the ltterature between high altitude measurements and measurements between sea level and mountain altitudes for the low energy nucleonic component. (Contractor's abstract)

CHI. t2:006

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

CHANGES IN AMPLITUDE OF THE COSMIC RAY 27-DAY INTENSITY VARIATION WITH SOLAR ACTIVITY, by P. Meyer and J. A. Simpson. [1954] 8p. illus. tables, refs. ([AF OSR-TN-54-198] [AF t8(600)666] Unclassified

Also published in Phys. Rev., v. 96: 1085-t088, Nov. 15, 1954.

Both cosmtc ray neutron and ionization chamber intenstty observations reveal that the amplttude of the 27-day recurring intensity vartation has been changing over an interval of several years. A method of studying thts phenomenon, using tonizatton chamber data for the period 1936-1946 and neutron tntensity data for 1951-53, ts described whtch not only selects preferentially the 27-day vartations, but also selects the variations which are worldwide. The amplitude of the 27-day intenstty variation over these years displays minima and a maxima closely related in time to the minima and maxima of the approximately 11-year cycle in general solar activity. These results, thus, provide additional and independent evidence that solar active regions are responsible for producing the mechanism which controls the 27-day cosmic ray primary intensity variations. (Contractor's abstract)

CHI. 12:007

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

SOLAR MAGNETIC MOMENT AND DIURNAL VARIATION IN COSMIC-RAY INTENSITY, by J. W. Firor, F. S. Jory, and S. B. Treiman. Feb. 1, 1954 [3]p. incl. diagrs. refs. [AF 18(600)666] Unclassified

Published in Phys. Rev., v. 93: 551-553, Feb. 1, 1954.

The expected diurnal variation in cosmic-ray intensity at geomagnetic latitude 60° has been calculated assuming a solar magentic dipole moment of 6.5×10^{33} gauss-cm^3. The calculation is based on new estimates of the intenstty of cosmic radiation in the trapped orbits of the solar dipole fteld. The method of Dwight is followed, but with an tmportant modification. The magnitude of the expected dturnal variation turns out to be about 12 percent. (Contractor's abstract)

CHI. 12:008

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

COSMIC-RADIATION INTENSITY-TIME VARIATIONS AND THEIR ORIGIN. III. THE ORIGIN OF 27-DAY VARIATIONS, by J. A. Simpson. [1954] [15]p. incl. diagrs. tables, refs. [AF t8(600)666] Unclassified

Published in Phys. Rev., v. 94: 426-440, Apr. t5, 1954.

Expertmental observaltons of variations in cosmic ray intensity measured by means of neutron-intensity monitor piles over a 19-month period (t95t-t952) show a 27-day cycle of vartatton in primary radiation intensity, associated with geomagnetic field disturbances which usually occur about 2 days after the 27-day maxima of cosmic ray intensity. Occasionally radiation intensity changes of ~3-6 percent are not followed by geomagnetic disturbances. These results suggest a

common mechanism producing both cosmic-ray particle acceleration and, indirectly, the geomagnetic disturbances. Investigation of various terrestrial fields whereby the incoming radiation would undergo acceleration or deceleration either before entering the field, within the field, or after passing through it, show that neither these possibilities nor a combined geomagnetic-geoelectric field storm can account for all established experimental facts. The accelerating mechanism is concluded to be probably of nonterrestrial origin. The 27-day cycle corresponds in time to the proper rotation of the solar equatorial latitudes; since active solar regions at these latitudes are associated with the 27-day cosmic-radiation intensity variations, the required accelerating mechanism is probably controlled by solar processes and may be located near the sun.

CHI. 12:009

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

COSMIC RADIATION INTENSITY-TIME VARIATIONS AND THEIR ORIGIN. IV. INCREASES ASSOCIATED WITH SOLAR FLARES, by J. W. Firor. [1954] [12]p. incl. diagrs. tables, refs. [AF 18(600)666]
Unclassified

Published in Phys. Rev., v. 94: 1017-1028, May 15, 1954.

The distribution on the earth of the impact points for particles of magnetic rigidities 1 to 10 Bv, which originally approach the earth from the direction of the sun, is derived, using principally the published results of numerical integrations of cosmic-ray orbits and model experiments on the motion of charged particles in a dipole magnetic field. Three impact zones for such particles are discussed. Two of these zones include only a small range of local times, and for the special case of the sun in the plane of the geomagnetic equator, are centered near 4 AM and 9 AM. The third zone has no strong local time dependence. Assuming the source of charged particles to subtend a finite angle at the earth, the relative counting rates for detectors in the 3 zones are estimated. The counting rate due to particles from the sun is expected to be 3 to 7 times larger in the morning zones than in the background, or non-local-time-dependent zone. The morning impact zones are shown to have a seasonal motion of several hr in local time. Reports of observations made during 4 large increases of cosmic-ray intensity at the times of solar flares are compared with the distribution predicted for particles from the sun. The observed increases agree with the predicted distribution and counting rate except at very high latitudes on the earth. A possible reason for this discrepancy is suggested. Cosmic-ray data from the Climax, Colorado, neutron detectors are analyzed for possible increases associated with small solar flares. An increase of $\approx 1\%$ is found for flares occurring when the detector is in a morning impact zone for particles from the sun. No increase of more than $\approx 0.3\%$ is found for flares occurring when the detector is not in these zones. The mean daily cycle of cosmic-ray intensity is also shown to depend on the rate of flares occurring on the sun. The intensity curve is peaked during the early morning hr for flare periods relative to periods in which few or no flares occurred, in agreement with the supposition that new particles approach the earth from the direction of the sun at the times of flares. (Contractor's abstract)

CHI. 12:010

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

COSMIC RADIATION INTENSITY-TIME VARIATIONS AND THEIR ORIGIN. V. THE DAILY VARIATION OF INTENSITY, by J. W. Firor, W. H. Fonger, and J. A. Simpson. [1954] [6]p. incl. diagrs. tables, refs. [AF 18(600)666]
Unclassified

Published in Phys. Rev., v. 94: 1031-1036, May 15, 1954.

Properties of the 24 hr intensity variations which were established by ion chamber and counter telescope measurements at high primary-particle energies have now been extended to the low-energy portion of the primary spectrum by measurements with high-altitude neutron piles at geomagnetic latitudes 0° and 48°. The observations demonstrate that the peak-to-peak amplitude of the 24 hr variation increases with latitude and, hence, is dependent on primary-particle rigidity. The latitude ratio for the peak-to-peak variation is $\sim 1.4 \pm 0.2$, and the amplitude at 48° is of the order 1%. These facts preclude primary neutrons or a general solar dipole field as the origin of this intensity variation. It is shown that although the amplitude of the variation changes from day to day, the amplitudes of the intensity variations of particles at low and at high energy are related. It is further shown that the amplitude on 1 day persists for only the next 1 or 2 days, and that there is not a strong 27-day recurrence tendency. The general features of the changes in peak-to-peak amplitudes of the monthly average 24 hr variations appear in both neutron detectors and in the Freiburg ionization chamber. Arguments based on the experimental observations are presented to exclude meteorological factors, the terrestrial magnetic field variations, and simple geoelectric field accelerations as the origin of the variation. Since it is shown that the particles which produce the 24 hr variation are charged and have their highest intensity near or after noon local time, it does not appear probable that they come from the direction of the sun. Although it is doubtful that this variation is of terrestrial origin, no proof has yet been given that the variation is of extra terrestrial origin. (Contractor's abstract)

CHI. 12:011

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

SOLAR MAGNETIC MOMENT AND COSMIC-RAY EFFECTS ASSOCIATED WITH SOLAR FLARES, by S. B. Treiman. [1954] 2 p. [AF 18(600)666]
Unclassified

CHI. 12:012 - CHI. 12:014

Published in Phys. Rev., v. 94: 1029-1030, May 15, 1954.

A close correlation between solar flares and small cosmic-ray intensity increases has recently been established by the Climax, Colorado, neutron monitor data. The correlation, however, is restricted only to those flares which occur when the station lies within a certain interval of local solar time. This has been explained by supposing that the new cosmic-ray particles approach the earth preferentially along the earth-sun line, before deflection in the terrestrial magnetic field takes place. In the present paper, this evidence is used to establish an upper limit to a possible solar magnetic dipole field. Allowance is made for the fact that the dipole field may be seriously perturbed by local fields near the sun; but on the assumption that the dipole field predominates far from the sun (at distances greater than one-fifth the earth-sun distance), the upper limit on the solar dipole moment is 5×10^{32} gauss-cm^3. (Contractor's abstract)

CHI. 12:012

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

PRODUCTION OF COSMIC RADIATION AT THE SUN, by J. W. Firor, J. A. Simpson, and S. B. Treiman. [1954] 17p. incl. illus. (AF 18(600)666)
Unclassified

Published in Phys. Rev., v. 95: 1015-1019, Aug. 15, 1954.

A calculation is made of the average production rate of 4-Bv cosmic-ray particles at the sun. The calculation is based upon the recent experimental evidence that the frequently occurring small solar flares produce temporary increases of neutron intensity in suitably located neutron pile detectors. This production rate, averaged over the 11-yr solar cycle, is somewhat in excess of the absorption rate of 4-Bv particles by bodies in the solar system. If the production at the sun is to account for most of the observed cosmic radiation intensity, a trapping magnetic field is required. Limits on the size of such a trapping volume are estimated by considering the limits of cosmic ray lifetime; the requirement of a high degree of radiation isotropy at the earth is satisfied. The existence of high energy particles in the cosmic radiation imposes the principal difficulty for any solar origin hypothesis. (Contractor's abstract)

CHI. 12:013

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

RECURRENCE PHENOMENON IN THE 24 HOUR VARIATION OF COSMIC RAY INTENSITY, by R. P. Kane. [Dec. 1, 1954] 25 p. incl. diagrs. table. [AF 18-(600)666] Unclassified

Also published in Phys. Rev., v. 98: 130-135, Apr. 1, 1955.

In this study evidence is presented that the fluctuations in the amplitude of the 24-hr variation of cosmic-ray intensity have a recurrence tendency of 27-28 days. Recurrence tendencies of the same period are known to exist in the mean daily intensity of cosmic rays; however, at present there does not appear to be any unique relationship between the mean daily intensity and the amplitude of the 24-hr variation. Phase relationships with the 27-day recurrence phenomenon in the intensity of geomagnetic disturbances, represented by worldwide K_p indices, have also been studied. In general, it is not possible to identify a phase relationship of all the K_p maxima with either the daily mean cosmic-ray intensity or the amplitude of the 24-hr variation. Nevertheless it seems to be true for particular 27-day sequences of K_p maxima that the daily mean cosmic-ray intensity precede the K_p maxima by about 3 days, whereas the maxima of the amplitude of the 24-hr variation of cosmic-ray intensity coincide with the maxima of K_p values. This latter relation is in agreement with the increase found in the amplitude of the 24-hr variation of cosmic-ray intensity on magnetically disturbed days.

CHI. 12:014

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

GEOMAGNETIC COORDINATES DERIVED FROM COSMIC RAY OBSERVATIONS, by J. A. Simpson, K. B. Fenton and others. [1955] [20]p. incl. diagrs. tables, refs. [In cooperation with National Research Council of Canada] (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)666 and AFCRC Geophysics Research Directorate)
Unclassified

Presented at the International Conference on Cosmic Rays, Guanajuato (Mexico), Sept. 1955.

The distribution of the geomagnetic field extending far from the surface of the earth is investigated by using cosmic ray particles as probes. Since for any longitude the cosmic-ray intensity reaches a minimum at the effective geomagnetic equator of this outer field, a series of determinations of the minimum intensity at several longitudes defines its effective equatorial plane. Measurements using the neutron intensity from the nucleonic component prove that large discrepancies exist between experimental observations and the presently accepted geomagentic coordinates derived from surface magnetic field measurements. It is also found that meson intensity data from the past 20 yr or more may be used to determine minima at other longitudes. The results indicate that the effective geomagnetic equator for cosmic rays is represented by a westward shift of the inclined magnetic dipole of the earth by about 40° - 45°, without requiring an appreciable change in the angle of inclination. Several anomalous results, which have been reported at intermediate and equatorial latitudes for primary α particles and heavy-stripped nuclei detected in photoemulsions, are readily explained by this shift in coordinates, supporting the

view that the discrepancies are worldwide in character. Since the surface magnetic field measurements do not account for this large scale effect, it is suspected that the explanation may be found from the interaction of the rotating and inclined magnetic dipole field with the highly ionized interplanetary medium. (Contractor's abstract)

CHI. 12:015

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

ON THE TRANSITION EFFECT OF COSMIC RAY NEUTRONS, by P. Meyer. [1955] 8p. incl. illus. (AF 18(600)666) Unclassified

Published in Zeit. f. Phys., v. 141: 28-32, Apr. 25, 1955.

The altitude dependence of neutron intensity in the atmosphere had been determined for different mean neutron energies. For neutrons below 0.4 ev the intensity maximum has been obtained by Yuan at a pressure of 83 mm Hg. For energies above 0.4 ev we find the intensity maximum at 50 mm Hg and for energies above ~1 kev at 35 mm Hg. This shift in the position of the maximum is predicted by the slowing down theory of neutrons in the atmosphere. A comparison with work on the altitude dependence of nuclear disintegrations shows a coincidence between the position of the maximum for these processes and that for fast neutrons. (Contractor's abstract)

CHI. 12:016

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

ASSOCIATION OF A "UNIPOLAR" MAGNETIC REGION ON THE SUN WITH CHANGES OF PRIMARY COSMIC-RAY INTENSITY, by J. A. Simpson, H. W. Babcock, and H. D. Babcock. [1955] 19p. incl. illus. tables. (In cooperation with Carnegie Inst. of Washington and Calif. Inst. of Tech.) (AF 18(600)666) Unclassified

Published in Phys. Rev., v. 98: 1402-1406, June 1, 1955.

A new instrument for observing weak magnetic fields on the photosphere of the sun has recently revealed the presence of an unusual area on the solar surface which may be called a "unipolar" magnetic (UM) region because the field is of one sign and no magnetic flux has been found returning to the sun. This UM region was observed at central solar meridian on seven consecutive solar rotations in 1953. In the present paper it is shown that there is a striking association of this UM region with: (1) times of maximum primary cosmic ray intensity as measured by neutron detectors and an ionization chamber; and with (2) the recurring geomagnetic storms, the geomagnetic disturbances being most pronounced ~3-4 days after both the central meridian passage of the UM region and the time of maximum cosmic ray intensity. (Contractor's abstract)

CHI. 12:017

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

THE COSMIC RADIATION AND SOLAR-TERRESTRIAL RELATIONSHIPS, by J. A. Simpson. [1955] [25]p. incl. illus. diagrs. refs. [AF 18(600)666] Unclassified

Presented at meetings of the Special Committee for the I. G. Y. and U. G. G. I., Assoc. of Geomagnetism and Aeronomy, Rome (Italy), Sept. 1954.

Published in Ann. de Geophysique, v. 11: 305-329, July-Sept. 1955.

A brief review of the properties of cosmic radiation, and the association of cosmic ray phenomena with solar and geophysical processes, introduces a survey of recent experimental methods developed to study the low energy cosmic ray particles which have been hitherto inaccessible to continuous observation. These low energy particles which contribute to the main effects are found to be associated with solar processes; namely, variations of primary intensity and energy. The low energy cosmic radiation may be used to investigate, for example, the existence and limits of geoelectric fields, the magnitude of interplanetary magnetic fields, properties of solar initiated ionic beams, and the role of solar flares in producing temporary increases of cosmic ray intensity at the earth. (Contractor's abstract)

CHI. 12:018

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

CHANGES IN THE LOW-ENERGY PARTICLE CUTOFF AND PRIMARY SPECTRUM OF COSMIC RADIATION, by P. Meyer and J. A. Simpson. [1955] [7]p. incl. diagrs. [AF 18(600)666] Unclassified

Published in Phys. Rev., v. 99: 1517-1523, Sept. 1, 1955.

The low-rigidity cutoff for particles in the primary cosmic-ray spectrum has decreased within the period 1948 through 1951. This decrease corresponds to a 3° change (northward) in the "knee" position of the geomagnetic latitude curve for the nucleonic component. The phenomenon is accompanied by both a change in the primary spectrum for particle rigidities less than approximately 4 Bv and by an increase in total primary intensity. The spectral change is such that if the differential primary intensity, j, at low rigidities in 1948 was $j = C(p/z)^{-2}$, then the new spectrum for 1951 through 1954 is approximately $j = C'(p/z)^{-2.7}$. The total change of intensity arising from the changes in spectrum and low-rigidity cutoff is more than 13%. The measurements were obtained in 1948 and 1951, and have been confirmed and extended in November 1954 using nucleonic component detectors. The vertical charged particle intensity was also measured and displays changes equivalent to those reported for the

CHI. 12:019 - CHI. 12:022

nucleonic component. Three regions of space are considered for the location of the mechanism producing the low energy cutoff; namely, the vicinity of the earth, the region of the solar system, and regions of the galaxy outside our solar system. Although the general solar dipole moment is at least an order of magnitude too small to account for the observations, it is concluded that the mechanism is operative within the solar system and is not a terrestrial phenomenon. (Contractor's abstract)

CHI. 12:019

Chicago U. [Enrico Fermi] Inst. for Nuclear Studies, Ill.

ON DERIVING GEOMAGNETIC DIPOLE FIELD COORDINATES FROM COSMIC RAY OBSERVATIONS, by J. A. Simpson, F. Jory, and M. Pyka. [1956] [24] p. incl. diagrs. refs. [AF 18(600)666] Unclassified

Published in Jour. Geophysical Res., v. 61: 11-22, Mar. 1956.

It is pointed out that the earth's external magnetic field, extending far beyond the ionosphere, is presently inaccessible to direct observation. By measuring the nucleonic component longitude and latitude effects in the region of the geomagnetic equation, however, the coordinates of an equivalent geomagnetic dipole may be determined which represents this external field. The method of measurement and the theory relating cosmic ray intensity changes to the geomagnetic coordinates are outlined for deriving the two angles which determine the orientation of the dipole, and the three coordinates giving the position of the magnetic center with respect to the earth's center. In appendixes, the effect of local magnetic surface anomalies upon the trajectories of cosmic ray particles moving in the magnetic dipole field of the earth are evaluated and the effect of an overhead horizontal, electric-current system in the upper atmosphere (ionosphere) is discussed.

CHI. 12:020

Chicago U. [Enrico Fermi Inst. for Nuclear Studies] Ill.

THE INFLUENCE OF GEOMAGNETIC QUADRUPOLE FIELDS UPON COSMIC-RAY INTENSITY, by F. S. Jory. [1956] [7] p. [AF 18(600)666] Unclassified

Published in Phys. Rev., v. 102: 1167-1173, May 15, 1956.

The effect upon cosmic ray particles of the quadrupole part of the earth's magnetic field has been calculated, using the results of the magnetic survey of 1945. The effect predicted from the zonal quadrupole term is a northern shift of the cosmic ray latitude curve. The 1945 magnetic center was calculated, using Schmidt's method, and it is 0.0629 earth radii from the center of the earth, as compared to 0.0536 earth radii in 1922. The shift in magnetic center results in an increase in the predicted longitude effect. The residual or sectorial quadrupole effect upon cosmic-ray intensity is predicted to be a 2-period sine curve in the longitude effect. (Contractor's abstract)

CHI. 12:021

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

THE EFFECTIVE GEOMAGNETIC FIELD COORDINATES FOR COSMIC-RAY PARTICLES, by J. A. Simpson. Feb. 1, 1956 [4] p. incl. diagrs. table. [AF 18(600)666] Unclassified

Presented at Conference on Theoretical Geophysics, Washington, D. C., Feb. 1-3, 1956.

Published in Jour. Geophysical Res., v. 61: 364-367, June 1956.

The location of the geomagnetic equatorial plane derived from cosmic-ray observations is studied, and the implications of this study are considered for a world-wide system of cosmic-ray geomagnetic coordinates effective for cosmic-ray particles. The location of cosmic-ray intensity minima (derived from latitude curves) around the earth is examined; and measurement by use of a neutron-intensity monitor carried across the geomagnetic equator of the secondary component of cosmic radiation generated within the atmosphere is analyzed.

CHI. 12:022

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

EFFECTIVE GEOMAGNETIC EQUATORS FOR COSMIC RADIATION, by J. A. Simpson, K. B. Fenton and others. [1956] [6] p. incl. diagrs. tables, refs. [In cooperation with National Research Council of Canada] (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)666] and AFCRC Geophysics Research Directorate) Unclassified

Presented at International Conference on Cosmic Rays, Guanajuato (Mexico), Sept. 1955.

Published in Phys. Rev., v. 102: 1648-1653, June 15, 1956.

The distribution of the geomagnetic field extending far from the surface of the earth is investigated by using cosmic-ray particles as probes. Since for any longitude the cosmic-ray intensity reaches a minimum at the effective geomagnetic equator of this outer field, a series of determinations of the minimum intensity at several longitudes defines its effective equatorial plane. Measurements using the neutron intensity from the nucleonic component prove that large discrepancies exist between experimental observations and the presently accepted geomagnetic coordinates derived from surface magnetic field measurements. It is also found

that meson intensity data from the past 20 years or more may be used to determine minima at other longitudes. The results indicate that the effective geomagnetic equator for cosmic rays is simulated by a westward shift of the inclined magnetic dipole of the earth by about 40° - 45°, without requiring an appreciable change in the angle of inclination. Several anomalous results which have been reported at intermediate and equatorial latitudes for primary alpha particles and heavy stripped nuclei detected in photoemulsions are readily explained by this shift in coordinates, supporting the view that the discrepancies are world-wide in character. Since the surface magnetic field measurements do not account for this large-scale effect, it is suggested that the explanation may be found from the interaction of the rotating and inclined magnetic dipole field with a highly ionized interplanetary medium. (Contractor's abstract)

CHI. 12:023

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

SELECTED COSMIC-RAY ORBITS IN THE EARTH'S MAGNETIC FIELD, by F. S. Jory. [1956] [8]p. incl. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)666] and AFCRC Geophysics Research Directorate) Unclassified

Published in Phys. Rev., v. 103: 1068-1075, Aug. 15, 1956.

A set of 663 charged-particle orbits in the earth's dipole magnetic field has been obtained by integration, using the AVIDAC computer of the Argonne National Laboratory, Lemont, Ill. The orbits integrated were selected according to their usefulness in the analysis of cosmic-ray intensity increases associated with solar flares. The calculation of intensity increases for different locations on the earth is discussed using the orbit results. Tabular data are presented for values of λ_∞, asymptotic latitude, and ϕ_∞ asymptotic longitude, for orbits with 0°, 10°, 20°, 30°, 40°, 50°, 60°, 70°, and 80° impact latitudes, λ_0. (Contractor's abstract, modified)

CHI. 12:024

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

THE SOLAR COSMIC RAYS OF FEBRUARY 1956 AND THEIR PROPAGATION THROUGH INTERPLANETARY SPACE, by P. Meyer, E. N. Parker, and J. A. Simpson. June 1956 [56]p. incl. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)666] and AFCRC Geophysics Research Directorate) Unclassified

Also published in Phys. Rev., v. 104: 768-783, Nov. 1, 1956.

The data from 6 neutron intensity monitors distributed over a wide range of geomagnetic latitudes have been used to study the large and temporary increase of cosmic ray intensity which occurred on Feb. 23, 1956, in association with a solar flare. During the period of enhanced intensity a balloon-borne neutron detector measured the absorption mean free path and intensity of the flare particles at high altitudes. From these experiments, the primary particle intensity spectrum as a function of particle rigidity, over the range < 2 to > 15-30 Bv rigidity, has been deduced for different times during the period of enhanced intensity. It is shown that the region between the sun and the earth must be free of magnetic fields greater than $\sim 10^{-6}$ gauss, and that the incoming radiation was practically isotropic for more than 16 hr following maximum flare particle intensity. The decline of particle intensity as a function of time t depends upon the power law $t^{-3/2}$, except for high energy particles and late times, where the time dependence approaches an exponential. The experiments lead to a unique model for the inner solar system which requires a field-free cavity of radius greater than the sun-earth distance enclosed by a continuous barrier region of irregular magnetic fields [B (rms) $\approx 10^{-5}$ gauss] through which the cosmic-ray particles must diffuse to reach interstellar space. This barrier is also invoked to scatter flare particles back into the field-free cavity and to determine the rate of declining intensity observed at the earth. The diffusion mechanism is strongly supported by the fact that the time dependence $t^{-3/2}$ represents a special solution of the diffusion equation under initial and boundary conditions required by experimental evidence. The coefficient of diffusion, the magnitude of the magnetic field regions, the dimensions of the barrier and cavity, and the total kinetic energy of the high-energy solar-injected particles have been estimated for this model. Recent studies of interplanetary space indicate that the model prescribed by the experiments may be established from time to time in the solar system. The extension of the model to the explanation of earlier cosmic ray flare observations appears to be satisfactory. The solar flare event was superposed by chance upon a large but typical intensity decrease of nonsolar cosmic rays which began several days prior to Feb. 23, 1956. Hence, the flare particles have been used as probes to explore the intensity modulation mechanism responsible for this decrease of background cosmic-ray intensity. (Contractor's abstract)

CHI. 12:025

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

LATITUDE EFFECT OF THE COSMIC-RAY NUCLEON AND MESON COMPONENTS AT SEA LEVEL FROM THE ARCTIC TO THE ANTARCTIC, by D. C. Rose, K. B. Fenton and others. 1956 [17]p. incl. diagrs. tables [In cooperation with National Research Council of Canada] (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)666 and AFCRC Geophysics Research Directorate) Unclassified

Presented at the International Conference on Cosmic Rays, Guanajuato (Mexico), Sept. 1955.

CHI. 12:026 - CHI. 13:002

Published in Canad. Jour. Phys., v. 34: 968-984, Sept. 1956.

Results are presented of cosmic ray measurements taken at sea level during 1954-55 from the Arctic to the Antarctic. The equipment consisted of a neutron monitor and a meson telescope. Latitude effects of 1.77 for the nucleonic component and 1.15 for the meson component were measured. The longitude effect at the equator was much less than expected on the basis of the geomagnetic eccentric dipole, and the longitude effect at intermediate northern latitudes shows that the longitude of the effective eccentric dipole is considerably west of that of the geomagnetic eccentric dipole. In a previous paper by the same authors, the positions of the equatorial minima were combined with other published cosmic ray measurements to calculate a new cosmic ray geomagnetic equator. In this paper new coordinates are derived on the assumption that these equatorial coordinates apply to a new eccentric dipole, and, therefore, that the equatorial coordinates may be extended to high latitudes. When the complete results are plotted on these coordinates, it is found that an eccentric dipole representation of the earth's magnetic field is inconsistent with the combined observations at all latitudes. (Contractor's abstract)

CHI. 12:026

Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

MODULATION OF PRIMARY COSMIC-RAY INTENSITY, by E. N. Parker. [1956] [16]p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)666] and AFCRC Geophysics Research Directorate) Unclassified

Published in Phys. Rev., v. 103: 1518-1533, Sept. 1, 1956.

The cosmic-ray particles observed at the earth are assumed to be of galactic origin, except for the occasional bursts from solar flares. With this interpretation the 11-year variation of the cosmic-ray intensity and the Forbush decreases represent depressions of the steady galactic intensity. The observed rigidity dependence of the depression indicates that magnetic fields are responsible. A quantitative investigation of the possible motion and configuration of magnetic fields capable of producing the observed effects is carried out. It is shown that, within the limitations imposed by what we think we know today of the galactic magnetic field, of solar activity, and of interplanetary fields, serious difficulties are encountered by any mechanism, such as Morrison's interplanetary cloud model, modulating the galactic cosmic-ray intensity throughout the solar system. It is proposed that the modulation of the intensity is produced locally, within a few earth's radii, by interplanetary magnetic gas clouds captured by the terrestrial gravitational field. Such a model seems to produce the observed effects on the basis of the known facts about solar activity. The most straightforward test of this geocentric model, independent of inferences from cosmic-ray effects, is the question of whether the absorption of the captured magnetic hydrogen gas can be detected as a narrow line in the center of the broad solar L_α emission line. (Contractor's abstract)

CHI. 13:001

Chicago U. Inst. for the Study of Metals, Ill.

SELF-DIFFUSION IN SODIUM NEAR THE MELTING POINT, by R. E. Meyer and N. H. Nachtrieb. [1955] [1]p. incl. table. [AF 18(600)1489] Unclassified

Published in Jour. Chem. Phys., v. 23: 405, Feb. 1955.

Self-diffusion coefficients for solid Na, previously reported for the 0°-94.5°C temperature range (Jour. Chem. Phys., v. 20: 1185, 1952) are determined for temperatures to within 0.10°C of the melting point of polycrystalline and single crystal states of the metal. Spectrographic examination of the once-distilled metal revealed 0.05 percent K, 0.001 percent Si, and less than 0.001 percent of Fe, Mg, and Cu. Its melting point was determined to be 97.91 ± 0.06°C by means of a cooling curve taken in vacuum with a chromel-alumel thermocouple calibrated at the steam point and several other standard thermometric points. Cylinders of radioactive and ordinary Na of very coarse grain size (~2 mm diam) were pressure-welded together at liquid nitrogen temperatures and diffusion was allowed to proceed in an oil thermostat which was controlled to ± 0.015°C. The composite cylinder was then sectioned in a microtome and the diffusion coefficient calculated. The results of four runs are tabulated, together with values of D calculated for 94.4° and the melting point from the empirical equation resulting from the earlier study. The newer values are slightly higher, but the agreement is to within the limits of error. Diffusion coefficients for the liquid were measured from 98.0° to 226° by the capillary reservoir technique. The results of these runs may be represented by the equation: $D = 1.10 \times 10^{-3} \exp(-2450/RT)$. The values found just above the melting point, also tabulated, deviate only slightly from the value of 4.06×10^{-7} cm^{2}sec^{-1} calculated for 98.0° by means of this equation. It appears that the transition from the rate of solid state self-diffusion to the rate of liquid state self-diffusion is as discontinuous in Na as the melting process, itself.

CHI. 13:002

Chicago U. Inst. for the Study of Metals, Ill.

SELF-DIFFUSION OF SILVER IN SILVER-PALLADIUM ALLOYS, by N. H. Nachtrieb. Feb. 27, 1956 [17]p. incl. diagrs. table, refs. (AFOSR TN-56-89) (AF 18-(600)1489) AD 82003 Unclassified

Also published in Jour. Chem. Phys., v. 26: 106-109, Jan. 1957.

The self-diffusion of Ag has been studied in alloys

containing 0.00, 1.49, 3.69, 9.87, and 21.84 at-% Pd at 4 temperatures: 715.4°, 799.4°, 861.8°, and 942.0°C. The rate decreases with increasing Pd atom fraction according to the relation: $D_{Ag} = 0.270\, e^{-8.20X}\, e^{-43,700/RT}$. An alternative expression is $D_{Ag} = 0.270\, e^{-17.75T_m/T}$. Within experimental error, the activation energy is independent of Pd content. The rate of self-diffusion of Ag is related to the solidus line of the Ag-Pd phase diagram, and a simple corresponding states explanation is given. (Contractor's abstract)

CHI. 13:003

Chicago U. Inst. for the Study of Metals, Ill.

THE EFFECT OF HIGH PRESSURES ON THE RATES OF ATOM MOVEMENTS IN CRYSTALS, by N. H. Nachtrieb. Apr. 30, 1956 [24]p. incl. diagrs. table. (AFOSR-TN-56-174) (AF 18(600)1489) AD 86594 Unclassified

Presented at Third International Meeting on the Reactivity of Solids, Madrid (Spain), Apr. 3-7, 1956.

Also published in Trans. Third International Conference on the Reactivity of Solids, Madrid (Spain), 1957, p. 545-564.

Also published in its Forty-first Quarterly rept. to sponsors of the Inst. for the Study of Metals, June 1956, p. 137-148; AD 103589.

The significance of diffusion measurements as a function of pressure is considered for the provision of information about the volume of the activated state. The basic assumption is that diffusing atoms pass through a transition state whose existence is sufficiently well defined to have meaningful thermodynamic functions ΔF, ΔH, ΔS, ΔV, etc. Two crystalline solids (Na and P) were studied. Curves are presented which show (1) the effect of pressure on 90°C diffusion profiles for Na for pressures up to 12,000 kg/sq cm^{-2}; (2) the variation of ln D (diffusion coefficient) with pressure for Na at 90°C and for P at 30° and 41.30°C; and (3) $\overline{V}_{act}$ (activated volume) as a function of pressure. Results indicate that the volume of the defect (presumably a moving lattice vacancy) is not greater than half the atomic or molecular volume which implies an inward relaxation of atoms toward a lattice vacancy. Experiments showed no temperature dependence in the enthalpy of activation for self diffusion and a significant variation of ΔH with pressure. The simularity of the ratio of the enthalpies of activation and fusion to the ratio of the volumes of activation and fusion suggests that the fusion mechanism is the same as the self-diffusion mechanism. The proposition is being examined that an atom neighboring a vacancy in a solid must surmount the same activation barrier as in the liquid state.

CHI. 13:004

Chicago U. Inst. for the Study of Metals, Ill.

AN EXPERIMENTAL STUDY OF THE OPTICAL PROPERTIES OF LIQUID HG AND LIQUID GA IN THE WAVELENGTH RANGE OF 0.23μ TO 13μ, by L. G. Schulz. Nov. 30, 1956 [21]p. incl. diagrs. tables, refs. (AFOSR-TN-56-468) (AF 18(600)1489) AD 97352 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 47: 64-69, Jan. 1957.

Modifications were used of methods previously developed for studying the optical properties of solid metals. Reflectivities were measured at an angle of incidence of 45° at glass-metal, quartz-metal and NaCl-metal interfaces in the wavelength range of 0.23μ to 13μ. In a 2nd type of experiment the phase change accompanying reflection at normal incidence at a mica-metal interface was measured in the range 0.4μ to 0.87μ. In this range the measured quantities reflectivity and phase change were used to compute the optical constants n and k. The values thus obtained agreed to within the experimental accuracy with those calculated with the Drude free electron theory. The fact that the experimentally determined reflectivity for the complete range of 0.23μ to 13μ agreed closely with that predicted by the Drude theory strongly suggests that the theory applies throughout this entire wavelength range. (Contractor's abstract)

CHI. 13:005

Chicago U. Inst. for the Study of Metals, Ill.

COMPARISON OF CALCULATED AND EXPERIMENTAL VALUES FOR THE OPTICAL REFLECTIVITY OF THE LIQUID ALLOYS Hg-In, Hg-Tl, Ga-In AT 25°C, by L. G. Schulz. Nov. 30, 1956 [13]p. incl. diagrs. (AFOSR-TN-56-469) (AF 18(600)1489) AD 97353 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 47: 70-72, Jan. 1957.

The alloys (Hg-In), (Hg-Tl) and (Ga-In) are inspected for optical reflectivity in the wavelength range of 0.3μ to 10μ. The results from the alloys with components of different valences can possibly be explained by chemical union in the alloy. The experimental results on reflectivity measurements are insufficient for n or k ($\bar{n} = n - ik$ with $\bar{n}$ the complex index of refraction), but they are adequate for indicating the extent of agreement with the Drude theory. Different valence combinations gave disagreement of experimental and calculated values for the reflectivity. Ga and In combined gave agreement of experiment and theory apparently due to the agreement in valence.

CHI. 13:006 - CHI. 14:002

CHI. 13:006

Chicago U. Inst. for the Study of Metals, Ill.

THE EXPERIMENTAL STUDY OF THE OPTICAL PROPERTIES OF METALS AND THE RELATION OF THE RESULTS TO THE DRUDE FREE ELECTRON THEORY, by L. G. Schulz. Nov. 30, 1956 [86]p. incl. diagrs. tables, refs. (AFOSR-TN-56-499) (AF 18(600)1489) AD 110335 Unclassified

Also published in Advances in Phys., v. 6: 102-144, Jan. 1957.

Better experimental values of the index of refraction and the absorption index were sought to find (1) the limits of validity of the free-electron theory of metals proposed by Drude and (2) experimental procedures yielding information of interest to solid state physics. The Drude theory was valid to within the experimental accuracy from $\lambda = 0.4$ to 0.57μ for both liquid Hg and liquid Ga at room temperature (25°C). Reflectivity measurements alone suggest that the theory is valid down to $\lambda = 0.25\mu$. Beyond about 2μ the Drude theory passes into that for the classical skin effect where the number of free electrons is of no significance and only the dc conductivity of the metal determines the optical properties. For $\lambda > 2\mu$, good agreement with theory resulted for solid Ag and Au when the mass (m) of the electron equalled its effective mass (m^*) and for solid Cu when $m^*/m = 1.45$. The liquid Hg-In and Hg-Tl alloys showed no agreement with the Drude theory. The reflectivity of a liquid Ga-In alloy was independent of the composition. Preliminary reflectivity measurements on pure liquid In agreed with the Drude theory to the limits of the experimental accuracy. When 2 liquid metals which follow the Drude theory are combined the resulting alloy does not necessarily follow the theory. Values of m^*/m are tabulated for Ag, Au, Cu, and Al and compared with previous literature values obtained from optical experiments and from electronic specific heat determinations. Agreement is sufficiently close to show that the respective values are concerned with the same quantity.

CHI. 13:007

Chicago U. Inst. for the Study of Metals, Ill.

EVIDENCE FOR VACANCY MECHANISM IN INTERMETALLIC DIFFUSION, by L. Slifkin and C. T. Tomizuka. [1956] [2]p. incl. diagr. (Sponsored jointly by Atomic Energy Commission and [Air Force Office of Scientific Research under AF 18(600)1489]) Unclassified

Published in Phys. Rev., v. 104: 1803 1804, Dec. 15, 1956.

An analysis is made of recent data (Kuper, et al, Phys. Rev., v. 104: 1536 1541, Dec. 15, 1956) of self diffusion in 47-48 atomic % Zn copper-zinc (beta brass) with regard to the ratio (G) of the coefficients of self-diffusion. Atomic movement by a vacancy mechanism involving nearest neighbor jumps would result in equal diffusion coefficients for both species whereas migration of atoms interstitially would not. Comparison of the experimental results and the calculated dependence of G on the long-range order parameter s for beta brass indicate a satisfactory agreement between the experimental and predicted results. The experimental results on the diffusion of antimony in the beta brass, which are explainable in terms of the interstitialcy mechanism, appear to require further experimental confirmation. Investigation of the diffusion of other impurities is also required before definite conclusions can be made as to the behavior of the impurity atoms in the ordered lattice. It is proposed that the experiments on beta brass constitute convincing evidence for the vacancy mechanism.

CHI. 14:001

Chicago U. Inst. of Radiobiology and Biophysics, Ill.

CONCERNING THE USE OF HIGH ENERGY PARTICLES AND QUANTA IN THE DETERMINATION OF THE STRUCTURE OF LIVING ORGANISMS, by R. J. Moon. [1953] 7p. illus. diagr. (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)566, Public Health Service, and Office of Naval Research under N6ori-02029) Unclassified

Presented at the I. R. E. Convention, New York, Mar. 26, 1953.

The important basic principles for the determination of the structure of living organisms by means of high energy quanta and particles are developed. Primary emphasis is put upon obtaining the information relative to structure of the organisms with a minimum amount of damage to it and a maximization of the amount of information derived. Several instruments are considered with reference to their ability to fulfill these conditions. Systems which employ "thick detectors" and derive their information in serial time sequence seem to fulfill these conditions best. Experimental work, with a scanning x-ray system, which has been performed with regard to these principles is described. (Contractor's abstract)

CHI. 14:002

Chicago U. Inst. of Radiobiology and Biophysics, Ill.

THE SCANNING X-RAY SYSTEM AS A FLUOROSCOPE AND MICROSCOPE, by R. J. Moon. [1953] 9p. illus. diagrs. (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)566, Public Health Service, and Office of Naval Research under N6ori-02029) Unclassified

Presented at the Seventh International Congress of Radiology, Copenhagen (Denmark), 1953.

The development, characteristics, and use are described of an x-ray scanning system employing single large fluorescent crystal detectors to study

microscopic and macroscopic objects, including living tissue, with minimal distortion. X-ray quanta transmitted from the intense scanning microbeam, are converted by the thick detector into proportional fluorescent light which is converted into electrical impulses by a photomultiplier tube, then amplified and passed through a pulse sorter to produce "color x-ray images" on a kinescope. When quantum yields are low, a memory tube driven by the timing device of the scanning x-ray tube produces a sharp image which is then read out by the kinescope.

CHI. 14:003

Chicago U. Inst. of Radiobiology and Biophysics, Ill.

ELECTROSTATIC POTENTIAL PLOTTING FOR USE IN ELECTRON OPTICAL SYSTEMS, by K.-C. Ho and R. J. Moon. [1953] [27]p. incl. illus. diagrs. tables. [Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)566, Public Health Service, and Office of Naval Research under N6ori-02029] Unclassified

Also published in Jour. Appl. Phys., v. 24: 1186-1193, Sept. 1953.

A non-iterative numerical method has been found for solving a partial differential equation, when its boundary conditions are not known, on the entirety of a closed boundary. Under such conditions, the iterative numerical methods which are generally used, such as the relaxation technique, are not applicable. As an example, this non-iterative numerical method has been used to calculate the shapes of a pair of beam-forming electrodes for use in an electron gun in which rectilinear flow is desired. The calculated shapes are in almost complete agreement with Pierce's experimental results. Equipotential surfaces calculated by this method have been checked by means of an electrolytic trough which employs a semi-automatic detecting and plotting system. (Contractor's abstract)

CHI. 14:004

Chicago U. Inst. of Radiobiology and Biophysics, Ill.

THE SCANNING ROENTGEN SYSTEM AS A FLUOROSCOPE AND MICROSCOPE, by R. J. Moon. [1954] [9]p. incl. illus. diagrs. (AF 18(600)566) Unclassified

Also published in Acta Radiologica (Stockholm), Supplementum 116: 479-487, 1954.

The scanning roentgen system has been used for the study of structure of microscopic and macroscopic objects. The resolution of the instrument has been measured. An extrapolation of the results so far achieved indicates that a microscope with 10 to 100 times resolving power of the usual optical microscope may be achieved with sufficiently minute pinholes. If a Patterson B screen is placed between the object and the detector and its brightness photometered while the object is being scanned, and this brightness compared with the photometered brightness of the kinescope screen, the brightness gain is found to be of the order of a million to one. Useful magnifications of several hundred times have been achieved. (Contractor's summary)

CHI. 15:001

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

[COMPUTATIONS IN QUANTUM CHEMISTRY], by R. S. Mulliken, C. W. Scherr and others. Technical rept. 1953-1954, Part II, 434p. incl. illus. diagrs. tables, refs. [AFOSR-TN-55-94] (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)471, Office of Naval Research under N6ori-20, T.O. 9, and Office of Ordnance Research under DA-11-022-ord-1002) AD 62123 Unclassified

This report is issued under contract AF 18(600)471 with the Air Force Office of Scientific Research (AFOSR), contract N6ori-20, task order 9 with the Office of Naval Research (ONR), and contract DA-11-022-ord-1002 with the Office of Ordnance Research (OOR). It covers approximately the period of Oct. 1, 1952 to Sept. 30, 1954 for the AFOSR contract, and the period of Apr. 1, 1954 to Sept. 30, 1954 for the ONR and OOR contracts. The following technical papers, prepared by the Laboratory of Molecular Structure and Spectra, Department of Physics, University of Chicago staff members under the above AFOSR contract, are presented:

(1) AN SCF [SELF-CONSISTENT FIELD] LCAO [LINEAR COMBINATION OF ATOMIC ORBITALS] STUDY OF N_2, by C. W. Scherr. n.d. [23]p. incl. tables, diagrs.
(2) STRUCTURES OF THE HALOGEN MOLECULES AND THE STRENGTHS OF SINGLE BONDS, by R. S. Mulliken, n.d. [10]p.
(3) BOND ANGLES IN WATER-TYPE AND AMMONIA-TYPE MOLECULES AND THEIR DERIVATIVES, by R. S. Mulliken. n.d. [17]p. incl. tables, diagrs.
(4) A STUDY OF TWO-CENTER INTEGRALS USEFUL IN CALCULATIONS ON MOLECULAR STRUCTURE. IV. THE AUXILIARY FUNCTIONS $C_{\alpha\beta}^{\gamma L'}(\rho_a \rho_b)$ for $\alpha \geq 0$, by C. C. J. Roothaan. n.d. [32]p. incl. tables, diagrs.
(5) ELECTRONIC POPULATION ANALYSIS ON LCAO-MO MOLECULAR WAVE FUNCTIONS, by R. S. Mulliken. n.d. [43]p. incl. tables, diagrs.

Each of the above papers is abstracted and subject indexed individually.

CHI. 15:002

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

STRUCTURES OF THE HALOGEN MOLECULES AND THE STRENGTHS OF SINGLE BONDS, by R. S. Mulliken. [1955] [10]p. refs. (Rept. no. 1) (Bound with its Technical rept. 1953-1954 Part II,

CHI. 15:003 - CHI. 15:005

[AFOSR-TN-55-94]; AD 62123) (AF 18(600)471)
Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 884-887, Feb. 20, 1955.

In this study, it is pointed out that a very low dissociation energy for F_2 is consistent with the exceptionally large observed reduced interatomic distance and with other empirical properties of F_2. Theoretical reasons for a low value are discussed in terms of MO (molecular orbital) and VB (valence-bond) theory. In MO theory, the fact that antibonding MO's are more powerfully antibonding than bonding MO's are bonding provides a reasonable explanation, in view of the fact that F_2 contains 3 pairs of antibonding as against 4 pairs of bonding electrons. The corresponding explanation in VB theory is that the numerous lone-pair and other nonbonded repulsions largely cancel out the effect of the 1 bonding electron pair. In Cl_2 and higher-row halogens, on the other hand, even rather small amounts of $d\sigma$ and $d\pi$ hybridization should suffice, in MO theory, to strengthen the bonding MO's and to weaken the antibonding MO's very considerably. Thus d hybridization may reasonably account, in spite of the adverse factor of increased inner-shell: outer-shell nonbonded repulsions in VB theory, or "forced hybridization" in MO theory, for the observed relatively much smaller reduced interatomic distance and larger dissociation energy in Cl_2 than in F_2. In VB theory, d hybridization involves a considerable amount of multiple bond character in the Cl-Cl "single" bond, this being absent in F_2. Similar considerations apply to other second-row (e.g., P-P and S-S) and analogous higher row single bonds. In connection with the discussion of Cl_2, it is shown how the use of "unnatural" d orbitals with increased Z values can be legitimate and important in p-d hybridization. (Contractor's abstract)

CHI. 15:003

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

BOND ANGLES IN WATER-TYPE AND AMMONIA-TYPE MOLECULES AND THEIR DERIVATIVES, by R. S. Mulliken. [1955] [13]p. incl. diagrs. tables, refs. (Rept. no. 2) (Bound with its Technical rept. 1953-1954, Part II, [AFOSR-TN-55-94]; AD 62123) (AF 18(600)471) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 887-891, Feb. 20, 1955.

In this study, the factors which may determine the smaller bond angles in the hydrides of the higher-row fifth-column and sixth-column atoms as compared with NH_3 and H_2O, and the much larger energies required to flatten PH_3 and AsH_3 to planar form than for NH_3, are discussed using LCAO (linear combination of atomic orbitals) molecular-orbital and valence-bond theory. It is shown that the observed differences can reasonably be understood as a result of d hybridization in the e-type or b_2 type bonding molecular orbitals, together, perhaps, with smaller nonbonded repulsions between H atoms, in the higher-row hydrides. Significant factors affecting the bond angles in the halides of fifth-column and sixth-column atoms are also surveyed. (Contractor's abstract)

CHI. 15:004

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

A STUDY OF TWO-CENTER INTEGRALS USEFUL IN CALCULATIONS ON MOLECULAR STRUCTURE. IV. THE AUXILIARY FUNCTIONS $C_{\alpha\beta}{}^{\gamma\delta\varepsilon}(\rho_a, \rho_b)$ FOR $\alpha \geq 0$, by C. C. J. Roothaan. [1955] [32]p. incl. tables. (Rept. no. 3) (Bound with its Technical rept. 1953-1954, Part II, [AFOSR-TN-55-94]; AD 62123) (AF 18(600)471) Unclassified

Also published in Jour. Chem. Phys., v. 24: 947-960, May 1956.

A new method is developed for the numerical computation of the auxiliary functions $C_{\alpha\beta}{}^{\gamma\delta\varepsilon}(\rho_a, \rho_b)$ which are used in Technical rept. 1953-1954, Part II, p. 137 (I) in this series, for the case $\alpha \geq 0$. The present method is suitable for all values of the parameter $\tau = (\rho_a - \rho_b)/(\rho_a + \rho_b)$, avoiding the excessive loss of significant figures which occurs in the methods developed in the earlier report (I) for the physically important case of small τ. (Contractor's abstract)

CHI. 15:005

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

ELECTRONIC POPULATION ANALYSIS ON LCAO-MO MOLECULAR WAVE FUNCTIONS, by R. S. Mulliken. [1955] [43]p. incl. diagrs. tables, refs. (Rept. no. 4) (Bound with its Technical rept. 1953-1954, Part II, [AFOSR-TN-55-94]; AD 62123) (AF 18(600)471) Unclassifted

Also published in Jour. Chem. Phys., v. 23: 1833-1846; 2338-2346, Oct., Dec. 1955.

In this study, it is pointed out that with the increasing availability of good all-electron LCAO MO (linear combination of atomic orbital-molecular orbital) wave functions for molecules, a systematic procedure for obtaining maximum insight from such data has become desirable. A useful analysis in quantitative form can be made in terms of various breakdowns of the electronic population into partial and total "gross atomic populations," or into partial and total "net atomic populations" together with "overlap populations." Gross atomic populations are so defined as to distribute the electrons almost perfectly among the various AO's (atomic orbitals) of the various atoms in the molecule. From these numbers, a definite figure is obtained for the amount of promotion (e.g., from 2s to 2p) or (what is the same thing) of "gross hybridization," in each atom, and

also for the gross charge Q on each atom if the bonds are polar. The total overlap population for any pair of atoms in a molecule is in general made up of positive and negative contributions. If the total overlap population for 2 atoms is positive, they are bonded; if negative, they are antibonded. The latter situation is described in the language of AO-VB [valence-bond] (generalized Heitler-London) theory, by saying that there is a nonbonded repulsion between them. In LCAO-MO theory, besides gross hybridization, "forced" and "free" hybridization must be distinguished. The former makes negative and the latter positive contributions to overlap populations and covalent resonance energies. The negative contributions from forced hybridization in LCAO theory correspond to various nonbonded repulsions which occur even between bonded atoms in AO-VB theory. Free hybridization in LCAO theory corresponds to ordinary hybridization in AO-VB theory. Its effect can be determined from the gross atomic populations, and expressed as amount of promotion or gross hybridization. Overlap populations give in general more flexible and probably better measures of covalent resonant and bond energies than do bond orders, since they reflect directly the effects of both forced and free hybridization, as well as of conjugation or mesomerism. Bond orders are, essentially, covalent resonance energies expressed in units of LCAO parameters β. Various kinds of bond orders are discussed in the appendix. In general, if all β's are assumed to be proportional to corresponding overlap integrals S times suitable mean atomic ionization energies Ī, a simple approximate formula for covalent resonance energies is obtained in terms of partial overlap populations and Ī's, including 1 or 2 empirical coefficients. This formula indicates that forced hybridization resulting from inner shells should make important negative contributions to bond energies. The application of the formula to H_2, CO, and H_2O is discussed. The assumption of proportionality of β values to SĪ values may also be useful in estimating unknown β values. Tables of gross atomic populations, overlap populations, and gross atomic charges Q computed from SCF (self-consistent-field) LCAO-MO data on CO and H_2O, are given. The degree of s-p promotion or gross isovalent hybridization is found to be nearly the same for the O atom in CO and in H_2O (14% in CO and 15% in H_2O). For the C atom in CO it is 50%. For the N atom in N_2 it is 26% according to calculations by Scherr. In spite of very strong polarity in the π bonds in CO, the σ and π overlap populations are very similar to those in N_2. In CO the total overlap population for the π electrons is about twice that of the σ electrons. The most easily ionized electrons of CO are in a MO such that the gross atomic population is 94% localized on the C atom. These electrons account for the (weak) electron donor properties of CO. A comparison between changes of bond lengths observed on removal of an electron from one or another MO of CO and H_2 and corresponding changes in computed overlap populations shows good correlation. (Contractor's abstract, modified)

CHI. 15:006

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

AN SCF LCAO MO STUDY OF N_2, by C. W. Scherr. [1955] [23]p. incl. diagrs. tables, refs. (Bound with its Technical rept. 1953-1954, Part II; [AFOSR-TN-55-94]; AD 62123) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)-471, and Office of Naval Research under N6ori-20, T. O. 9) Unclassified

Also published in Jour. Chem. Phys., v. 23: 569-578, Mar. 1955.

The self-consistent-field molecular orbital (SCF MO) method in the LCAO (linear combination of atomic orbitals) approximation is applied to the ground-state configuration of the N_2 molecule at the observed equilibrium internuclear separation. No other approximations are used. All electrons are included. The forms of the resulting molecular orbitals are discussed. The s-p hybridization is computed to be 26.1% in agreement with Mulliken's Magic Formula estimation of 21%. The quadrupole moment is computed to be -1.87 atomic units (experiment, 1.11 atomic units of undetermined sign). The ratio of the computed to the experimental total molecular energy is found to be .9905. Ionization potentials and single-electron excitation energies are computed, and compared with experimental spectroscopic values. The spectral results are more encouraging than have been hitherto reported from calculations by the LCAO MO method. The approximation of neglecting the inner-outer-shell mixing, as it has usually been done in computations of this type, changes the present results and is not recommended. (Contractor's abstract)

CHI. 15:007

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

CORRIGENDA: AN SCF LCAO MO STUDY OF N_2 [THIS TECHNICAL REPORT, 1953-1954, PART II, p. 241-263] by C. W. Scherr. [1955] [1]p. incl. diagrs. (Bound with its Technical rept. 1955, [AFOSR-TN-56-79]; AD 81531) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)471 and Office of Naval Research under N6ori-20, T. O. 9) Unclassified

Corrections are presented on item no. CHI. 15:006. They include corrections to the orbital energies (ionization potentials) and single electron excitation energies found on page 254 of the original report, and to an equation found on page 262.

CHI. 15:008

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

COMPUTATIONS IN QUANTUM CHEMISTRY [], by R. S. Mulliken, C. W. Scherr and others. Technical rept. 1955, 253p. incl. diagrs. tables, refs.

CIN. 01:001 - CIN. 03:001

[AFOSR-TN-56-79] (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)471, Office of Naval Research under N6ori-20, T.O. 9, Office of Ordnance Research under DA-11-022-ord-1002, and AFCRC Geophysics Research Directorate under AF 19(604)1019) AD 81531 Unclassified

This report is issued jointly under contract AF 18(600)-471 with the Air Force Office of Scientific Research (AFOSR), contract AF 19(600)1019 with the Air Force Cambridge Research Center (AFCRC), contract N6ori-20, task order 9 with the Office of Naval Research (ONR), and contract DA-11-022-ord-1002 with the Office of Ordnance Research (OOR). It covers approximately the period Oct. 1, 1954 to Sept. 30, 1955 for the AFOSR, ONR, and OOR contracts, and the period January 26, 1954 to Sept. 30, 1955 for the AFCRC contract. The following item is the only one concerning an AFOSR-sponsored project contained in this report:

Chicago U. Lab. of Molecular Structure and Spectra, Ill.

AN SCF LCAO MO STUDY OF N_2 [THIS TECHNICAL REPORT, 1953-54, PART II, [P.] 219] CORRIGENDA, by C. W. Scherr. n.d. [1]p. incl. diagrs., Item no. CIII. 15:007.

CIN. 01:001

Cincinnati U. Applied Science Research Lab., Ohio.

A STUDY OF SELECTIVE OXIDATIVE CLEAVAGE OF OLEFINIC BONDS, by W. Soller, C. E. Frank and others. Final rept. Oct. 1, 1954, 22p. incl. tables, refs. [AFOSR-TR-55-2] (AF 18(600)351) Unclassified

Research was conducted to define conditions such that oxidative attack by atmospheric oxygen would occur at the double bond. Cyclohexene was employed as a model compound in the hope of achieving the following transformation: $CH_2CH_2CH_2CH_2CH = CH \longrightarrow$

$$HOOCCH_2CH_2CH_2CH_2COOH.$$

In the first series of experiments, homogeneous free radical conditions were employed. A stream of air was passed through a solution of the hydrocarbon in the presence of free radical initiators, ultraviolet light, and transition metal catalysts. When the reaction was conducted in the presence of CH_3COOH-$(CH_3CO)_2O$, it was possible to isolate 3-cyclohexenol acetate and 1,2-cyclohexanediol diacetate. Neither adipic acid nor its ester could be isolated. The original objective was abandoned, and attempts were made to devise alternate processes of producing dibasic acids. Preliminary studies with undecylenic acid, utilizing an alkaline fusion technique, gave pelargonic acid under extreme conditions. The only identifiable products were 3-cyclohexenol acetate, and 1,2-cyclohexanediol diacetate. Adipic acid could not be found in the undistillable residue.

CIN. 02:001

Cincinnati U. Applied Science Research Lab., Ohio.

DIELECTRIC DISPERSION IN VISCOUS POLAR LIQUIDS (Abstract), by J. W. Winslow, R. J. Good, and P. E. Berghausen. [Dec. 17, 1956] [4]p. incl. diagrs. tables, refs. (AFOSR-TN-56-290) (AF 18-(600)1318) AD 90001 Unclassified

Presented at the National Research Council Conference on Electrical Insulation, Schenectady, N. Y., Oct. 8-10, 1956.

Also published in Jour. Chem. Phys., v. 27: 309-312, July 1957.

The low-frequency dielectric dispersion of tolyl xylyl sulfone, pentachlorobiphenyl and hexachlorobiphenyl follow the Davidson-Cole equation for "skewed arc":

$$\varepsilon^* = \varepsilon_\infty + \frac{\varepsilon_0 - \varepsilon_\infty}{(1 + i\omega\tau_0)^\beta}$$

rather than the Cole-Cole equation for "semicircular arc with depressed center." β lay in the range 0.50-0.65. This behavior (with β in the range 0.50-0.65) had previously been observed only for glycerol and propylene glycol. On dilution with o-terphenyl, obedience to equation with low values of β was maintained rather than the expected approach of β to unity ("Debye behavior"). It is concluded that departure from "Debye behavior" is not directly related to chemical structure or to the effect of dipoles on the internal field. (Contractor's abstract)

CIN. 03:001

Cincinnati U. Dept. of Mathematics, Ohio.

QUESTIONS OF SIGNS IN POWER SERIES, by W. B. Jurkat. Sept. 30, 1953, 12p. (AF 18(600)691) Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 964-970, Dec. 1954.

This paper deals with the signs of the (real) coefficients of a power series $k(x) = \sum_{\nu=0}^{\infty} k_\nu x^\nu$, which is the quotient of the two power series $q(x) = \sum_{\nu=0}^{\infty} q_\nu x^\nu$ and $p(x) = \sum_{\nu=0}^{\infty} p_\nu x^\nu$. Questions of this type have been previously treated by Kaluza (1928) and Szegö (1926) in the special case of $q(x) = 1$. By consideration of a general power series $q(x)$ instead of $q(x) = 1$, it is possible to include the known results of this subject in a single theorem. Moreover the method of proof used allows us to establish a second type of theorem using simpler conditions. For this second type of theorem the introduction of a general $g(x)$ is essential for applications, because the results are still trivial for $g(x) = 1$. There are two different principles to generalize. Thereby the second kind of theorem becomes also applicable in the case of $q(x) = 1$. The statements now obtained can even be used

conversely for a second proof of the theorems first obtained. The results of this paper are fundamentally for application to inclusion of Nörlund means and related questions. (Contractor's abstract, modified)

CIN. 03:002

Cincinnati U. [Dept. of Mathematics] Ohio.

ON RELATIONSHIPS BETWEEN NÖRLUND MEANS FOR DOUBLE SERIES, by C. N. Moore. [1954] [7]p. (AFOSR-TN-54-1) (AF 18(600)691) AD 36739 Unclassified

Also published in Proc. Amer. Math. Soc., v. 5: 957-963, Dec. 1954.

Certain theorems concerning relationships between Nörlund means for single series are generalized to double series. If p_{ij}, q_{ij} are two infinite sequences of non-negative numbers, the author writes

$$P_{mn} = \sum_{i=0,\ j=0}^{m,\ n} p_{ij}, \qquad Q_{mn} = \sum_{i=0,\ j=0}^{m,\ n} q_{ij},$$

$$N_{mn}^{(p)}(s) = \sum_{i=0,\ j=0}^{m,\ n} p_{m-i,\,n-j} s_{ij} / P_{mn}$$

(and p, P replaced by q, Q), where the s_{ij} are the partial sums of a double series $\sum u_{ij}$, which remain bounded for all (i, j). Necessary and sufficient conditions for the regularity of Nörlund means for such double series have been given by the author in his book (Summable Series and Convergence Factors. Amer. Math. Soc. Colloq. Publ., v. 22, New York, 1938, Ch. II, Th. II). It is now shown that any two regular Nörlund methods for summing double series where each row and each column furnishes a regular method for simple series are consistent. Next, if (N, p_{mn}) and (N, q_{mn}) are two such regular Nörlund methods, necessary and sufficient conditions are found in order that (N, q_{mn}) should include (N, p_{mn}). Finally, necessary and sufficient conditions are obtained in order that (N, p_{mn}) and (N, q_{mn}) should be equivalent (mutually consistent). (Math. Rev. abstract)

CIN. 03:003

Cincinnati U. Dept. of Mathematics Ohio.

FUNCTIONAL NÖRLUND METHODS, I, by K. Knopp and B. Vanderburg. Mar. 1954, 45p. (Rept. no. 6) ([AF]OSR-TN-54-68) (AF 18(600)691) AD 29030 Unclassified

Also published in Rend. Circ. Mat. Palermo, v. 4: 5-32, 1955.

The treatment of R. Kuttner (Proc. London Math. Soc., v. 47: 142-173, Feb. 1941) of the Nörlund methods for the summability of series or the limitability of sequences is extended to a consideration of integrals and functions. Special inclusion theorems are proved, and proofs are presented for the functional case of the analogs to the theorem of M. Riesz for series (Proc. London Math. Soc., v. 22: 412-419, Feb. 1924). Necessary and sufficient conditions are given for the inclusion $N_p \subseteq N_q$ and the equivalence $N_p \sim N_q$; N_p and N_q denote different Nörlund methods. The proofs contain weaker hypotheses than those of Kuttner and remain in the real domain.

CIN. 03:004

Cincinnati U. [Dept. of Mathematics] Ohio.

FUNCTIONAL NÖRLUND METHODS, II, by K. Knopp. Apr. 1954, 21p. (Rept. no. 7) ([AF]OSR-TN-54-100) (AF 18(600)691) AD 32359 Unclassified

Two general theorems are proved about integral transformations $\sigma(x) = \int_0^{\infty} a(x, t)s(t)dt$ with sufficient conditions given to transform a function s(t) of bounded variation into a function $\sigma(x)$ of the same kind or into a convergent function. Based on these theorems, 2 theorems on absolute inclusion and 3 theorems on multiplication are given; the latter are analogs of certain theorems proved by F. M. Mears for series. The 3 theorems correspond to known theorems on series by Cesaro, Belinfante, and Mertens. (ASTIA abstract)

CIN. 03:005

Cincinnati U. [Dept. of Mathematics] Ohio.

AN EXTENSION PROBLEM FOR FUNCTIONS WITH MONOTONIC DERIVATIVE, by W. B. Jurkat. May 1954, 14p. (Rept. no. 8) ([AF]OSR-TN-54-118) (AF 18(600)691) AD 32470 Unclassified

The problem is to find a function f(x), that is the n^{th} integral of a nondecreasing function for all $x(-\infty < x < \infty)$, with the property $f(x) = F(x)$ for all large positive x and $f(x) = 0$ for all large negative x. F(x) is the n^{th} integral of a positive nondecreasing function for all large positive x. A complete solution is given by means of the theory of moment problems, and for a large class of functions F(x) the problem can easily be settled.

CIN. 03:006

Cincinnati U. [Dept. of Mathematics] Ohio.

ON CONVERGENCE FIELDS OF NÖRLUND MEANS, by A. Peyerimhoff. June 1954, 15p. (Rept. no. 9) ([AF]OSR-TN-54-136) (AF 18(600)691) AD 35483 Unclassified

CIN. 03:007 - COL. 01:001

Also published in Proc. Amer. Math. Soc., v. 7: 335-347, June 1956.

Given a function $p(z) = \sum P_n z^n$, regular for $|z|<1$, and corresponding to a Nörlund mean, the convergence fields of $p(z)$ and $\zeta(z);(z)$, where $\zeta(z)$ is a polynomial, are compared. The following result is obtained. If $p_n = O(P_n)$ $(P_n = \sum_{v=0}^{n} p_v)$, and if $\zeta(z) \neq 0$ for $|z| = 0$, the convergence field corresponding to $\zeta(z)p(z)$ is obtained by adding the sequences of the convergence fields corresponding to $p(z)$ and $\zeta(z)$. A similar result is obtained for absolute Nörlund summability. The convergence fields of some Cesàro and discontinuous Riesz means are compared.

CIN. 03:007

Cincinnati U. [Dept. of Mathematics] Ohio.

THE CONSISTENCY OF NÖRLUND AND HAUSDORFF METHODS (SOLUTION OF A PROBLEM OF E. ELIRICH), by W. B. Jurat and A. Peyerimhoff. June 1954, 11p. (Rept. no. 11) ([AF]OSR-TN-54-145) (AF 18(600)691) AD 75436 Unclassified

Also published in Ann. Math., v. 62: 498-503, Nov. 1955.

Two summability methods are said to be consistent if they cannot sum the same series to different sums. It is well-known that all regular Hausdorff methods are consistent, as well as all regular (real) Nörlund methods. It is the problem of E. Ullrich whether these two classes of methods together are consistent. The paper gives an affirmative answer to this question, and the corresponding question for functional methods. In the course of our proof we obtain a result concerning the analytic extension by Hausdorff methods which is interesting in itself. A special case of this result was previously obtained by Agnew. (Contractor's abstract)

CIN. 03:008

[Cincinnati U. Dept. of Mathematics, Ohio]

[THEORY OF NÖRLUND MEANS] by C. N. Moore, K. Knopp and others. June 15, 1954, 12p. ([AF]OSR-TR-54-16) (AF 18(600)691) Unclassified

Investigations are reported concerning the theory of Nörlund means applied to summation of series. The report is comprised of brief separate summaries by (1) C. N. Moore on relationships of Nörlund means for double, triple, and multiple series; (2) K. Knopp and B. Vanderburg on various properties of functional Nörlund means, as well as a proof of the main Tauberian theorem for the C_k- and H_k methods of Knopp; (3) H. D. Lipsich on Nörlund transformations and convergence of series; and (4) W. Jurkat and A. Peyerimhoff concerning establishment of various inclusion theorems.

CIN. 03:009

Cincinnati U. [Dept. of Mathematics] Ohio.

ON THE PROOF OF THE MAIN TAUBERIAN THEOREM FOR THE C_k- AND H_k- METHODS, by K. Knopp. [1954] 4p. (AF 18(600)691) AD 35966 Unclassified

Also published in Proc. Amer. Math. Soc., v. 5: 571-573, Aug. 1954.

An inductive proof is given of the following theorem: if the a_v are real, $k>0$, and (1) $\sum_0^\infty a_v = s\ (C_k)$ (2) $va_v \leq M$, $(v = 0, 1, 2, \ldots)$, where M is independent of v, then (3) $\sum a_v = s$. The theorem for $k = 1$, the fundamental Hardy-Landau theorem (Hardy, G. H., Divergent Series, p. 145, Oxford, 1949), is assumed to be true. The theorem is first proved for the H_k-method, and then proved again more directly with the aid of the fact that C_k implies $C_1 C_{k-1}$. The following result is also given: Let (B) $a_n = \sum_v b_{nv} a_v$, $(n = 0, 1, 2, \ldots)$, be a series-to-series transform of the series $\sum a_v$ into the series $\sum a_n$. Let (4) $a_v = 0(c_v)$ be a Tauberian condition for the summation method B. Then condition 4 is also a Tauberian condition for the method $B \cdot B = B^2$ and therefore for all iterated methods $B^k = B \cdot B^{k-1}$, $(k = 2, 3, \ldots)$, if $\sum |b_{nv} c_v| = 0(c_n)$. If B is regular and 4 is a best Tauberian condition for the method B, then it is also a best condition for the method B^k. This theorem, and the last addition to it, are true for a 1-sided Tauberian condition $a_v = 0_R(c_v)$ for real a_v if the b_{nv} are ≥ 0 and $\sum_v b_{nv} c_v = 0_R(c_n)$.

COL. 01:001

Colorado U. Dept. of Chemistry, Boulder.

SOME DERIVATIVES OF 2-AMINO-3-BROMOTETRAHYDROPYRAN, by E. F. Godefroi, J. S. Meek, and J. R. Clopton. Nov. 20, 1954 [2]p. [AF 18(600)648] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 5788-5789, Nov. 20, 1954.

During the course of investigation of the preparation of nucleotide-like compounds a number of derivatives of 2-amino-3-hromotetrahydropyran were prepared. Dihydropyran was quantitatively converted to 2, 3-dibromotetrahydropyran (I). Treatment of I with silver cyanate resulted in a 92% yield of 3-bromo-2-tetrahydropyranyl isocyanate (II). The action of aqueous ammonia on II gave the corresponding urea (III); the disubstituted urea, 1, 2, bis-(3-bromo-2-tetrahydropyranyl)-urea (IV), could be obtained by the hydrolysis of II, whereas the reaction of II with absolute ethyl alcohol afforded the urethan (V). Furthermore,

when II reacted with ethyl glycinate, ethyl-3-bromo-2-tetrahydropyranylhydantoate (VI) was obtained. The reaction of 2,3-dibromotetrahydropyran with silver thiocyanate gave upon distillation the thiocyanate (VII). The reaction of 2,3-dibromotetrahydropyran and o-bromoaniline gave N-(3-bromo-2-tetrahydropyranyl)-o-bromoaniline (VIII), in good yield. (Contractor's abstract, modified)

COL. 01:002

Colorado U. Dept. of Chemistry, Boulder.

THE OXIMES OF 9-ANTHRALDEHYDE, by J. S. Meek and J. R. Dann. Dec. 20, 1955 [2]p. [AF 18(600)-648] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 6677-6678, Dec. 20, 1955.

$NH_2OH.HCl$ (I) (7 g) and 15 g 9-anthraldehyde (II) gave 15.5 g syn-9-anthraldoxime (III), long yellow needles, mp 165-6° (from EtOH). II (5 g) and 5 g I in 25 cc pyridine and 25 cc absolute EtOH heated 1.5 hr on the steam bath, the pyridine and EtOH removed during 4 hr on the steam bath under an air jet, and the solid residue ground with 25 cc H_2O, filtered, and washed with 10 cc. H_2O gave 5.2 g anti-9-anthraldoxime (IV), mp 218-20° (from EtOH). IV (2 g) heated on the steam bath 0.5 hr in 50 cc 5% aq NaOH was dissolved only to a trace amount. III. (0.200 g) in 10 cc. EtOH containing 2 drops concentrated HCl heated 17 hr at 75° and cooled gave 0.150 g IV, mp 218-20°. III and IV (0.22 g each) warmed 10 min on the steam bath in 2 cc Ac_2O, and solution basified with 2 g Na_2CO_3 in 10 cc H_2O, and filtered gave from III the acetate, mp 132-3°, which refluxed 15 min with Ac_2O gave 9-cyanoanthracene (V); IV gave V, mp 173-4°, directly. CH_2:$CHCH_2Cl$ (0.5 cc) and 0.2 g NaOH in 2 cc H_2O and 10 cc EtOH heated to 80° with 1.1 g III, cooled, treated with an additional 0.5 cc CH_2:$CHCH_2Cl$, heated again to 70°, cooled, and diluted with 25 cc H_2O gave 0.4 g o-allyl-syn-9-anthraldoxime (VI), mp 85-6°, and a low-melting, polymeric material. VI (0.1 g) heated 10 min at 200° was converted partially to an oil, 0.04 g was recovered unchanged. IV (1.1 g), 2 cc CH_2:$CHCH_2Cl$, and 0.2 g NaOH in 2 cc H_2O and 50 cc. EtOH refluxed 20 min and diluted hot with 10 cc H_2O gave 0.90 g crude solid which crystallized gave 0.55 g V. III heated with CH_2:$CHCH_2OH$, CH_2:$CHCO_2H$ in aq NaOH, CH_2:$CHCH_2Cl$, CH_2:$CHCOCl$, and refluxed with CH_2:$CHCONH_2$ in zylene gave little evidence of adduct formation. III (1.1 g) in 10 cc 5% aq NaOH and 6 cc. CH_2:$CHCH_2OH$ refluxed 21 hr gave 1.1 g V, mp 175-6° cc. Either III or IV, treated with CH_2:$CHCOCl$, gave V. (C. A., 1956:9362a)

COL. 01:003

Colorado U. Dept. of Chemistry, Boulder.

THE SYNTHESIS OF β-CYCLOPROPYL-α-AMINOPROPIONIC ACID, by J. S. Meek and J. W. Rowe. Dec. 20, 1955 [2]p. [AF 18(600)648] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 6675-6677, Dec. 20, 1955.

Cyclopropylcarbinol (72g) in 300 cc dry Et_2O treated with cooling with dry ice-Me_2CO and stirring slowly with 35 cc PBr_3, the mixture warmed to room temperature, diluted with 10 cc H_2O, and the Et_2O layer worked up gave 357 g cyclopropylcarbinyl bromide (I), b_{627} 101.5-102°, $d_{26.5}$ 1.433. $OHCNHCH(CO_2Et)_2$ (II) (101.5 g) refluxed 5-10 min with 11.5 g Na in 500 cc. Absolute EtOH, treated with 70.2 g I, refluxed 20 hr filtered, and worked up gave 68.2 g. Et cyclopropylcarbinylformamidomalonate (III), white crystals, mp 65-6° (from 30% EtOH). CH_2:$CHCH_2$ CH_2OH (from CH_2:$CHCH_2Cl$ with Mg and paraformaldehyde) treated with PBr3 gave CH_2:$CHCH_2CH_2Br$ (IV), b_{610} 91-2° n_D^{20} 1.4607. IV (9.5 g) condensed with II yielded 10.8 g CH_2:$CHCH_2CH_2C(NHCHO)(CO_2Et)_2$ (V), mp 94-4.5° (from aqueous EtOH). V in EtOH). V in EtOH hydrogenated under ambient conditions over a catalyst yielded $OHCNHCBu(CO_2Et)_2$, mp 82.5-83°. III (25.7 g) refluxed 8 hr with 250 cc 10% HBr and evaported to dryness in vacuo on the water bath, the residual solid dissolved in 500 cc H_2O and passed through Duolite A-2 anion exchange resin, and the eluate worked up gave 6.5 g. β-cyclopropyl-α-aminopropionic acid hemihydrate (VI), mp 227° (decomposition) (from EtOH), white solid with a sweetish taste; recrystallized from EtOH mp 239° (decomposition) (Cor.). VI heated with phthalic anhydride gave the phthaloyl derivative, mp 140.5-41° (from 50% EtOH). III (25.7 g) refluxed 6 hr with 250 cc 15% aqueous KOH, diluted with one l H_2O, run through Duolite C-10, and evaporated in vacuo gave 14 g cyclopropylcarbinylaminomalonic actd (VII), decomposing with gas evolution at 210°. VII gave a weak ninhydrin test. VII refluxed with 10% HBr gave with CO_2 evolution VI (purified with Duolite A-2). VI was a potent antagonist to Escherichia coli A.T.C.C. 9723. (C.A., 1956:930tt)

COL. 02:001

Colorado U. Dept. of Chemistry, Boulder

REACTION HEATS OF ORGANIC HALOGEN COMPOUNDS. PART VII. THE HEATS OF HYDROGENATION OF MONOCHLOROTRIFLUOROETHYLENE, t,t DICHLORODIFLUOROETHYLENE, AND MONOCHLORODIFLUOROETHYLENE, by J. R. Lacher, A. Kianpour, and J. D. Park. Aug. 1, 1955, 6p. incl. diagr. tables. (Technical note no. 1) (AFOSR-TN-55-390) (Sponsored jointly by Atomic Energy

COL. 02:002 - COL. 02:005

Commission under AT(29-1) and Air Force Office of Scientific Research under AF 18(600)1151) AD 82076 Unclassified

In this study, the heats of hydrogenation of $CF_2=CFCl$, $CF=CH_2$, and $CF_2=CCl_2$ were obtained using a low temperature calorimeter whose accuracy had been determined hy measuring the known heat of formation of gaseous HCl over 5% Pd on C catalyst. A summary is presented of the preparation of the various fluorinated organic compounds used. In addition, the physical properties and IR spectra of the reactants, and their products are reported. The heats of hydrogenation are presented in tables.

COL. 02:002

Colorado U. Dept. of Chemistry, Boulder.

REACTION HEATS OF ORGANIC HALOGEN COMPOUNDS. PART VIII. CALORIMETRIC STUDIES OF HEATS OF CHLORINATION OF PERFLUORINATED BUTENE-1, PENTENE-1, AND ISOBUTENE, by J. R. Lacher, A. Kianpour, and J. D. Park. Oct. 1, 1955 [5]p. incl. diagrs. tables. (Technical note no. 2) ([AF]OSR-TN-55-390[a]) (AF 18(600)1151) AD 82075 Unclassified

Also published in Jour. Phys. Chem., v. 61: 584-586, May 1957.

The heats of chlorination of perfluorobutene-1, perfluorisobutene and perfluoropentene-1 were found to be -44,966, -42,222 and -44,966 cal/mole respectively. The physical properties of the adducts were also determined, and the infrared spectra of the compounds determined. (Contractor's abstract)

COL. 02:003

Colorado U. Dept. of Chemistry, Boulder.

NEW ANALYTICAL METHOD FOR CALORIMETRIC STUDY OF HYDROGENATION OF SOME FLUORO-ORGANIC COMPOUNDS, by J. R. Lacher, A. Kianpour, and J. D. Park. Oct. 1, 1955 [6]p. incl. diagr. (Technical note no. 3) ([AF]OSR-TN-55-442) (AF 18(600)1151) AD 82074 Unclassified

The weighing method for measuring the rate of hydrogenation of halogen-free olefins was unsatisfactory: the term halogen is applied only to Cl, Br, and I in this study. An analytical method was developed which uses H as an unlimited reactant with a constant rate flow throughout the run with the olefin as the limiting reactant. The method involves passing H at a constant rate through the reaction chamber of the calorimeter containing 5% Pd on a C catalyst into a trap containing activated C; the H reacts with an excess of Cl in a Monel catalyst chamber containing 3% Pd on asbestos. The products, HCl and excess Cl, are washed by cold H_2O in a scrubbing tower and are collected in a beaker containing 3 M cold KI solution. The free I and HCl are analyzed by means of known-normality $Na_2S_2O_3$ and KOH solution. The H passing through the calorimeter is determined and part of it reacts in the reacting chamber of the calorimeter. The product and excess H enter a trap containing activated charcoal. All of the products are assumed to be adsorbed on the surface of the charcoal. The excess H enters the second catalyst chamber and reacts with an excess of Cl, and a determination of the quantity of HCl yields the amount of H consumed in the reaction.

COL. 02:004

Colorado U. Dept. of Chemistry, Boulder.

PREPARATION AND PROPERTIES OF THE ISOMERS OF 1,2-DIFLUORO-1,2-DICHLOROETHYLENE, by J. R. Lacher, R. Sullivan, and J. D. Park. [1956] 6p. incl. diagrs. table. [Technical note no. 4] (AFOSR-TN-56-107) (AF 18(600)1151) AD 82501 Unclassified

The separation of the cis and trans isomers of 1,2-difluoro-1,2-dichloroethylene was first attempted by Locke, Brode, and Henne (Jour. Am. Chem. Soc., v. 56: 1726, 1934). No attempt was made to determine the purity of the resulting fractions. The lower boiling isomer was assigned the cis configuration, apparently because it showed the lower melting point. The freezing points are -105.5° and -128.7°C for the cis and trans isomers, respectively. The boiling points are 14.5° for the cis isomer, and 16.5°C for the trans isomer at 630 mm pressure. The object of the present research program was to separate the cis and trans isomers of CFCl-CFCl by means of fractional distillation, to determine their purity by means of time-temperature freezing point curves, to study their magnetic susceptibilities, and by means of the infrared spectra to make a positive assignment of configuration. (Contractor's abstract, modified)

COL. 02:005

Colorado U. [Dept. of Chemistry] Boulder.

REACTION CALORIMETRY: THE HYDROGENATION OF ORGANIC FLUORIDES AND CHLORIDES, by J. R. Lacher, A. Kianpour and others. [Mar. 1956] [19]p. incl. diagrs. tables, refs. [Technical note no. 5] [AFOSR-TN-56-128] (AF 18(600)1151) AD 86005 Unclassified

Also published in Trans. Faraday Soc., v. 52: 1500-1508, Nov. 1956.

Calorimeters are described which permit direct measurement of the heats of vapor phase reactions. They operate in an isothermal fashion by having the reaction heat transferred to a surrounding volatile liquid which is simultaneously being cooled by bubbling an inert gas through it. A steady state is obtained when this cooling just balances the heat produced by the reaction. In order to be useful, a reaction must take place

practically quantitatively in the catalyst chamber. Using a Pd-on-C catalyst, the hydrogenation of the following compounds was studied:
CH_3Cl, C_2H_5Cl, C_2H_3Cl, CH_3F, C_2H_5F, n-C_3H_7F, iso-C_3H_7F, $CF_2{=}CF_2$, $CF_2{=}CFCl$, $CF_2{=}CCl_2$, $CF_2{=}CH_2$, $CF_2{=}CHCl$, $CF_2{-}CF_2{-}CF{=}CF$, CF_2Cl_2, $CF_2Cl{-}CF_2Cl$, and $CF_2Cl{-}CFCl_2$. It was found that:

(1) the lower members of an homologous series were more difficult to hydrogenate than the members of higher molecular weight; (2) F is more difficult to replace by H than Cl-; and (3) in an ethylenic compound, the Cl is first substituted by H and then saturation of the double bond takes place. Thermochemical data on the heats of hydrogenation of the following compounds are given: CH_3Cl, C_2H_5Cl, C_2H_3Cl, n-C_3H_7F, iso-C_3H_7F, $CF_2{=}CFCl$, $CF_2{=}CHCl$, and $CF_2{=}CCl_2$. (Contractor's abstract)

COL. 03:001

Colorado U. [Dept. of Mathematics] Boulder.

ON DISCRIMINANTS OF BINARY QUADRATIC FORMS WITH A SINGLE CLASS IN EACH GENUS, by S. Chowla and W. E. Briggs. Jan. 1954 [12]p. (Rept. no. C-1) ([AF]OSR-TN-54-15) (AF 18(600)758) AD 35964 Unclassified

Also published in Canad. Jour. Math., v. 6: 463-470, 1954.

Consideration is given binary quadratic forms $ax^2 + bxy + cy^2 = 0$ with discriminant $d = b^2 - 4ac < 0$, letting $\Delta = -d$. Use is made of the L-series $L_k(s) = \sum_1^\infty x(n)n^{-s}$, where throughout $x(n)$ is real non-principal character modulo k and $R(s) > 0$, to prove that (1) with the assumption that $L_k(53/54) \geq 0$ for $k > 10^{14}$, there are no discriminants with a single class in each genus for $\Delta > 10^{14}$; and (2) without this assumption, there is at most 1 fundamental discriminant with a single class in each genus with $\Delta > 10^{60}$.

COL. 03:002

Colorado U. [Dept. of Mathematics] Boulder.

ON THE NUMBER OF POSITIVE INTEGERS $\leq X$ ALL OF WHOSE PRIME FACTORS ARE $\leq Y$, by S. Chowla and W. E. Briggs. Mar. 1954, 6p. (Rept. no. C-2) ([AF]OSR-TN-54-63) (AF 18(600)758) AD 36865 Unclassified

Also published in Proc. Amer. Math. Soc., v. 6: 558-562, Aug. 1955.

Simplified proofs are presented of 2 special cases of estimates given by N. G. de Bruijn (Koninkl. Ned. Akad. Wetenschap. Proc., Ser. A., v. 53: 803-812, 1950 and v. 54: 50-60, 1951) of the functions $f(x, y)$ and $g(x, y)$; the first function denotes the number of positive integers $\leq x$, all of whose prime factors are $\leq y$; the second function represents the number of positive integers $\leq x$, all of whose prime factors are $> y$. The special cases are the estimates

(1) $f\left[x, (\log x)^h\right] = O\left(x^{1 - \frac{1}{h} + \varepsilon}\right)$, and (2)

$$g\left[x, (\log x)^h\right] = x \prod_{p < (\log x)^h} (1 - p^{-1}) + O\left(x^{1 - \frac{1}{h} + \frac{2}{h^2} + \varepsilon}\right),$$

where ε is an arbitrarily small positive number, p denotes primes, and $h \geq 2$.

COL. 03:003

Colorado U. Dept. of Mathematics, Boulder.

ON SOME INFINITE SERIES, by W. E. Briggs, S. Chowla and others. Apr. 1954, 3p. (Rept. no. C-3) ([AF]OSR-TN-54-92) (AF 18(600)758) Unclassified

Published in Scripta Math., v. 21: 28-30, Mar. 1955.

The following two formulas are proved:

$$2\zeta(3) = \sum_1^\infty \frac{1}{n^2}\left(1 + \tfrac{1}{2} + \ldots + \frac{1}{n}\right)$$

$$\zeta(3) = \sum_1^\infty \frac{1}{n}\left\{\frac{1}{(n+1)^2} + \frac{1}{(n+2)^2} + \cdots\right\}.$$

These formulas, the second in a slightly different form, had been stated as problems by M. S. Klamkin, Amer. Math. Monthly, v. 59: 471, 1952. (Math. Rev. abstract)

COL. 03:004

Colorado U. [Dept. of Mathematics] Boulder.

THE POWER SERIES COEFFICIENTS OF $\zeta(s)$, by W. E. Briggs and S. Chowla. June 1954, 4p. (Rept. no. C-4) ([AF]OSR-TN-54-137) (AF 18(600)758) AD 34008 Unclassified

Also published in Amer. Math. Monthly, v. 62: 323-325, May 1955.

Two proofs are given of the following theorem: If the Riemann-zeta function is reduced to the form

$$\zeta(s) = \frac{1}{s-1} + \sum_{n=0}^{\infty} A_n(s-1)^n, \text{ then } A_n = \frac{(-1)^n}{n!}\gamma_n \text{ where}$$

$$\gamma_n = \lim_{x \to \infty}\left(\sum_{1}^{x} \frac{\log^k n}{n} - \frac{\log^{k+1} x}{k+1}\right) = \gamma_k + o(1).$$

COL. 03:005 - COL. 03:009

COL. 03:005

Colorado U. [Dept. of Mathematics] Boulder.

ON A THEOREM OF S. BERNSTEIN, by N. C. Ankeny and T. J. Rivlin. Sept. 1954, 5p. (Repl. no. C-5) (In cooperation with Johns Hopkins U., Baltimore, Md.) ([AF]OSR-TN-54-184) (AF 18(600)758) AD 82067 Unclassified

The following result is stated. If $p(z)$ is a polynomial of degree n such that $[\max|p(z)|, |z| = 1] = 1$, and $p(z)$ has no zero within the unit circle, then

$[\max|p(z)|, |z| = R>1] \leq \frac{1+R^n}{2}$ with equality only for

$p(z) = \frac{\lambda + z^n}{2}$, where $|\lambda| = 1$. The converse is false,

but the following result is proved. If $p(z)$ is a polynominal of degree n such that

$p(1) = [\max|p(z)|, |z| = 1] = 1$ and

$[\max|p(z)|, |z| = R>1] \leq \frac{1+R^n}{2}$ for $0<R-1<\delta$,

where δ is any positive number, then $p(z)$ does not have all its roots within the unit circle.

COL. 03:006

Colorado U. [Dept. of Mathematics] Boulder.

EQUATIONS IN FINITE FIELDS, by N. C. Ankeny. Sept. 1954, 2p. (Repl. no. C-6) ([AF]OSR-TN-54-189) (AF 18(600)758) AD 82068 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 40: 1072-1073, 1954.

The paper is concerned with the equation

(*) $a_0x_0^{m_0} + a_1x_1^{m_1} + \ldots + a_rx_r^{m_r} = 0$

in the finite field GF(p), where the a_j are different from zero and $m_j | (p-1)$. I. If $N(p)$ denotes the number of solutions of (*) then $N(p) = p^r + A\theta_p p^{(r+1)/2}$, where the constant A depends only on the m_j's, $|\theta_p| < 1$ for all p and $\limsup |\theta_p| = 1$. Moreover, $|\theta_p|$ is everwhere dense in the unit interval. II. Let m = l.c.m. of m_0, m_1, ..., m_r, and let

$$(a_j|p)_{m_j} = \exp\left\{(2\pi i/m)l_j\right\},$$

where the l_j are fixed integers and $(a/p)_{m_j}$ denotes the number of solutions of (*) subject to these conditions. Then $N'(p) = p^r + A'\theta_p p^{r/2}$, where A' is a constant depending only on the l_j's, $|\theta_p| < 1$ for all p and $\limsup |\theta_p| = 1$. The proofs of these theorems are not given. (Math. Rev. abstract)

COL. 03:007

Colorado U. [Dept. of Mathematics] Boulder.

THE POWER SERIES COEFFICIENTS OF L-SERIES, by W. E. Briggs. Nov. 1954, 3p. (Repl. no. C-7) ([AF]OSR-TN-54-333) (AF 18(600)758) AD 55657 Unclassified

The results of a previous paper on the power series coefficients of $\zeta(s)$ are generalized to Dirichlet L-series, $L_k(s) = \sum_1^\infty X(n)n^{-s}$, $R(s) > 0$, where $X(n)$ is a nonprincipal character modulo k, and s is a complex variable. The expansion about $s = 1$ is given by

$$a_n = \frac{(-1)^n}{n!} \sum_{t=1}^{k-1} X(t)\nu_{n,k,t}.$$

COL. 03:008

Colorado U. [Dept. of Mathematics] Boulder.

A NOTE ON THE NUMBER OF LATTICE POINTS IN A REGION BOUNDED BY HYPER-PLANES, by S. Chowla and W. E. Mientka. Jan. 1955, 3p. (Rept. no. C-8) ([AF]OSR-TN-55-30) (AF 18(600)758) AD 100908 Unclassified

An extension is given of a result of G. H. Hardy (Ramanujan, Cambridge University Press, 1940) which gives the number of lattice points in a triangle bounded by the lines $X_1 = 0$, $X_2 = 0$, $aX_1 + bX_2 = \eta$, where a and b are coprime integers. The extension is an expression for the number of lattice points bounded by the hyperplanes $X_1 = 0$, $X_2 = 0$, ..., $X_n = 0$, $a_1X_1 + a_2X_2 + \ldots + a_nX_n = \eta$, where the a_i, $1 \leq i \leq n$, are integers and coprime in pairs. By defining $A = \prod_{i=1}^{n} A_i$ and $W = \frac{\eta}{A}$, the formula can be expressed as

$N_n^*(\eta) = B_n W^n + B_{n-1}W^{n-1} + \ldots + B_1W + B_0$, where the B_i are polynomials in the a_i $(1 \leq i \leq n)$, and B_0, given by an infinite series, is a function of η and the a_i with period A in η and is bounded as $\eta \to \infty$. (ASTIA abstract)

COL. 03:009

Colorado U. [Dept. of Mathematics] Boulder.

A NOTE ON THE NUMBER OF LATTICE POINTS IN A REGION BOUNDED BY A CERTAIN RIGHT-ANGLED TRIANGLE, by S. Chowla and W. E. Mientka. Feb. 1055, 5p. (Rept. no. C-9) ([AF]OSR-TN-55-55) (AF 18(600)758) AD 100909 Unclassified

Proofs are given for the following theorems. Theorem 1: If η is a positive integer which is a multiple of ab,

and if a, b are relatively prime odd positive integers, then

$$L^*(\eta) = \frac{\eta^2}{2ab} + \frac{\eta}{2a} + \frac{\eta}{2b} + \frac{a^2 + b^2 + 3ab}{12ab} + \frac{1}{12ab} - \frac{1}{4a} f(a, b)$$

$$- \frac{1}{4b} f(b, a), \text{ where } f(a, b) = \sum_{g=1}^{a-1} \cot \frac{\pi g}{a} \cot \frac{\pi g b}{a}, \text{ and}$$

$$f(b, a) = \sum_{g=1}^{b-1} \cot \frac{\pi g}{b} \cot \frac{\pi g a}{b}. \quad \text{Theorem 2: } \frac{1}{a} f(a, b)$$

$$+ \frac{1}{b} f(b, a) = \frac{a^2 + b^2 + 1 - 3ab}{3ab}. \quad \text{(ASTIA abstract)}$$

COL. 03:010

Colorado U. [Dept. of Mathematics] Boulder.

THE NUMBER OF LATTICE POINTS IN AN n-DIMENSIONAL TETRAHEDRON, by S. Chowla and W. E. Mientka. Feb. 1955, 5p. (Rept. no. C-10) ([AF]OSR-TN-55-60) (AF 18(600)758) AD 100907 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 51-53, Feb. 1956.

Proofs are given of the following theorems. Theorem 1: If $\eta \equiv 0 \pmod{A}$, the number of solutions of $\sum_{i=1}^{n} a_i x_i \leq \eta$, $x_i \geq 0$ $(1 \leq i \leq n)$ is a polynomial with rational coefficients in the quantities η/A and the a_i. Theorem 2: If $\eta \equiv 0 \pmod{A}$, the number of soluitons of $\sum_{i=1}^{n} a_i x_i = \eta$, each $x_i \geq 0$, is a polynomial with rational coefficienis in the quantities η/A and the a_i. In both theorems, A denotes the produci of the a_i, and the a_i $1 \leq i \leq n$, are positive integers, no 2 of which have a common factor.

COL. 04:001

Colorado U. Engineering Experimeni Station, Boulder.

SEPARATION OF ISOTOPES BY ELECTROLYSIS, by F. A. Rohrman, J. H. Andrews and others. Yearly rept. [1953] 1v. incl. illus. diagrs. table. (AF 18-(600)440) AD 37533 Unclassified

Investigations were undertaken to determine the feasibility of elecirolytic isotope separation for isotopes other than H. Aqueous solutions of various plateable elements were used. A portion of the material in the solution was plated onto a cathode, and this material was checked to see if the isotopic abundance ratios were changed during the plating process. Such a change would indicate a partial separation of the isotopes. Three plating baths were prepared with Ni solutions containing no radioactive tracer. The first bath conlained $NiSO_4 \cdot 6H_2O$, $NiCl_2 \cdot 6H_2O$, H_3BO_3, and H_2O. After a small portion of the Ni was removed, the bath became acid, making it difficult to obtain a satisfactory plate. The second bath contained $NiSO_4 \cdot 6H_2O$, H_3BO_3, and H_2O, while the third bath contained $NiCl_2 \cdot 6H_2O$. and H_2O. Baths containing the latter and a radioactive tracer solution are being investigated. Pt electrodes were used in the initial experiments on plating technique. Since the Ni would not adhere well to the Pt sheets, the Pt was used for the anode only. Cu planchets 0.010 in. thick were used as cathodes. The Pt electrodes were made of 0.001-in. foil with a Cu planchet for backing to give it mechanical strength. A description is given of the apparatus for counting Ni^{63} β-rays. Sample preparation and the mechanical problems in counting are discussed extensively.

COL. 04:002

Colorado U. Engineering Experiment Station, Boulder.

SEPARATION OF ISOTOPES BY ELECTROLYSIS, by F. A. Rohrman, W. J. Utlaut, and I. Ceresna. Final technical rept. Sept. 13, 1954 [13]p. incl. diagrs. [AFOSR-TR-54-27] (AF[18](600)440) AD 43734 Unclassified

A standard Q-gas counter, model 165, was employed for β counting. The leakage of gas around the irrigation area was stabilized through the installation of a special clamp on the Geiger boitom plate. This modification made the readings more uniform. Attempts at separating any of the isotopes of U were unsuccessful. Continued research on Ni-Ni^{63} electrolysis and plating tesis showed by counting techniques thai some separation of the isotopes was being effected. The condition which seemed to favor the separation of the heavier isotopes of Ni was a low current density which further indicated that the Ni^{63} responded more like a metal lower in the electromotive lable of the elemenis. Allempts were made to separate Ag^{110} and Ag^{111} from natural Ag. The electrolyte used for plating Ag consisted of $AgNO_3$, NaCN, KNO_3, H_2O, and CS_2. The radioactive Ag isotopes were added as the nitrate. Samples were plaied on 1-in. siainless-sieel cylinders acting as cathodes, and a weighi-vs-count curve was ploited. A number of plaies were deposited at differeni temperatures, curreni densities, and circulation rates. Data evaluation indicaied that no Ag separations were made. Further work on Cd separation was indicaied. The need of a mass specirometer capable of handling the heavier elemenis was considered desirable.

COU. 01:001

Columbia U. Columbia Radiation Lab., New York.

BROADENING OF MICROWAVE ABSORPTION LINES DUE TO WALL COLLISIONS, by M. Danos and S. Geschwind. [1953] [4]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and

COU. 01:002 - COU. 01:006

[Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 91: 1159-1162, Sept. 1, 1953.

The broadening of microwave absorption lines due to wall collisions is calculated using a method correcting the error in previous rough estimates which assumed the line broadening to be Lorentz-shaped. Two types of absorption cell are studied, i.e., infinite plane parallel plates and a circular cylinder, each in a region of uniform microwave field. The usual assumption that the half-power half-width is given by $\Delta\nu = 1/2\pi\tau$, where τ is the mean time between collisions is in good agreement with the detailed calculations of the present work which shows that the error in the line width as calculated by the above expression is not larger than 30 percent. Experimentally observed line widths agree with the predicted values. (Contractor's abstract, modified)

COU. 01:002

Columbia U. Columbia Radiation Lab., New York.

ČERENKOV EFFECT AT MICROWAVE FREQUENCIES, by M. Danos, S. Geschwind and others. [1953] [2]p. incl. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42519) Unclassified

Published in Phys. Rev., v. 92: 828-829, Nov. 1, 1953.

Čerenkov radiation at microwave frequencies was experimentally detected. The radiation was excited by a flat electron beam which passed as closely as possible over the surface of a dielectric material after having been bunched at a K-band frequency. The radiation left the dielectric through a quarter-wave matching plate and was then picked up by a microwave horn and detected with a 1N26 crystal. Approximately 10^{-7} watt of Čerenkov radiation at a wavelength of 1.25 cm was obtained.

COU. 01:003

Columbia U. Columbia Radiation Lab., New York.

MICROWAVE SPECTRA OF CsF, CsCl, AND CsBr, by A. Honig, M. L. Stitch, and M. Mandel. [1953] [2]p. incl. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 92: 901-902, Nov. 15, 1953.

Molecular constants for CsF, CsCl, and CsBr were determined from measurements of their pure rotational spectra in the microwave region. These and other data allow a test of the constancy of ionic bonding radii. Measurements of isotopic species of these molecules give the mass ratios of the stable Cl and Br isotopes. (Contractor's abstract)

COU. 01:004

Columbia U. Columbia Radiation Lab., New York.

SPIN OF Si^{29} AND MASS RATIOS OF THE STABLE Si ISOTOPES, by R. L. White and C. H. Townes. [1953] [2]p. (Sponsored jointly by Atomic Energy Commission, [Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 92: 1256-1257, Dec. 1, 1953.

The $J = 0 \rightarrow 1$ microwave transition of $Si^{29}D_3F$ was examined under high resolution for hyperfine structure due to Si^{29}. No hyperfine structure was found, which sets an upper limit of $1 \times 10^{-28} cm^2$ to the quadrupole moment of Si^{29}. This is good evidence that the Si^{29} spin is ½. The measurement also allows an accurate determination of mass difference ratios for the Si isotopes.

COU. 01:005

Columbia U. Columbia Radiation Lab., New York.

NUCLEAR MOMENTS OF Se^{79}, by W. A. Hardy, G. Silvey and others. [1953] [6]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, Atomic Energy Commission and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 92: 1532-1537, Dec. 15, 1953.

Microwave measurements of the $J = 2 \rightarrow 3$ rotational transition of OCSe containing the radioactive-nucleus Se^{79} have established the Se^{79} spin as 7/2 and the Se^{79} quadrupole moment as $0.7 \times 10^{-24} cm^2 \pm 20$ percent. The quadrupole coupling constant eqQ is $7.52.09 \pm 0.05$ mc/sec. The magnetic moment of Se^{79} has been determined as -1.015 ± 0.015 nuclear magnetons by observation of the Zeeman splitting of one hyperfine component. The 7/2 spin and the large positive Q are inconsistent with the single-particle nuclear-shell model, but suggest the configuration $(g9/2)^7$ 7/2. This assignment is substantiated by the negative magnetic moment. Measurement of isotopic shifts gives a value for the Se^{79} mass, and an odd-even mass difference of 2.4 millimass units for this nucleus. (Contractor's abstract)

COU. 01:006

Columbia U. Columbia Radiation Lab., New York.

ABSORPTION OF MICROWAVES BY OXYGEN IN THE MILLIMETER WAVELENGTH REGION, by

J. O. Artman. Special tecb. rept. June 1, 1953, 84p. incl. illus. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office of Scientific Research] under DA 36-039-sc-42519) AD 21111 Unclassified

Also published in Phys. Rev., v. 96: 1237-1245, Dec. 1, 1955.

The spin reorientation spectrum of 0 in the millimeter wave length region was investigated at high and low pressures with the untuned cavity spectrometer. The resolved 0 lines observed at low pressures corresponded to values of the rotational quantum number K extending from 1 to 19. The line breadth parameters were found to be fairty independent of the values of K, averaging to 1.94 mc/mm Hg. For several lines both the peak tnlensity v_{peak} and the line breadth parameter $\Delta v/P$ were tndependently determined. The product $v_p \Delta v/P$ agreed to ± 5% with theoretical values expressed tn terms of known matrix elements and physical constanls. The ratio of the O-N broadening parameter to the O self-broadening parameter was determined by observations on a number of individual lines to be 0.90 ± 15%. The absorption of O in dry air was measured of 1/4, 1/2, and 1 atm. At these pressures, adsorption was attribuled to the addition of the many overtapping individual lines. The data obtained and formulas presented are useful tn predicting atmospheric adsorption of O under various conditions. This is tllustrated by the presentation of O absorption in air computed at 223°K and 1/4 atm pressure.

COU. 01:007

Columbia U. Columbia Radiation Lab., New York.

ČERENKOV RADIATION FROM EXTENDED ELECTRON BEAMS (Abstract), by M. Danos. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scie.tific Research under DA 36-039-sc-42519]) Unclassified

Presented al annual meeting of the Amer. Phys. Soc., Cotumbia U. New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 758, May 1, 1954.

The energy emitted by a flal etectron beam having the charge densily $\rho = \rho_0 \{1 + a \cos[(\omega/v)(z-vt)]\}$ and moving with the vetocity $v = c\beta$ at a distance d over the surface of a dielectric with dietectricity constani ϵ is given by

$$P = 189 I^2 a^2 \exp\left[-\frac{4\pi d}{\lambda}(1-\beta^2)^{1/2}\right] \frac{\epsilon}{\beta} \frac{(1-\beta^2)(\epsilon\beta^2-1)^{1/2}}{(\epsilon\beta^2-1)+\epsilon^2(1-\beta^2)} \times$$

μ watts/cm^2 if the beam current t is measured in ma; $\lambda = \omega/2\pi c$ is the free space wavetength. The dependence of the radialed energy on v is here qualtatively different than in the wett known case of cylindrical geometry (V. L. Ginsburg and I. M. Frank, Doklady Akad. Nauk, v. 56: 699, 1947), where the radiation reaches a maximum al v → c. If in lhe plane case a second dielectric is added so as to sandwich the electron beam between the two dielectrics the behavior ts similar to the cylindrical case. An experiment has been performed to detect the Čerenkov radiation at microwave frequencies. The power observed ts in reasonable agreement with the theoretical predictions. (Contractor's abstract)

COU. 01:008

Columbia U. [Columbia Radiation Lab.] New York.

DETERMINATION OF ATOMIC MASSES BY MICROWAVE SPECTROSCOPY, by S. Geschwind, G. R. Gunther-Mohr, and C. H. Townes. [1954] [12]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unctassified

Published in Rev. Modern Phys., v. 26: 444-455, Oct. 1954.

Microwave spectroscopy gives information about atomic masses from the isotopic shift tn the pure rotational spectrum of molecules. Improvements in techniques allow measurement of frequency intervals to 0.002 mc so that future mass measurements may give an accuracy near 0.02 in mass units. This compares favorably with the best mass spectrographic and nuclear reaction measuremenls recently obtained. The theory involved in the determination of masses from rotational spectra of diatomic molecules and of molecules that are linear or symmetric rotors, is presented, including a discussion of results. Wtth the exception of Ge^{73} and Te^{120} mass information has been obtained from microwave spectra for all the stable isotopes of Li, C, O, Si, S, Cl, K, Br, Ge, Se, Rb, and Te as well as of the radioactive tsotopes H^3, S^{35}, Cl^{36}, Se^{75}, and Se^{79}. Mass ratios obtained from diatomic molecules and mass-difference ratios obtained from polyatomic motecules are collected. The microwave resulls are compared with those obtained from mass spectrometers.

COU. 01:009

Columbia U. [Columbia Radiation Lab.] New York.

EXAMINATION OF METHODS FOR DETECTING OH, by T. M. Sanders, Jr., A. L. Schawlow and others. [1954] [2]p. incl. diagrs. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientiftc Research under DA 36-039-sc-42519]) Unclassified

Published in Jour. Chem. Phys., v. 22: 245-246, F.b. 1954.

The microwave spectrum of OH affords a new method of determining the abundance of Olt in a low-pressure gas mixture. This method applied lo the producls of a discharge in H_2O shows that certain previous methods

COU. 01:010 - COU. 01:013

for detecting the presence of OH radicals in fact are not sensitive to OH, but to some other reactive components of a discharge in H_2O. OH radicals are obtained from a discharge in concentrations near 10 percent and with a lifetime of approximately 1/3 sec. (Contractor's abstract)

COU. 01:010

Columbia U. Columbia Radiation Lab., New York.

HARMONICS AT MILLIMETER WAVELENGTHS, by A. H. Nethercot, Jr. [1954] [4]p. incl. diagrs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Published in I. R. E. Trans. on Microwave Theory and Techniques, v. MTT-2: 17-20, Sept. 1954.

Two techniques for obtaining millimeter waves with sufficient power to physical measurements were investigated. One technique is to use the harmonics of the fundamental frequency directly emitted by a magnetron when it is in oscillation. Harmonics up to 1.25 mm have been observed. The only advantage of the magnetron is in the ease of adjustment. A moderately experienced operator could probably produce 1.5 mm radiation within a few hours using this method. The other technique is to frequency multiply the power emitted by a klystron by means of a silicon-tungsten contact used as a non-linear device. This method has produced 1.5 mm wavelength radiation. It has the advantages that the radiation is stable in power and frequency, is monochromatic, and also is tunable. A distinct disadvantage is in the time involved in adjustment and alignment. Magnetron harmonics and frequency multipliers are not the best methods of obtaining the shorter wavelengths, but they are the only ones available for longer wavelengths. Some quantitative data are given on the performance of these devices as various parameters are changed.

COU. 01:011

Columbia U. Columbia Radiation Lab., New York.

A HIGH-TEMPERATURE MICROWAVE SPECTROMETER, by M. L. Stitch, A. Honig, and C. H. Townes. [1954] [6]p. incl. diagrs. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Rev. Scient. Instruments, v. 25: 759-764, Aug. 1954.

A spectrometer for measurement of microwave absorption by gases at temperatures as high as 1000°C is described. Microwaves pass through a 5-ft nickel absorption cell. Absorption lines are modulated by Stark effect to give sensitive detection. The spectrometer has been used to study spectral lines of some alkali halides and several other high boiling point diatomic molecules between 300°C and 775°C. (Contractor's abstract)

COU. 01:012

Columbia U. [Columbia Radiation Lab.] New York.

HYPERFINE STRUCTURE IN DCCCl, DCN, AND HCN DUE TO DEUTERON QUADRUPOLE COUPLING AND FIELD ASYMMETRIES (Abstract), by R. L. White. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 789, May 1, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 52, Jan. 28, 1954.

The spectrum arising from the $J = 1 \rightarrow 2$ transition in deuterated chloroacetylene has been observed in a high-resolution spectrometer and hyperfine structure due to the quadrupole coupling of the deuteron detected. A value for the coupling of $(eqQ)_D = +175 \pm 20$ kc/sec was obtained, to be compared with -114 ± 1 kc in HD obtained by molecular beam methods. The deuteron quadrupole coupling was also observed in transitions between 1-type doublets in DCN where an unresolved hyperfine structure resulted in line broadening. Comparison with unbroadened lines from HCN gave the less accurate but consonant evaluation $(eqQ)_D = +145 \pm 60$ kc/sec. Since the deuteron quadrupole moment is known, $(eqQ)_D$ yields an experimental value of the field gradient. The value thus obtained was compared with the gradient calculated from a Heitler London molecular model. The calculated value was too large and of wrong sign, indicating the inadequacy of the model for this calculation. Asymmetry in the quadrupole coupling of N^{14} in the 1-type doublet transitions of HCN and DCN also produced hyperfine structure. From this structure, variations in the C-N bond due to bending can be detected. (Contractor's abstract)

COU. 01:013

Columbia U. [Columbia Radiation Lab.] New York

MAGNETIC INTERACTIONS IN $^3\Sigma$ MOLECULES (Abstract), by R. L. White. [1954] [1]p. (Sponsored jointly by [Signal Corps, Office of Naval Research and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Presented at meeting of the Amer. Phys. Soc., Seattle, Wash., July 7-10, 1954.

Published in Phys. Rev., v. 96: 845, Nov. 1, 1954.

In a second-order approximation the electronic angular momentum of a rotating $^1\Sigma$ molecule is not zero. The associated magnetic field is on the same order of magnitude as the field arising from the rotation of the positively-charged nuclear frame. The total resultant field interacts with the magnetic moments of the nuclei of the molecule to produce an interaction of the form $W_{mag} = [c_1 + (c_2 - c_1)K^2J^{-1}(J + 1)^{-1}]I.J$ for a nucleus on the symmetry axis of a symmetric top molecule. The c_i may be of either sign, depending upon both nuclear and molecular parameters. The algebraic values of c_i for the molecules $O^{17}CS$, OCS^{33}, $OCSe^{79}$ $Cl^{35}CN^{14}$, $Cl^{35}CN^{15}$, CH_3Cl, SiH_3Cl and GeH_3Cl have been measured on a high resolution bridge-type microwave spectrometer. A correlation between measured and theoretical c_i for these molecules and for a number of others for which c_i is known (primarily from molecular beams data) will be given. The molecular parameters thus obtained will be compared with those inferred from molecular g factors and diamagnetic susceptibilities. (Contractor's abstract)

COU. 01:014

Columbia U. Columbia Radiation Lab., New York.

MAGNETRON RESEARCH AT COLUMBIA RADIATION LABORATORY, by M. J. Bernstein and N. M. Kroll. [1954] [5]p. incl. diagrs. table. [Sponsored jointly by Signal Corps, Office of Naval Research and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Published in I. R. E. Trans. on Microwave Theory and Techniques, v. MTT-2: 33-37, Sept. 1954.

Current magnetron research and development at Columbia Radiation Laboratory is principally directed towards the production of the shortest wavelengths in the millimeter region; the development of high power in the millimeter region; the development of wide range tunable tubes; and the investigation of low field magnetron operation. Two methods have been employed to produce short wavelengths, by means of conventional magnetron techniques and by use of "low-field" operation.

COU. 01:015

Columbia U. Columbia Radiation Lab., New York.

MICROWAVE ABSORPTION SPECTRA OF MnO_3F and ReO_3Cl, by A. Javan and A. Engelbrecht. [1954] [10]p. incl. diagrs. tables, refs. [Sponsored jointly by Signal Corps, Office of Naval Research, Air Force Office of Scientific Research, and Atomic Energy Commission under DA 36-039-sc-42519] Unclassified

Published in Phys. Rev., v. 96: 649-658, Nov. 1, 1954.

The microwave spectra of MnO_3F and ReO_3Cl near 1-cm wavelength have been studied. From the spectra of the first molecule and its isotopic species Mn $(O^{16})_2O^{18}F$, the structural parameters were determined as: Mn - O = 1.586A, Mn - F = 1.724A, $\angle$ (O, Mn, F) = 108°27′. The nuclear quadrupole coupling constant of Mn^{55} was measured as eqQ = 16.8 mc/sec. Because of the spin and statistics of O^{16} nuclei not all of the rotational states are allowed. It was found that, whereas in the ground vibrational states only states with K a multiple of three are permissible, in the excited vibrational states of the perpendicular normal modes the states with K-1 a multiple of three can occur. For K = 1 = ± 1 appreciable l-type doubling was observed. The amounts of l doubling and their corresponding values of α_v were determined for MnO_3F. The molecular dipole moment of this molecule was found to be μ = 1.5 Debye units. The hyperfine structure of ReO_3Cl gives for the ratio of quadrupole moments of the two abundant isotopes of Re a value of $Q_{Re^{187}}/Q_{Re^{185}} = 1.067 \pm 0.045$ and for the quadrupole coupling constant of Re^{187} eqQ = 253 mc/sec. This coupling constant and the known optical value of the quadrupole moment of Re^{187} give some information about the electronic structure of the molecular bonds, from which an approximate value of the nuclear quadrupole moment of Mn^{55} was obtained as $Q = 0.55 \times 10^{-24} cm^2$. (Contractor's abstract)

COU. 01:016

Columbia U. Columbia Radiation Lab., New York.

MICROWAVE SPECTRA OF THE ALKALI HALIDES, by A. Honig, M. Mandel and others. [1954] [14]p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 96: 629-642, Nov. 1, 1954.

Data from the microwave spectra of all alkali halides excepting LiF, NaF, KF, RbF, and LiCl are given and analyzed in terms of molecular and nuclear constants. These yield internuclear distances and ionic radii for the gaseous alkali halides, molecular dipole moments, potential constants including four constants for some molecules, amount of covalent character from quadrupole coupling constants and from rotational effects, and mass ratios for isotopes of Li, K, Rb, Cl, and Br. (Contractor's abstract)

COU. 01:017

Columbia U. [Columbia Radiation Lab.] New York.

MICROWAVE SPECTRUM OF THE FREE OD RADICAL (Abstract), by G. C. Dousmanis. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 29-30, 1954.

Published in Phys. Rev., v. 94: 789, May 1, 1954.

COU. 01:018 - COU. 01:020

Published in Bull. Amer. Phys. Soc., v. 29: 52, Jan. 28, 1954.

A microwave spectrum resulting from the free $O^{16}D$ radical has been found with a Zeeman spectrometer similar to tbe one with which OH spectrum had been observed (Phys. Rev., v. 89: 1158, 1953). The lines are due to transitions between the two members of the doublet resulting from the Λ-type splitting of eacb J-level in the ground paramagnetic state of the radical. The observed frequenctes and their assignments are as follows:

K	J	Frequency (Megacyctes)
5	5½	867.36 ± 0.10
6	6½	12,918.0t
7	7½	18,009.60
8	8½	23,907.12

The parameters describing the Λ-type doubling have been obtained as $4\Sigma(-1)^8$ $(\Pi|ALy + 2BLy|\Sigma)$ $(\Sigma|BLy\ \Pi)/V_{\pi\Sigma} = 2096 \pm 16$mc and $4\Sigma(-1)^8|(\Pi\ BLy|\Sigma)|^2/V_{\pi\Sigma} = 149.3 \pm 0.4$ mc. These are tn agreement with the values found in OH. The magnetic hyperftne structure In OD, in contrast to that tn OH, ts too smalt to be resolved (< 3 mc for K = 8). This gives some information about the source of hyperfine structure tn OH and OD. (Contractor's abstract)

COU. 01:018

Columbia U. [Columbia Radiation Lab.] New York.

THE MICROWAVE SPECTRUM OF ReO_3F (Abstract), by J. F. Lotspetch, A. Javan, and A. Engelbrecht. [1954] [1]p. [Sponsored jointly by Signal Corps, Offlce of Naval Research, and Air Force Offtce of Scientiflc Research under DA 36-039-sc-42519]
Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 789, May 1, t954.

The mlcrowave absorption spectrum of ReO_3F has been observed for the rotational transitions 2 → 3 and 3 → 4. In addition to the lines originating from the ground vibrational state, a number of degenerate and nondegenerate excited vibrational state lines were found from which were obtained the vibrational and t-type doubling constants. The quadrupole hyperfine structure due to Re was resolved. The following quantities have been calculated: $B_0 = 3566.75t \pm 0.050$ mc; $eqQ_{Re} = -53 \pm 4$ mc. The lsotopic change of B_0 and of eqQ due to the two Re lsotopes t85 and 187 is within the quoted errors. The l-type doubling constants of two of the three degenera ' vibration modes were found to be 4.82 and t6.35 m_; their corresponding a_v values are + 2.64 and -10.5 mc, respectively. A value of a_v for a nondegenerate mode was measured as + t2.4 mc. (Contractor's abstract)

COU. 01:019

Columbta U. Columbia Radiation Lab., New York.

MILLIMETER WAVE GENERATION BY ČERENKOV RADIATION, by M. Danos and H. Lashinsky. [1954] [5]p. tncl. diagrs. [Sponsored jointly by Signal Corps, Offlce of Naval Research, and Air Force Office of Sclentific Research under DA36-039-sc-42519]
Unclassifted

Published in I. R. E. Trans. on Microwave Theory and Techniques, v. MTT-2: 21-22, Sept. 1954.

An electron moving through a refractive medium with a velocity greater than the phase vetocity of ltght in that medium emtts radiation with a continuous spectrum. If one uses a bunched electron beam, not only is tne radiated power greatly increased but the radiated spectrum now is a line spectrum consisting of the bunching frequency and tts harmonics. It is actually not necessary that the electrons pass through the medium. It ls sufficient that the beam be located at a small distance from the dielectric. An experiment was conducted tn which a flat electron beam was passed through a klystron-type bunching cavity. After an appropriate drifting time density bunches were formed and the beam passed over a dielectric at a close distance. The emitted radiation passed through a quarter wave matching plate and was collected by a horn. With this set-up radiation of roughly 10^{-7}W was obtained. The beam current was C.4mA, the beam width 4 mm, the length over the dtelectrtc 1.7 cm; the klystron was squarewave modulated at 6 kc/s; and the beam was switched on and off at a rate of 20 c/s. A modulation of 6 kc was employed to enable the use of a narrow band 6 kc amplifier system; by switching the beam on and off it was possibte to distinguish between leakage and radiation associated with the electron beam.

COU. 0t:020

Columbia U. [Columbia Radiation Lab.] New York.

MOLECULAR MICROWAVE OSCILLATOR AND NEW HYPERFINE STRUCTURE IN THE MICROWAVE SPECTRUM OF NH_3, by J. P. Gordon, H. J. Zeiger, and C. H. Townes. [t954] [3]p. Incl. iltus. diagrs. (Sponsored jointly by Signal Corps, Offlce of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 95: 282-284, July 1, t954.

A high-resolution microwave spectrometer is described. The hyperfine structure of the NIt_3 inversion transitions J = K = 2 and J = K = 3 were examined, and a previously unresolved structure due to the reorientation of the H spins were observed. (C.A., t954:9808h)

COU. 01:021

Columbia U. Columbia Radiation Lab., New York.

THE RATIOS OF QUADRUPOLE COUPLING CONSTANTS OF ISOTOPES AND THEIR VARIATION WITH TEMPERTURE (Abstract), by T. C. Wang and C. H. Townes. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Sctentific Research under DA 36-039-sc-42519])
Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 767, May 1, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 30, Jan. 28, 1954.

Measurements on nuclear quadrupole resonances tn solids show the ratio of coupling constants for Cl^{35} and Ct^{37} in any molecule to vary with temperature as well as with molecular environment (Phys. Rev., v. 86: 809, 1952); the ratio ts not solely dependent on nuclear properties as might be expected. A decrease of temperature from 300°K to 78°K decreases the ratio eqQ_{Cl35}/eqQ_{Cl37} by as much as 0.02 percent. Measurement of the quadrupote coupling ratio of Sb^{123} to that of Sb^{121} in several antimony halides and in stibnite shows similar effects. This ratio ranged from 1.27414 to t.274770 depending on molecular environment. The asymmetry parameter η for the two antimony tsotopes agrees to tess than 0.01 percent. The change of ratio can be attributed largely to molecular vibrations. Extending Bayer's discussion (Zeitschr. Phystk, v. 130: 227, t95t) of thermal vil.rations, the variation tn coupting ratio can be calculated for the case of p-$C_6tH_4Cl_2$ where the vibrational frequenctes are known. The calculated change tn ratio between 300°K and 78°K is 2.2×10^{-5} whereas the measured value is $(4.7 \pm 1) \times 10^{-5}$. (Contractor's abstract)

	$Rb^{85}Cl^{35}$	$Rb^{87}Cl^{35}$
Y_{01} (mc/sec)	2627.394±0.002	2609.799±0.003
$-Y_{11} \approx a_e$ (mc/sec)	13.601±0.005	13.464±0.005
$Y_{21} \approx \gamma_e$ (mc/sec)	0.021±0.002	0.021±0.002
B_e (mc/sec)	2627.414±0.010	
r_e (A)	2.78670±0.00006	

The quadrupole (eqQ) and spin-rotation (c) interaction constants of $Rb^{85}Cl^{35}$ are:

	v = 0	v = 1
$(eqQ)_{Rb}$ (mc/sec)	-52.675±0.005	-52.306±0.030
$(eqQ)_{Cl}$ (mc/sec)	+ 0.774±0.009	+ 0.612±0.013
c_{Rb} (kc/sec)	+ 0.3 ±0.3	
c_{Cl} (kc/sec)	0.0 ±0.8	

	v = 2
$(eqQ)_{Rb}$ (mc/sec)	-51.903±0.040
$(eqQ)_{Cl}$ (mc/sec)	+ 0.470±0.017
c_{Rb} (kc/sec)	
c_{Cl} (kc/sec)	

For the v = 0 state of $Rb^{87}Cl^{35}$, $(eqQ)_{Rb}$ = -25.485± 0.006 mc/sec. The ratio of the Rb quadrupole moments ts Q_{85}/Q_{87} = 2.0669±0.0005. The mass ratio of the Rb isotopes ts M_{85}/M_{87} = 0.0770163±0.0000045. (Contractor's abstract)

COU. 0t:022

Columbta U. [Columbta Radiation Lab.] New York.

ROTATIONAL SPECTRA OF RbCl BY THE MOLECULAR BEAM ELECTRIC RESONANCE METHOD, by J. W. Trischka and R. Braunstetn. [t954] [5]p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office ot Scientific Research under DA 36-039-sc-425t9])
Unclassified

Published in Phys. Rev., v. 96: 968-972, Nov. t5, t954.

The rotational transitions for which J = 0 → t were studied by the molecular beam electric resonance method for the first three vibrational states, v = 0, t, 2, of $Rb^{85}Cl^{35}$ and the ground vibrational state, v = 0, of $Rb^{87}Cl^{35}$. The molecutar constants are:

COU. 0t:023

Columbta [Columbia Radiation Lab.] New York.

SOME OBSERVATIONS OF DOUBLE- AND TRIPLE-QUANTUM TRANSITIONS, by P. Kusch. [t954] [4]p. tnct. dtagrs. tables. [Sponsored jotntly by Signal Corps, Offtce of Naval Research, and Air Force Offtce of Scientific Research under DA 36-039-sc-425t9]
Unclassified

Published in Phys. Rev., v. 93: 1022-t025, Mar. t, t954.

Data are presented which show that it ts possible to observe transttions for which $\Delta J = 0$, $\Delta m_j = \pm 2$ or ± 3 in a molecule charactertzed by a total angular J. It is also possible to observe transitions for which $\Delta F = 0$, $\Delta m_F = \pm 2$ or ± 3 in an atom charactertzed by a totat angular momentum F. tn each case the process occurs by the absorption or stimulated emission of two or

COU. 01:024 - COU. 01:028

three equienergetic quanta. (Contractor's abstract)

COU. 01:024

Columbia U. [Columbia Radiation Lab.] New York.

THE SPIN AND QUADRUPOLE MOMENT OF Se^{75} (Abstract), by L. C. Aamodt, P. C. Fletcher and others. [1954] [1]p. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 789, May 1, 1954.

The spin and nuclear quadrupole moment of radioactive Se^{75} have been determined from the microwave spectrum of $OCSe^{75}$. The Se^{75} was produced by the reaction $As^{75}(d, 2n)Se^{75}$ using 22-mev deuterons from the Brookhaven National Laboratory's cyclotron. The presence and abundance of Se^{75} in OCSe was determined by observing characteristic γ rays of this nucleus. Three lines of the quadrupole hyperfine structure of the $J = 2 \rightarrow 3$ transition of $OCSe^{75}$ were observed. Their measured frequencies, relative intensities, and Stark patterns agree with a spin of 5/2 for Se^{75} and a quadrupole constant of 946 mc. This spin is not consistent with predictions from the single particle version of the shell model. The quadrupole coupling constant indicates the large positive quadrupole moment of $0.9 \times 10^{-24} cm^2$ for Se^{75}. (Contractor's abstract)

COU. 01:025

Columbia U. Columbia Radiation Lab., New York.

SULFUR BONDS AND THE QUADRUPOLE MOMENTS OF O, S, AND Se ISOTOPES, by G. R. Bird and C. H. Townes. [1954] [6]p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 94: 1203-1208, June 1, 1954.

Quadrupole couplings of S^{33} in HDS, SO_2 and CH_3SH have been measured. These and previously measured quadrupole couplings of S^{33} in OCS, HNCS, CS, and S_8 are examined to determine the nature of sulfur bonds and the best value for the S^{33} quadrupole moment; s - p hybridization is found to be common, but not universal, in sulfur bonds. The S^{33} quadrupole moment is $-0.064 \pm 0.01 \times 10^{-24} cm^2$. If O and Se bonds are assumed to be similar to those of S, the quadrupole moments of O^{17} and Se^{79} are $-0.004 \times 10^{-24} cm^2$ and $0.9 \times 10^{-24} cm^2$, respectively.

COU. 01:026

Columbia U. [Columbia Radiation Lab.] New York.

VACUUM POLARIZATION IN A STRONG COULOMB FIELD, by E. H. Wichmann and N. M. Kroll. [1954] [3]p. incl. diagr. (Sponsored jointly by Atomic Energy Commission, [Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 96: 232-234, Oct. 1, 1954.

The polarization current is the trace of Υ_μ times the electron external field propagator. This is expressed as a sum over the solutions to the Dirac equation, the sum over angular momentum being carried out by means of a contour integral. An exact double integral for the polarization charge density in a static field is thus obtained, in a form which can be completely renormalized. Expansion in $Z\alpha$ gives the Uehling term, and corrections to it. These prove to be very small for small r, even for lead. The expansion is proved to converge for $Z\alpha < 1$.

COU. 01:027

Columbia U. [Columbia Radiation Lab.] New York.

VARIATION OF THE l-TYPE DOUBLING CONSTANT IN HCN, by J. F. Westerkamp, [1954] [1]p. incl. table. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Published in Phys. Rev., v. 93: 716, Feb. 15, 1954.

Microwave measurements on six transitions between the l-type doublets of HCN show that the l-type doubling constant depends on rotational angular momentum J as follows: $q = 224.471 - 0.002613J(J + 1)mc/sec$. (Contractor's abstract)

COU. 01:028

Columbia U. Columbia Radiation Lab., New York.

ČERENKOV RADIATION FROM EXTENDED ELECTRON BEAMS, by M. Danos. [1955] [6]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42519]) Unclassified

Presented at spring meeting of the Amer. Phys. Soc., Washington, D. C., Apr 29-May 1. 1954.

Published in Jour. Appl. Phys., v. 26: 2-7, Jan. 1955.

The Čerenkov radiation emitted by a bunched electron beam passing along a dielectric material at a close distance is calculated for a flat beam near a plane surface, a flat beam between two plane surfaces and for a circularly cylindrical hole.

COU. 01:029

Columbia U. Columbia Radiation Lab., New York.

FINE STRUCTURE OF SINGLY IONIZED HELIUM, by R. Novick, E. Lipworth, and P. F. Yergin. [1955] [21]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, [Air Force Office of Scientific Research] and National Science Foundation under [DA 36-039-sc-42519]) Unclassified

Presented at spring meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 100: 1153-1173, Nov. 15, 1955.

The energy difference (δ) between the $2^2S_{1/2}$ and $2^2P_{1/2}$ states of ionized helium has been measured by a pulsed microwave method. Helium atoms are excited to the metastable $2^2S_{1/2}$ state of the ion by a microsecond pulse of electrons of about 250-ev energy. After bombardment and after the atoms and ions excited to nonmetastable states have decayed to their respective ground states, a pulse of microwave power is applied to induce the $2^2S_{1/2}$ - $2^2P_{1/2}$ transition. This transition is followed immediately by spontaneous emission of a 40.8-ev photon associated with the $2^2P_{1/2}$ - $1^2S_{1/2}$ transition. The photons are observed by counting photoelectrons with high-speed counters gated on synchronously with the pulses of microwave power. Two different levels of rf power are used alternately to provide a means of normalizing the data for variations in the population of the $2^2S_{1/2}$ state. The present value of δ for He^+ is 14,043 ± 13 mc/sec. The stated uncertainty is equal to three times the standard deviation plus an estimated 3 mc/sec for the uncertainty in the corrections for systematic effects. This result, consistent with previous results, is in agreement with the best available theoretical value of 14,043.2 ± 3.0 mc/sec. (Contractor's abstract)

COU. 01:030

Columbia U. Columbia Radiation Lab., New York.

FOURTH-ORDER RADIATIVE CORRECTIONS TO ATOMIC ENERGY LEVELS, II, by R. L. Mills and N. M. Kroll. [1955] [12]p. incl. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 98: 1489-1500, June 1, 1955.

A rigorous method is described for treating the problem of the hydrogen-like atom in quantum electrodynamics by the separation of integrals into parts which can be evaluated with relativistic and nonrelativistic approximations. The method is based on that developed by Baranger, Bethe, and Feynman for the second-order problem, and is applied here to the problem of the fourth-order radiative energy level displacement. It is shown that the result inferred by Weneser, Bersohn, and Kroll from the study of fourth-order radiative corrections to elastic scattering by a given external potential is correct to order $\alpha^2(\alpha z)^4 mc^2$ for a hydrogenic atom. It is also shown that the αZ corrections to this result can be obtained using this method, just as was done in the second-order problem by Baranger, Bethe, and Feynman. (Contractor's abstract)

COU. 01:031

Columbia U. Columbia Radiation Lab., New York.

MAGNETIC HYPERFINE EFFECTS AND ELECTRONIC STRUCTURE OF NO, by G. C. Dousmanis. [1955] [4]p. incl. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., New York, Jan. 27, 1955.

Published in Phys. Rev., v. 97: 967-970, Feb. 15, 1955.

The theory of magnetic hyperfine structure in diatomic molecules is briefly reexamined. Previously reported hyperfine effects in the $N^{14}O^{16}$ molecule, both magnetic and electric quadrupole, are interpreted with corrected theoretical expressions in terms of an electronic structure consisting of 65 percent N = O and 35 percent $N^- = O^+$. The unpaired electron is shown to be The umpaired electron is shown to be essentially in a $2p\pi$ orbital but with 2.5 percent s character. Discrepancies of about 8 percent between experimental and calculated values of the magnetic hyperfine constants indicate limitations in the use of atomic wave function approximations for electronic orbitals. (Contractor's abstract)

COU. 01:032

Columbia U. Columbia Radiation Lab., New York.

MAGNETIC MOMENT AND MASS OF CHLORINE-36, by L. C. Aamodt and P. C. Fletcher. [1955] [7]p. incl. diagrs. tables, refs. (Sponsored jointly by Atomic Energy Commission, Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 98: 1317-1323, June 1, 1955.

The magnetic moment of the Cl^{36} nucleus was measured by observing the Zeeman splitting of the $F = 2 \rightarrow 2$ line in the electric quadrupole hyperfine pattern of the molecule CH_3Cl^{36} ($J = 0 \rightarrow 1$, $K = 0$ transitions). It was found to be 1.32 ± 0.08 nuclear magnetons. The magnitude of the magnetic moment was measured by using a rectangularly cross-sectioned absorption cell

COU. 01:033 - COU. 01:035

with plane polarized microwave radiation, and observing the $\Delta M = \pm 1$ transitions. The sign of the magnetic moment was measured by using a circularly cross-sectioned absorption cell with circularly polarized microwave radiation. This allowed the $\Delta M = 1$ and the $\Delta M = 1$ transitions to be observed separately. The magnetic field was calibrated by observing the Zeeman splitting of the spectrum of CH_3Cl^{35}. This value of magnetic moment indicates a nuclear configuration $(d_{3/2})_N (d_{3/2})_P$. Measurements of the quadrupole spectrum without the Zeeman perturbation gave the following additional information: the spin of Cl^{36} was confirmed to be 2, the mass difference ratio $[m(Cl^{36})-m(Cl^{35})]/[m(Cl^{37})-m(Cl^{36})]$ was found to be 1.00168 ± 0.04 percent, the molecular rotational constant of the CH_3Cl^{36} molecule was found to be 13187.604 ± 0.015 mc/sec, and its quadrupole coupling constant to be -15.83 ± 0.20 mc/sec. (Contractor's abstract)

COU. 01:033

Columbia U. Columbia Radiation Lab., New York.

MICROWAVE SPECTRA OF TRITIUM IODIDE AND TRITIUM BROMIDE, by B. Rosenblum and A. H. Nethercot, Jr. [1955] [2]p. incl. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 97: 84-85, Jan. 1, 1955.

The $J = 1 \leftarrow 0$ rotational transitions in TI and TBr have been observed. A tritium-deuterium mass ratio has been determined, and electronic effects which cause errors in this ratio considered. (Contractor's abstract)

COU. 01:034

Columbia U. Columbia Radiation Lab., New York.

PARAMAGNETIC RESONANCE OF METHYL SUBSTITUTED p-BENZOSEMIQUINONES, by B. Venkataraman and G. K. Fraenkel. [1955] [2]p. incl. table. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Published in Jour. Chem. Phys., v. 23: 588-589, Mar. 1955.

Investigation is reported of the paramagnetic resonance absorption spectra of the semiquinone ions of p- and of m-xyloquinone as well as the spectrum of the p-tolusemiquinone ion. The spectra of the two xylosemiquinone ions contain 9 major lines split into from 19 to 21 incompletely-resolved components, while the spectrum of the tolusemiquinone ion consists of 7 major lines, split into 20 components. The spectra of the xylosemiquinone ions are readily interpreted by assuming that the structure is due to hyperfine interaction with two equivalent protons on the benzene ring (interaction constant a) and six equivalent protons on methyl groups (interaction constant b). Agreement between the calculated and experimental positions of the 21 components is within the experimental error, and the intensities, which have not been measured, are in qualitative agreement with the theory. The sequence of the line intensities shows b to be greater than a. The spectrum of the p-tolusemiquinone ion can be fitted approximately by assuming that two of the ring protons are equivalent ($a_1 = a_2 = a$) and cause a larger splitting than the third ring proton ($a > a_3$), and that the three equivalent methyl-group protons give rise to a splitting that is the average of the splitting due to the ring protons, i.e., $b = 1/2 \cdot (a + a_3)$. This model predicts twenty lines in 7 groups. The intensities of one half of the spectrum are calculated to be: (7, 3), (1, 6, 5, 3), (2, 3, 1) and (1), where the lines are enumerated from the center of the spectrum outwards. A more precise fit than predicted by this model can be obtained by allowing b to differ slightly from the mean of a and a_3 if the incomplete resolution of the components is taken into account. Values of a, b, and a_3 are tabulated. If the values of the interaction constants for protons situated in similar position in the same or different molecules can be interpreted as being proportional to the mean density of the unpaired electron at the protons, relative values of a and relative values of b should be proportional to the densities of the unpaired electron respectively at ring- and methyl-group protons. Such electron densities are not to be confused with the total π-electron density.

COU. 01:035

Columbia U. Columbia Radiation Lab., New York.

PURE NUCLEAR QUADRUPOLE SPECTRA OF CHLORINE AND ANTIMONY ISOTOPES IN SOLIDS, by T. C. Wang. [1955] [12]p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 99: 566-577, July 15, 1955.

Experimental measurements on nuclear quadrupole resonances of chlorine and antimony isotopes in solids have been made to an accuracy of about 0.001 percent. The results are compared in detail with theoretical results for (1) nuclear quadrupole interaction, (2) interaction between quadrupole coupling and thermal vibrations, and (3) effects of a nuclear hexadecapole. The ratio $(eQq)_{Cl35}/(eQq)_{Cl37}$ varies between 1.268736 and 1.268973 while $(eQq)_{Sb123}/(eQq)_{Sb121}$ varies from 1.274714 to 1.274770. These variations may be attributed to zero-point vibrations and to thermal vibrations, so that no clear evidence is found for nuclear polarization by surrounding electric fields. For p-dichlorohenzene, the temperature coefficient of the coupling constant of Cl and the variation of isotopic coupling ratio with temperature are shown to he in fair quantitative agreement with the extension of Bayer's theory of vibrational effects. Relaxation times, Zeeman effects, and certain effects due to crystal structure are

examined. Small discrepancies in the measured ratios of frequencies of transitions in Sb^{121} and Sb^{123}, which can be attributed to nuclear hexadecapole interactions are found. These indicate a hexadecapole coupling constant in Sb^{123} of 24 kc/sec and a ratio of the Sb^{123} hexadecapole coupling to that of Sb^{121} of 0.8 ± 0.3. A convenient high-sensitivity circuit for observation of nuclear resonances in solids has been developed and is discussed. (Contractor's abstract)

COU. 01:036

Columbia U. [Columbia Radiation Lab.] New York.

RADIATIVE CORRECTIONS TO ELECTRON SCATTERING, by M. Chrétien. [1955] [2] p. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519] Unclassified

Published in Phys. Rev., v. 98: 1515-1516, June 1, 1955.

Radiative corrections in lowest-order Born approximation terms in $\ln E/m$ – but not in $\ln^2 E/m$ or higher powers - occur. This conclusion is valid for any static potential.

COU. 01:037

Columbia U. [Columbia Radiation Lab.] New York.

REDETERMINATION OF THE HYPERFINE SPLITTINGS OF HYDROGEN AND DEUTERIUM IN THE GROUND STATE, by P. Kusch. [1955] [3] p. incl. diagr. (Sponsored jointly by Office of Naval Research, [Signal Corps, and Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Phys. Rev., v. 100: 1188-1190, Nov. 15, 1955.

The hyperfine splittings of hydrogen and deuterium in the $1^2S_{1/2}$ state have been remeasured by the atomic beam method. It is found that: $\Delta\nu$ (H) = (1420.405,73 ± 0.000,05) x 10^6 sec^{-1}; and $\Delta\nu$ (D) = (327.384,302 ± 0.000,030) x 10^6 sec^{-1}. The result for hydrogen is in agreement with a recent measurement of Wittke and Dicke. It is in significant disagreement with an earlier atomic beam measurement. (Contractor's abstract)

COU. 01:038

Columbia U. Columbia Radiation Lab., New York.

STARK EFFECT IN RAPIDLY VARYING FIELDS, by S. H. Autler and C. H. Townes. [1955] [20] p. incl. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42519) Unclassified

Published in Phys. Rev., v. 100: 703-722, Oct. 15, 1955.

A method is developed for calculating the effects of a strong oscillating field on two states of a quantum mechanical system which are connected by a matrix element of the field. Explicit approximate solutions are obtained for a variety of special cases, and the results of numerical computations are given for others. The effect of an rf field on the $J = 2 \rightarrow 1$ l-type doublet microwave absorption lines of OCS has been studied in particular both experimentally and theoretically. Each line was observed to split into two components when the frequency of the rf field was near 12.78 mc or 38.28 mc, which are the frequencies separating the $J = 1$ and $J = 2$ pairs of levels, respectively. By measuring the rf frequency, ν_0, at which the microwave lines are split into two equally intense components, one may determine the separation between the energy levels. The measured value of ν_0 depends upon the intensity of the rf field and the form of this dependence has been calculated and found to be in good agreement with the experimental results. (Contractor's abstract)

COU. 01:039

Columbia U. [Columbia Radiation Lab.] New York.

PURE ROTATIONAL SPECTRA OF THE THALLIUM HALIDES (Abstract), by M. Mandel and A. H. Barrett. Jan. 27, 1955 [1] p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 20, Jan. 27, 1955.

The pure rotational spectra of the thallium halides have been observed using a high-temperature microwave spectrometer. Internuclear distances, vibration-rotation interactions, and mass ratios of the chlorine and bromine isotopes have been determined.

Molecule	r_e(A)	a_e(mc/sec)
$Tl^{205}F$	2.0844 ± 0.0001	44.98 ± 0.05
$Tl^{205}Cl^{35}$	2.4848 ± 0.0001	11.90 ± 0.01
$Tl^{205}Br^{79}$	2.6181 ± 0.0001	3.927 ± 0.005
$Tl^{205}I$	2.8136 ± 0.0001	1.985 ± 0.005

The thallium chloride results revealed a discrepancy in the previous work on TlCl where the isotope identified as $Tl^{205}Cl^{35}$ is in reality $Tl^{203}Cl^{37}$. The electric quadrupole coupling constants of $Tl^{205}Br^{79}$ and $Tl^{205}I$ in the $v = 0$ state were found to be + 130 ± 5 mc and -550 ± 20 mc, respectively, and the electric dipole moment of $Tl^{205}F$ to be approximately 7 debye units. The results give evidence about the ionic character of these molecules and the electronegativity of Tl. (Contractor's abstract)

COU. 01:040 - COU. 01:043

COU. 01:040

Columbia U. [Columbia Radiation Lab.] New York.

HYPERFINE STRUCTURE OF METASTABLE HYDROGEN (Abstract), by H. A. Reich, J. W. Heberle, and P. Kusch. Jan. 29, 1955, [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 55, Jan. 27, 1955.

The hyperfine structure $\Delta\nu$ (2S) of the $2^2S_{1/2}$ state has been measured by a new atomic beam method. The frequency ν_{14} of the transition $F = m_F = 1 \rightarrow F = m_F = 0$ is given by $\Delta\nu + 1.40$ mc sec^{-1} $gauss^{-1}$; the frequency ν_{24} of the transition $F = 1$, $m_F = 0 \rightarrow F$ and $m_F = 0$ is given by $\Delta\nu + 0.022$. 2 mc sec^{-1} $gauss^{-2}$. To determine $\Delta\nu$ (2S) both ν_{14} and ν_{24} were measured in a field of 0.19 gauss. The line width $W \approx v/2L$ (v is the average velocity of the atoms) was reduced to 5.5 kc/ sec by making the separation L between the two rf regions as large as 40 cm. It has been found that $\Delta\nu$ $(2S)_{exp}$ = 177,556.6 ± 0.3 kc/ sec. Theoretically $\Delta\nu$ (2S) is related to $\Delta\nu$ (1S) of the ground state by $\Delta\nu$ (2S) = $\Delta\nu$ (1S)/ $(8 - 5a^2)$. From the two existing values of $\Delta\nu$ (1S) one obtains $\Delta\nu$ $(2S)_{theoret.}$ = 177,556.55 ± 0.03 and 177,556.634 ± 0.007 kc/ sec, respectively. Additional measurements are being made to investigate possible systematic errors and to improve the accuracy to 3 parts in 10^7. (Contractor's abstract)

COU. 01:041

Columbia U. [Columbia Radiation Lab.] New York.

NEW METHOD FOR INVESTIGATING THE HFS OF A METASTABLE STATE (Abstract), by J. W. Heberle, H. A. Reich, and P. Kusch. Jan. 29, 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at annual meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 55, Jan. 27, 1955.

An atomic-beam method has been developed for measurement of the hfs of the metastable $2^2S_{1/2}$ state of hydrogen. The Zeeman levels of the $2^2S_{1/2}$ state are classified as $\alpha(m_s = +\frac{1}{2})$ or $\beta(m_s = -\frac{1}{2})$ according to the high-field value of m_s. Molecules of H_2 or D_2 are dissociated in a hot tungsten oven. An 11-ev electron beam excites the atoms to the α and β states in a field of approximately 580 gauss. The β atoms are quenched immediately after formation because their lifetime in such a field is only about 5×10^{-8} sec. The remaining α atoms pass through two successive regions of rf magnetic field of variable frequency where transitions to a β state are induced. The atoms pass on into a second field of 580 gauss where the newly formed β atoms are quenched. The α atoms that remain strike a metal detector plate. Electrons ejected from the detector are collected. A resonance is observed as a decrease in detector current. (Contractor's abstract)

COU. 01:042

Columbia U. Columbia Radiation Lab., New York.

NUCLEAR QUADRUPOLE INTERACTION IN HCN AND DCN IN THE BENDING VIBRATIONAL MODE, by R. L. White. Feb. 1955 [3]p. incl. diagrs. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Jour. Chem. Phys., v. 23: 249-252, Feb. 1955.

The $\Delta J = 0$, $\Delta F = 0$ transition in HCN and DCN in an excited bending mode of vibration was observed to possess structure due to an asymmetry in the electric field gradient at the nitrogen nucleus coupling to the quadrupole moment of that nucleus. A selective breaking of the π bond perpendicular to the plane of bending when the molecule assumes its ionic structure is suggested as the source of the asymmetry. (Contractor's abstract)

COU. 01:043

Columbia U. Columbia Radiation Lab., New York.

QUADRUPOLE COUPLING OF THE DEUTERON IN DCCCl AND DCN, by R. L. White. Feb. 1955 [3]p. incl. diagrs. tables, refs. (Sponsored jointly by Atomic Energy Commission, Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Published in Jour. Chem. Phys., v. 23: 253-255, Feb. 1955.

The quadrupole coupling of the deuteron $(eqQ)_D$ was measured in DCCCl where it was found to be + 175 ± 20 kc/ sec. A less accurate determination of the absolute value $(eqQ)_D$ in DCN yielded approximately 290 kc/ sec. The field gradient, q, at the deuterium nucleus in DCCCl is + 8.85 ± 10% x 10^{14}esu. A calculation of q based on a Hund-Mulliken molecular model yields a q of the same sign as that observed but approximately twice as large, indicating the insufficiency of the model for such detailed calculations. (Contractor's abstract)

COU. 01:044

Columbia U. [Columbia Radiation Lab.] New York.

NUCLEAR MAGNETIC MOMENT AND MASS OF CHLORINE-36 (Abstract), by P. C. Fletcher and L. C. Aamodt. Apr. 28, 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at spring meeting of the Amer. Phys. Soc., Washington. D. C., Apr. 28-30, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 13, Apr. 28, 1955.

The magnetic moment of the Cl^{36} nucleus was measured by observing the Zeeman splitting in the electric quadrupole hyperfine pattern of the molecule CH_3Cl^{36} ($J = 0 \rightarrow 1$, $K = 0$, $F = 2 \rightarrow 2$). Its magnitude, as measured in a rectangularly cross-sectioned absorption cell, was found to be 1.32 ± 0.08 nuclear magnetons. Its sign, determined in a circularly cross-sectioned absorption cell allowing circular polarization, was found to be positive. These observations favor the nuclear configuration $(d_{3/2})^N(d_{3/2})_P$ which is that expected from nuclear shell theory. Measurements of the quadrupole spectrum without a magnetic field gave the following information: the spin of Cl^{36} was confirmed to be 2, the mass difference ratio $(M_{Cl36} - M_{Cl35})/(M_{Cl37} - M_{Cl36})$ was found to be 1.00168 ± 0.04 percent, the molecular rotational constant for CH_3Cl^{36} was found to be $13,187.604 \pm 0.015$ mc and its quadrupole coupling constant to be -15.83 ± 0.20 mc. (Contractor's abstract)

COU. 01:045

Columbia U. [Columbia Radiation Lab.] New York.

MICROWAVE SPECTRA OF INDIUM CHLORIDE AND BROMIDE (Abstract), by A. H. Barrett and M. Mandel. Apr. 30, 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-42519]) Unclassified

Presented at spring meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 66, Apr. 23, 1955.

The pure rotational spectra of indium monochloride and indium monobromide have been observed using a high-temperature spectrometer. Internuclear distances and vibration-rotation interaction constants determined are

Molecule	r_e(A)	a_e(mc/sec)
$In^{115}Cl^{35}$	2.4012 ± 0.0001	15.34 ± 0.15
$In^{115}Br^{79}$	2.5408 ± 0.0001	5.706 ± 0.025
$In^{115}Br^{81}$		5.605 ± 0.018

Since the nuclear spins of In^{115}, $Cl^{35,37}$, and $Br^{79,81}$ are 9/2, 3/2, and 3/2, respectively, the spectra are complicated by hyperfine structure resulting from the interaction of each electric quadrupole moment with the molecular field. The spectrum of $In^{115}Cl^{35}$ yielded values of -655 ± 6 mc for the In^{115} coupling constant and -24 ± 2 mc for the Cl^{35} coupling constant. The quadrupole structure was not sufficiently resolved to allow a determination of the coupling constants in $In^{115}Br$. Results are interpreted in terms of ionic character and bond hybridization of these molecules. (Contractor's abstract)

COU. 01:046

Columbia U. Columbia Radiation Lab., New York.

COLLECTED PAPERS ON THE MASER (MICROWAVE AMPLIFICATION BY STIMULATED EMISSION OF RADIATION), by J. P. Gordon, H. J. Zeiger, and C. H. Townes. July 1, 1955, 85p. incl. illus. diagrs. tables, refs. (Special tech. rept. no. Cu-11-55) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42519) AD 77467 Unclassified

This report is made up of the following reports and are abstracted separately: (1) A Molecular Microwave Spectrometer, Oscillator and Amplifier, by J. P. Gordon; (2) The Maser. A New Type of Microwave Amplifier, Frequency Standard, and Spectrometer, by J. P. Gordon, H. J. Zeiger, and C. H. Townes; and (3) A High Resolution Microwave Spectrometer and New Hyperfine Structure in the Inversion Spectrum of $N^{14}H_3$, by J. P. Gordon.

COU. 01:047

Columbia U. Columbia Radiation Lab., New York.

A MOLECULAR MICROWAVE SPECTROMETER, OSCILLATOR AND AMPLIFIER, by J. P. Gordon. [July 1, 1955] [16]p. incl. illus. diagrs. refs. (Part 1 of its Special tech. rept. no. CU-11-55; AD 77467) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42519) AD 77467(a) Unclassified

A description is presented of a microwave spectrometer and oscillator which effects an emission of energy from the molecules rather than an absorption. As a spectrometer it has an extremely high resolution and was used to reexamine the inversion spectrum of NH_3 near 24 kmc. The operation of the apparatus is based on the isolation of molecules in the higher energy states. These molecules are then irradiated so that the incoming microwave signal is amplified rather than attenuated. Separation of the higher energy states is accomplished in a beam of NH_3 molecules by an electrostatic focuser. Transitions of these molecules back to the lower inversion states are then produced in a resonant cavity. If power of varying frequency is transmitted

through the cavity then the presence of the beam shows up as spectral emission lines. The apparatus acts as a narrow-band microwave amplifier at the molecular transition frequencies. In this role very little noise is introduced by the beam; its noise figure can theoretically be made close to unity if the beam is sufficiently strong. At a critical beam strength, the power necessary to induce transitions in the beam is available in the beam itself. Microwave oscillations are then set up in the cavity, the frequency of which is determined by the molecules. The oscillation is very stable. Since the radiation emitted from molecules through induced transitions is coherent with the exciting radiation, the oscillation is also highly monochromatic. (ASTIA abstract)

COU. 01:048

Columbia U. Columbia Radiation Lab., New York.

THE MASER. A NEW TYPE OF MICROWAVE AMPLIFIER, FREQUENCY STANDARD, AND SPECTROMETER, by J. P. Gordon, H. J. Zeiger, and C. H. Townes. [July 1, 1955] [26]p. incl. diagrs. refs. (Part 2 of its Special tech. rept. no. CU-11-55; AD 77467) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42519) AD 77467(b) Unclassified

Also published in Phys. Rev., v. 99: 1264-1274, Aug. 15, 1955.

A type of device is described which can be used as a microwave amplifier, spectrometer, or oscillator. The device utilizes a molecular beam in which molecules in the excited state of a microwave transition are selected. Interaction between these excited molecules and a microwave field produces additional radiation and hence amplification by stimulated emission. The apparatus utilizing this technique is called a maser, which is an acronym for microwave amplification by stimulated emission of radiation. When operated as a spectrometer, the device has good sensitivity, and, by eliminating the usual Doppler broadening, a resolution of 7 kc/sec was achieved. Operated as an oscillator the device produced a frequency stable to at least four parts in 10^{12} in times of the order of a second, and stable over periods of one hr or more to at least a part in 10^{10}. The device was examined theoretically, and results are given for the expected sensitivity of the spectrometer, the stability and purity of the oscillation, and the noise figure of the amplifier. Under certain conditions a noise figure approaching the theoretical limit of unity along with reasonably high gain should be attainable.

COU. 01:049

Columbia U. Columbia Radiation Lab., New York.

A HIGH RESOLUTION MICROWAVE SPECTROMETER AND NEW HYPERFINE STRUCTURE IN THE INVERSION SPECTRUM OF $N^{14}H_3$, by J. P. Gordon. [July 1, 1955] [36]p. incl. illus. diagrs. refs. (Part 3 of its Special tech. rept. no. CU-11-55; AD 77467) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42519; continued by DA 36-039-sc-64630) AD 77467(c) Unclassified

Also published in Phys. Rev., v. 99: 1253-1263, Aug. 15, 1955.

A reexamination was made on the hyperfine structure of the inversion spectrum of $N^{14}H_3$ with an ultra-high-resolution spectrometer. Lines with total widths at half maximum of 7 kc were obtained. Such narrow lines allow resolution of magnetic hyperfine structure due to reorientation of the spins of the hydrogen nuclei. The new structure was satisfactorily explained to within the experimental error of about 1 kc/sec by considering the vartous interactions of the magnetic moments of the hydrogen nuclei with the molecular fields. The interaction energy of the nitrogen nucleus was remeasured with higher resolution than was possible previously, and indications were found that $|eqQ|$ for the lower inversion state is larger by about 0.01% than that for the upper state. The sign eqQ was directly determined to be negative. A theoretical treatment of the magnetic interactions was conducted which is slightly different from previous treatments and allows some simplification of the form of the magnetic interactions. (ASTIA abstract)

COU. 02:001

Columbia U. [Columbia Radiation Lab.] New York.

CONNECTIONS BETWEEN MOLECULAR STRUCTURE AND CERTAIN MAGNETIC EFFECTS IN MOLECULES, by C. H. Townes, G. C. Dousmanis and others. [1955] [9]p. incl. tables, refs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630; continuation of DA 36-039-sc-42519] Unclassified

Published in Faraday Soc. Discussions, No. 19: 56-64, 1955.

Several types of magnetic effects in molecules and their relation to molecular structure are discussed. Hyperfine structure in molecules with electronic angular momentum can give experimental determination of 3 independent parameters of the distribution of electronic angular momentum. These parameters are rather simply and directly related to the molecular electronic structure and hence afford critical tests for proposed structures. Fine structure for such molecules can also give useful information on electron distributions. O_2, NO and OH are examples which are discussed. A systematic investigation has been made of $l \cdot J$ interactions in $^1\Sigma$ molecules. Although these 2nd-order effects are not as easily interpretable as are magnetic interactions in molecules with electronic angular momentum, it now appears possible to make an approximate prediction of the magnitude of $l \cdot J$

tnteractions in common types of molecules. The interactton between an external magnetic field and rotatton of a $^1\Sigma$ molecule may be used to determine the ortentation (sign) of the molecule's electric dtpole moment. In order to eliminate obscurtng effects such as L-uncoupling, It is necessary to measure the molecular g-factor for two isotopic species. Determination of the sign of molecular dtpole moments by this method requires rather prectse measurement of Zeeman effects, but appears practical for certain molecules. (Contractor's abstract)

COU. 02:002

Columbia U. Columbta Radiation Lab., New York.

EFFECTS OF THE BENDING MODE OF VIBRATION ON THE HYPERFINE STRUCTURE OF ICN, by A. Javan. [1955] [5]p. incl. tables. (Sponsored jointly by Stgnal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 99: 1302-1306, Aug. 15, 1955.

The bending mode of vibration in ICN introduces an asymmetry in the electric field gradient at the iodine nucleus. From an observed variation in the l-type doublet splittings of various hyperfine components for the $v_2 = 1$ state, the asymmetry parameter is determined as $\eta = 0.0087$. It is found that the measured splittings can be accounted for fully by including second-order perturbation terms arising from field asymmetry. The ratio $(eqQ)\ v = 0/(eqQ)\ v_2 = 1$ is measured as 1.0039. This ratio and the observed value of η are discussed in terms of the molecular bending and I-C bonding electrons. (Contractor's abstract)

COU. 02:003

Columbia U. [Columbia Radiation Lab.] New York.

MICROWAVE SPECTRA OF THE FREE RADICALS OH AND OD, by G. C. Dousmanis, T. M. Sanders, Jr., and C. H. Townes. [1955] [20]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 100: 1735-1754, Dec. 15, 1955.

Free OH and OD radicals are produced in concentrations near 10% by an electric discharge at pressures of approximately 0.1 mm Hg. The spectra are detected by Zeeman modulation. They are due to direct transitions between the Λ-doublet levels of each rotational state in the ground vibrational level of the molecule. Spectra due to $O^{16}H$, $O^{18}H$, and $O^{16}D$ in $^2\Pi_{1/2}$ and $^2\Pi_{3/2}$ states have been observed in the 7.7 to 37 kmc/sec region. Intensity of the lines ranges from about $5 \times 10^{-6} cm^{-1}$ to $5 \times 10^{-8} cm^{-1}$. Van Vleck's theory of molecular energies in $^2\Pi$ and $^2\Sigma$ states is extended to include terms of order $(E_{rot}$ or $E_{fs})^2/E_e|^2$. The experimental results are in agreement with theoretical expectations to about one part in 2000. An improved agreement (to one part in 3500) is obtained by allowing a small variation of the electronic wave function from one rotational state to the next. The spectra include magnetic hyperfine structures which give values for parameters that describe the unpaired electron distribution in the molecule: $(1/r^3)_{Av} = (0.75 \pm 0.25) \times 10^{24}/cc$ and $(\sin^2 x/r^3)_{Av} = (0.49 \pm 0.01) \times 10^{24}/cc$. The hyperfine structure, the molecular magnetic moment and the line intensities are strongly dependent on the extent of intermediate coupling in agreement with theoretical expectations. The microwave spectrum can be used in studying chemical properties of the radical. Its lifetime was determined to be near 1/3 sec, and the effects of Cu, graphite, Ni, Kovar, Apiezon wax, Teflon, Glyptal, KCl, Al, and mica surfaces on radical concentrations were examined. (Contractor's abstract)

COU. 02:004

Columbta U. Columbta Radiation Lab., New York.

SPACE-CHARGE DISTRIBUTION IN A STATIC MAGNETRON, by H. C. Nedderman. [1955] [11]p. incl. diagrs. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630) Unclassified

Published in Jour. Appl. Phys., v. 26: 1420-1430, Dec. 1955.

The space-charge distribution in a static magnetron was investigated by a method involving measurement of the radiation intensity from excited gas atoms at low pressure. Results of the measurements show that space charge extends to the anode under all conditions. Evidence is presented to show that a considerable fraction of the space charge consists of electrons that are trapped for exceedingly long times within the interaction space. (Contractor's abstract)

COU. 02:005

Columbia U. Columbia Radiation Lab., New York.

NEW METHOD FOR THE OBSERVATION OF HYPERFINE STRUCTURE OF NH_3 IN A "MASER" OSCILLATOR, by K. Shimoda and T. C. Wang. [Sept. 13, 1955] [2]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630) Unclassified

Published in Rev. Scient. Instruments, v. 26: 1148-1149, Dec. 1955.

Weak hyperfine satellites have been observed with very large signal-to-noise ratios when microwave power at frequencies corresponding to these satellites

COU. 02:006 - COU. 02:009

is introduced into a "maser" which is oscillating at the frequency of the main inversion line of NH_3. The satellite transitions are accompanied by a reduction of the amplitude of oscillation at the main-line frequency. A composite oscilloscope trace showing the structure of the weakest of the four quadrupole satellites associated with the 3-3 inversion line of $N^{14}H_3$ is presented. (Contractor's abstract)

COU. 02:006

Columbia U. [Columbia Radiation Lab.] New York.

ANTIFERROMAGNETIC RESONANCE IN MnF_2, by F. M. Johnson and A. H. Nethercot, Jr. [1956] [2]p. incl. diagr. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 283, June 21, 1956.

Published in Phys. Rev., v. 104: 847-848, Nov. 1, 1956.

Antiferromagnetic resonance has been observed in a single crystal of MnF_2 at temperatures from 57° to 65°K and wavelengths from 2.2 to 2.6 mm. At a wavelength of 2.58 mm the temperature at which the peak absorption occurred at zero applied magnetic field was 62.3 ± 0.5°K. Further observations were made at different frequencies in this range. A magnetic field H_0 variable from 0 to 9000 gauss was used to tune the resonance. Frequencies corresponding to both signs in the expression $\omega/\gamma = (2H_E H_A)^{1/2} \pm H_0[1 - (a/2)]$, were observed. The observed g value was approximately the expected value of about two. These results are in reasonable agreement with the predictions of Keffer and Kittel. These resonances were characterized by extremely hroad lines (full width approximately 7000 gauss). (Contractor's abstract)

COU. 02:007

Columbia U. Columbia Radiation Lab., New York.

ČERENKOV RADIATION FROM EXTENDED ELECTRON BEAMS NEAR A MEDIUM OF COMPLEX INDEX OF REFRACTION, hy H. Lashinsky. [1956] [5]p. incl. diagrs. (Sponsored jointly hy Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Jour. Appl. Phys., v. 27: 631-635, June 1956.

An earlier theoretical treatment of the Čerenkov radiation excited by the passage of a bunched electron beam moving parallel to a dielectric medium at a small distance is extended to the case of a medium with a complex index of refraction. It is found that under suitable conditions, the use of a ferrite material as a medium can in principle enhance the radiated power. This effect is analyzed in terms of the work done by the beam on the field and the coupling between the beam and the medium.

COU. 02:008

Columbia U. [Columbia Radiation Lab.] New York.

[DISCUSSION ON THE PRESENT STATUS AND FUTURE OF MICROWAVE SPECTROSCOPY] [In Japanese], by C. H. Townes, M. Kotani and others. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630] Unclassified

Published in Kagaku, v. 26: 567-572, Nov. 1956.

Dr. C. H. Townes, the founder of microwave spectroscopy, came to Japan as a Fulbright exchange professor at Tokyo University. A discussion with a group of Japanese instructors considers the use of microwave spectroscopy in the study of molecular structure and its applications in various allied fields as well as its future possibilities.

COU. 02:009

Columbia U. [Columbia Radiation Lab.] New York.

FURTHER OBSERVATIONS OF MULTIPLE-QUANTUM TRANSITIONS. SATURATION EFFECTS IN RADIO-FREQUENCY TRANSITIONS, by P. Kusch. [1956] [10]p. incl. diagrs, tables, refs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630] Unclassified

Published in Phys. Rev., v. 101: 627-636, Jan. 15, 1956.

Multiple-quantum as well as the single-quantum transitions, $\Delta F = 0$, $\Delta m = \pm 1, 2, 3, 4$, have been observed in K^{39}. In the neighborhood of the rf amplitude, required to give a maximum transition probability, the lines have the behavior predicted for transitions induced by a rectangular rf pulse. For higher rf amplitudes, the line width becomes a constant or else decreases after having reached a maximum width, the line frequency is modified less rapidly than predicted and anomalous transition probabilities occur. All these effects are markedly dependent on the details of construction of the rf circuit in which transitions are induced. It is suggested that these effects may arise from the end regions of the circuit through an adiabatic traverse of the circuit by the atom. (Contractor's abstract)

COU. 02:010

Columbia U. [Columbia Radiation Lab.] New York.

Hfs SEPARATIONS AND Hfs ANOMALIES IN THE $^2P_{1/2}$ STATE OF Ga^{69}, Ga^{71}, Tl^{203}, AND Tl^{205}, by A. Lurio and A. G. Prodell. [1956] [5]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 101: 79-83, Jan. 1, 1956.

The ground-state hyperfine structure splittings have been measured in the two common gallium and thallium isotopes by use of the atomic beam magnetic resonance method. The measured values are: $\Delta\nu\ (Ga^{69}) = (2677.9875 \pm 0.0010) \times 10^6\ sec^{-1}$, $\Delta\nu\ (Ga^{71}) = (3402.6946 \pm 0.0013) \times 10^6\ sec^{-1}$, $\Delta\nu\ (Tl^{203}) = (21,105.447 \pm 0.005 \times 10^6\ sec^{-1}$, $\Delta\nu\ (Tl^{205}) = (21,310.835 \pm 0.005) \times 10^6\ sec^{-1}$. A comparison of the ratio of the dipole coupling constants in the ground state of the two isotopes with the ratio of the nuclear g_I factors yields the hfs anomaly. Theoretical and experimental values of the anomaly are compared. (Contractor's abstract)

COU. 02:011

Columbia U. Columbia Radiation Lab., New York.

HYPERFINE STRUCTURE OF METASTABLE HYDROGEN ATOM, by J. W. Heberle, H. A. Reich, and P. Kusch. [1956] [9]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 101: 612-620, Jan. 15, 1956.

The hyperfine separation $\Delta\nu$ (2S) of the metastable $2^2S_{1/2}$ state has been measured by a new atomic-beam magnetic-resonance method. Rf transitions were detected by utilizing a property peculiar to metastable hydrogen atoms, namely, that atoms with $m_J = -1/2$ decay much more rapidly in passing through a magnetic field of about 575 gauss than do atoms with $m_J = +1/2$. It was found that $\Delta\nu$ (2S) = 177556.86 ± 0.05 kc/sec. This result and the very accurately known hyperfine separation $\Delta\nu$ (1S) of the ground state yielded the following: $R \equiv \Delta\nu\ (2S)/\Delta\nu\ (1S) = 1/8\ (1.000,034,6 \pm 0.000,000,3)$. The deviation of R from the presently available theoretical value suggests the existence of a higher-order quantum-electrodynamic term. A method of velocity selection by electron impact is described. (Contractor's abstract)

COU. 02:012

Columbia U. Columbia Radiation Lab., New York.

HYPERFINE STRUCTURE OF THE METASTABLE DEUTERIUM ATOM, by H. A. Reich, J. W. Heberle, and P. Kusch. [1956] [8]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 104: 1585-1592, Dec. 15, 1956.

The hyperfine separation $\Delta\nu$ (2S;D) of the metastable $2^2S_{1/2}$ state of the deuterium atom has been measured by an atomic-beam magnetic-resonance method. It was found that $\Delta\nu$ (2S;D) = 40,924.439 ± 0.020 kc/sec. This result and the ground-state separation $\Delta\nu$ (1S;D) yielded the following: $R(D) \equiv \Delta\nu\ (2S;D)/\Delta\nu\ (1S;D) = 1/8\ (1.000,034,2 \pm 0.000,000,6)$. Comparison of this value with the corresponding quantity for hydrogen, $R(H) = 1/8\ (1.000,034,6 \pm 0.000,000,3)$, confirms within experimental error the theoretical prediction that R(D) = R(H). (Contractor's abstract)

COU. 02:013

Columbia U. Columbia Radiation Lab., New York.

HYPERFINE STRUCTURE OF THE METASTABLE STATE OF SINGLY IONIZED He^3, by R. Novick and E. Commins. [1956] [3]p. incl. diagr. refs. (Sponsored jointly by National Science Foundation, Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 103: 1897-1899, Sept. 15, 1956.

A beam of ions in the $2S_{1/2}(F = 0)$ state are obtained and magnetic dipole transitions to the $2S_{1/2}(F = 1)$ level are induced. The observed frequency allows one to separate off a small term arising from nuclear structure and nuclear interaction currents. (P. A. abstract)

COU. 02:014

Columbia U. [Columbia Radiation Lab.] New York.

LOW-FREQUENCY ELECTRODELESS DISCHARGE TUBE, by G. M. Grosof and J. C. Hubbs. [1956] [1]p. (Sponsored jointly by Office of Naval Research, [Signal Corps, and Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Rev. Scient. Instruments, v. 27: 171, Mar. 1956.

In the course of an investigation of the hyperfine structure of Ne^{21} the problem of rapid disappearance

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of gas into the electrode system of a Woods discharge tube arose. Although good results have been experienced for electrodeless discharges at radio-frequencies, the problem of shielding appeared to be formidable, so an alternative solution was sought, and found, in an electrodeless discharge at frequencies of a few hundred cycles per second. The discharge tube consists of the usual discharge channel, about 75 cm long and 7 mm in diameter with a Pyrex sphere 7 cm in diameter and 1 mm thick at either end. Connections to the source are established through an Aquadag layer on the outer surface of each sphere. A current of 20 ma is driven through the system by 5000 v rms at 500 c; the current is independent of pressure from 30μ, the lower limit of operation, to several cm pressure. No operational difficulties have been encountered in a thousand hours of operation. The loss rate of neon is now considerably less than 1 μ1 STP/hr; this may he compared with losses in the old system which were sometimes as high as 1 cc STP/hr. (Contractor's abstract)

COU. 02:015

Columbia U. [Columbia Radiation Lab.] New York.

MICROWAVE SPECTRA OF GALLIUM CHLORIDE, BROMIDE, AND IODIDE (Abstract), by M. Mandel and A. H. Barrett. [1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 284, June 21, 1956.

The pure rotational spectra of GaCl, GaBr, and GaI have oeen observed using a high-temperature spectrometer. Since the nuclear spins of Ga, Cl, Br and I are $> \frac{1}{2}$, the spectra are complicated by hyperfine structure resulting from the interaction of each electric quadrupole moment with the molecular fields. Rotation, vibration-rotation interaction, and quadrupole coupling constants determined are:

Molecule	B_e(mc/sec)	α_e(mc/sec)
$Ga^{69}Cl^{35}$	4493.73 ± 0.19	23.27 ± 0.12
$Ga^{69}Br^{79}$	2481.99 ± 0.05	9.740 ± 0.03
$Ga^{69}I$	1706.86 ± 0.05	5.667 ± 0.04

Molecule	r_e(A)	eqQ(mc/sec)
$Ga^{69}Cl^{35}$	2.2017 ± 0.0001	Ga^{69} - 84.7 ± 1.0 Cl^{35} - 20 ± 2
$Ga^{69}Br^{79}$	2.3525 ± 0.0001	Ga^{69} - 74 ± 5 Br^{79} 134 ± 3
$Ga^{69}I$	2.5747 ± 0.0001	Ga^{69} - 66 ± 8 I 549 ± 30.

COU. 02:016

Columbia U. Columbia Radiation Lab., New York.

ON THE INTERPRETATION OF Hfs IN MOLECULES IN TERMS OF MOLECULAR STRUCTURE AND NUCLEAR MOMENTS, by C. H. Townes. [1956] [8]p. incl. diagrs. tables. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630] Unclassified

Published in Nuovo Cimento, Suppl., v. 4: 1201-1208, 1956.

A large number of hyperfine interactions in molecular spectra have been measured by the techniques of microwave and molecular beam spectroscopy. The interpretation of these hyperfine interactions are discussed in terms of molecular structure and the nuclear moments with which they are associated. Some of the difficulties encountered in determining nuclear quadrupole moments are indicated. Hyperfine structure due to magnetic dipole moments is also mentioned. Interaction between a nuclear magnetic moment and an externally applied magnetic field is measured and the magnetic moment is determined.

COU. 02:017

Columbia U. [Columbia Radiation Lab.] New York.

PRODUCTION OF A BEAM OF METASTABLE HELIUM IONS (Abstract), by R. Novick and E. Commins. [1956] [1]p. (Sponsored jointly by National Science Foundation, Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 288, June 21, 1956.

Preliminary to determination of the hyperfine splitting of the $2S_{1/2}$ state of ionized helium-3, a beam of metastable helium-4 ions has been produced and detected. Helium atoms are ionized and excited to the $2S_{1/2}$ state by electron bombardment. The ions are then drawn out of the bombardment region and accelerated to 20 volts energy. After traversing a path of 30 cm they enter a microwave cavity through which passes radio-frequency power. The radio-frequency field induces transitions to the $2P'_{1/2}$ state, and the $2P'_{1/2}$ ions decay almost immediately to the ground state with the emission of 303.8 A photons. These photons eject electrons from a platinum photosurface. Photodetection is used in place of surface detection in order to avoid the background signal which would result from ground-state ions. The photoelectric current is approximately 4.4×10^{-15} ampere for an ion beam current of 10^{-8} ampere and electron bombardment energy of 200 volts. These currents are of sufficient intensity and stability

to permit a precise determination of the hyperfine splitting of ionized helium-3. The experiment is performed in a bakeable, stainless steel vacuum system to avoid surface charging effects. (Contractor's abstract)

COU. 02:018

[Columbia U. Columbia Radiation Lab., New York.]

[RECENT DEVELOPMENTS REGARDING THE MEASUREMENT OF TIME] Développements récents à propos de la mesure du temps, by C. H. Townes. [1956] [11]p. incl. diagrs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64630] Unclassified

Published in Arch. des Sciences, v. 9: 270-280, 1956.

A review is presented of time measurement methods developed as a result of research undertaken between 1952 and 1955; 5 references of international authorship are cited.

COU. 02:019

Columbia U. [Columbia Radiation Lab.] New York.

VACUUM POLARIZATION IN A STRONG COULOMB FIELD, by E. H. Wichmann and N. M. Kroll. [1956] [17]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office of Scientific Research under DA 36-039-sc-64630]) Unclassified

Published in Phys. Rev., v. 101: 843-859, Jan. 15, 1956.

A study is carried out of the vacuum polarization in a strong Coulomb field. Radiative corrections are neglected. A perturbation calculation is avoided by making use of the explicit solutions of the Dirac equation in a Coulomb field. The Laplace transform of the polarization charge density times r^2 is found and used as a basis for further study. It is proved to be an analytic function of the strength of the inducing charge. It is verified that the first-order term in a power series expansion in the strength of the inducing charge just corresponds to the Uehling potential. The third-order term is studied in some detail. The leading term in the polarization potential close to the inducing charge and the space integral of the induced potential divided by r are found to all orders in the strength of the inducing charge. Ambiguities are handled by a method corresponding to regularization. Some experimental applications are considered. The corrections to the Uehling term in these cases are found to be small. (Contractor's abstract)

COU. 02:020

Columbia U. Columbia Radiation Lab., New York.

COLLECTED PAPERS ON THE MASER. FURTHER ASPECTS OF THE THEORY OF THE MASER, by K. Shimoda, T. C. Wang, and C. H. Townes. Mar. 1, 1956, 39p. incl. diagrs. tables. (Special tech. rept. no. CU-1-56) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-64630) AD 89059 Unclassified

Also published in Phys. Rev., v. 102: 1308-1321, June 1, 1956.

The theory of the molecular transitions which are induced by the microwave field in a maser and the effects of various design parameters are examined in detail. It is shown that the theoretical minimum detectable beam intensity when the maser is used as a spectrometer for the 3-3 line of ammonia is about 10^9 mole/sec under typical experimental conditions. Various systematic frequency shifts and random frequency fluctuations of the maser oscillator are discussed and evaluated. The most prominent of the former are the "frequency-pulling" effect which arises from detuning of the cavity and the Doppler shift due to the asymmetrical coupling of the beam with the two travelling wave components of the standing waves which are set up in the cavity. These two effects may produce fractional shifts as large as one part in 10^9. If adequate precautions are taken, however, they can be reduced to one part in 10^{10} or possibly less. The random fluctuations are shown to be of the order of one part in 10^{12} under typical operating conditions. For molecular beams in which the electric-dipole transition is used, the TM_{010} mode is usually the most suitable for the maser; while in atomic beams in which magnetic transitions are utilized, the TE_{011} mode is to be perferred. (Contractor's abstract)

COU. 02:021

Columbia U. Columbia Radiation Lab., New York.

THE DEVELOPMENT OF A TUNABLE CW MAGNETRON IN THE K-BAND REGION, by Z. Fraenkel. June 1, 1956, 54p. incl. diagrs. tables, refs. (Special tech. rept. no. CU-3-56) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA-36-039-sc-64630) AD 103126 Unclassified

The development of a low field, K-band, tunable CW magnetron is described. The major characteristics of the device are presented and compared to the characteristics of other K-band magnetrons. The research leading towards the development of the magnetron is outlined. This research program had two major objectives: (a) the study of cathode back-bombardment in CW magnetrons, and (b) the study of low field operation. The cathode back-bombardment was found to be closely related to two voltage regions

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at which large anode currents were drawn without any connection to magnetron parameters. The research program culminated in the development of a low field, K-band, tunable CW magnetron, utilizing capacitive Crown of Thorns tuning. At a fixed operating point an output power exceeding 10 watts at an efficiency exceeding 5% can be obtained over a tuning range of 7%. The tuning range can be doubled by lowering the output power requirements and making use of two operating points. (Contractor's abstract)

COU. 02:022

Columbia U. [Columbia Radiation Lab.] New York.

MICROWAVE DETERMINATION OF CARBON AND OXYGEN MASS RATIOS (Abstract), by B. Rosenblum and A. H. Nethercot, Jr. [1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, [Air Force Office of Scientific Research], and Atomic Energy Commission under [DA 36-039-sc-64630]) Unclassified

Paper presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 13-14, Jan. 30, 1956.

Precision measurements of the J = 0 → 1 rotational transition in $C^{12}O^{16}$, $C^{13}O^{16}$, and $C^{12}O^{18}$ have been made in 120,000 mc. Accurate atomic mass ratios can be determined from such measurements only if a correction to the moment of inertia of the molecule is made for the excitation of higher electronic states by the rotation of the molecule. It has been shown that this correction can be computed from the magnetic moment resulting from this rotation-electronic interaction. The magnetic moment of the CO molecule has been measured by comparison with the known magnetic moment of the arsenic nucleus in the molecule AsD_3. With this correction the C^{13}/C^{12} and O^{18}/O^{16} ratios were determined, and the results are in excellent agreement with nuclear reaction data. The magnitude of the correction was approximately 20 parts per million. Work is in progress to further improve the accuracy of these measurements and to extend them to include C^{14} and O^{17}. (Contractor's abstract)

COU. 03:001

Columbia U. Dept. of Chemistry, New York.

THE MICROWAVE SPECTRUM OF ETHYL BROMIDE, by R. S. Wagner, N. Solimene, and B. P. Dailey. Jan. 3, 1955 [3]p. incl. table. (Rept. no. CU-7-55) [AFOSR-TN-55-6] (AF 18(600)1152) Unclassified

Also published in Jour. Chem. Phys., v. 23: 599, Mar. 1955.

Several rotational transitions for $C_2H_5Br^{79}$ and $C_2H_5Br^{81}$ have been observed and identified which yield exact values of B and C for both species and an estimate of eqQ along the C-Br bond axis. C_2H_5Br is a nearly prolate rotor (κ = -0.98) with the dipole moment having components along the A and B principal axes. From the assumed structure, a reduced moment of inertia of 5.11×10^{-40} g sq cm was calculated, and a sinusoidal barrier height of 2800 cal/mole was obtained.

COU. 03:002

Columbia U. Dept. of Chemistry, New York.

THE MICROWAVE SPECTRUM OF ETHYL CHLORIDE, by R. S. Wagner and B. P. Dailey. Preliminary rept. Jan. 3, 1955, 5p. incl. tables. (Rept. no. CU-3-55) (AFOSR-TN-55-7) (AF 18(600)1152) Unclassified

Also published in Jour. Chem. Phys., v. 22: 1459, Aug. 1954.

A study of the microwave spectrum of C_2H_5Cl led to the identification of 4 transitions for $C_2H_5Cl^{35}$ and 2 transitions for $C_2H_5Cl^{37}$ on the basis of their Stark patterns and quadrupole hyperfine structure. These transitions involve the dipole component along the A axis. From assumed parameters, calculation of the moments of inertia indicated that C_2H_5Cl was a nearly prolate rotor (κ = -0.95) with the dipole moment having components along the A and B principal axes. Calculated and observed rotational constants are given. From intensity ratio measurements, the torsional frequency was calculated to be 215 cm^{-1}. For a reduced moment of 4.76×10^{-40} g sq cm, a sinusoidal barrier height of 3000 cal/mole was obtained.

COU. 03:003

Columbia U. Dept. of Chemistry, New York.

THE STRUCTURE AND BARRIER TO INTERNAL ROTATION OF FORMIC ACID FROM MICROWAVE DATA, by R. G. Lerner, J. P. Friend, and B. P. Dailey. Jan. 3, 1955, 4p. incl. tables. (Rept. no. CU-6-55) (AFOSR-TN-55-8) (AF 18(600)1152) Unclassified

Also published in Jour. Chem. Phys., v. 23: 210, Jan. 1955.

The structure and barrier to internal rotation of formic acid have been determined from a study of the microwave spectrum of HCOOH, DCOOH, HCOOD, DCOOD and $HC^{13}OOH$. (Contractor's abstract)

COU. 03:004

Columbia U. Dept. of Chemistry, New York.

THE INTERPRETATION OF QUADRUPOLE SPECTRA, by B. P. Dailey. Jan. 3, 1955, 13p. incl. refs. (Rept. no. CU-5-55) (AFOSR-TN-55-9) (AF 18(600)-1152) Unclassified

Also published in Faraday Soc. Discussions, No. 19: 255-260, 1955.

The interpretation of the nuclear quadrupole coupling constant (eqQ) obtained by the analysis of several types of radio-frequency spectroscopy is discussed. It was pointed out that eqQ for an isolated molecule was largely determined by the number of electrons which occupy p atomic orbitals in the valence shell of the atom in which the quadrupolar nucleus is located. Several approximate relations between the quadrupole coupling constant, the amount of ionic character, and the type of hybridization occurring in the bonding orbitals formed by an atom in an isolated molecule are discussed. The views of several authors on the role of the overlap integral in such approximate calculations are reviewed.

COU. 03:005

Columbia U. [Dept. of Chemistry] New York.

PROOF OF THE STAGGERED CONFIGURATION OF ETHYL CHLORIDE, by R. S. Wagner and B. P. Dailey. Apr. 28, 1955 [3]p. incl. tables. (Rept. no. CU-8-55) [AFOSR-TN-55-114] (AF 18(600)1152) Unclassified

Also published in Jour. Chem. Phys., v. 23: 1355, July 1955.

The addition of DCl to CH_2=CH_2 resulted in the formation of 2 molecular species, both having the structural formula CH_2DCH_2Cl (I). One deuterated species has D in the plane of symmetry of the molecule and is called trans, since D is diagonally opposite the Cl atom in the symmetry plane. The cis species has the D atom occupying either of 2 equivalent positions not in the symmetry plane. The moments of inertia of these 2 forms of I depend to a great extent on whether they are in the staggered or eclipsed configuration. The calculated moments of inertia of trans I in the eclipsed and staggered configurations are given.

COU. 03:006

Columbia U. Dept. of Chemistry, New York.

RELATIVE ELECTRON DENSITIES IN SUBSTITUTED BENZENES, by P. L. Corio and B. P. Dailey. July 1, 1956 [28]p. incl. diagrs. tables, refs. (AFOSR-TN-55-440) (AF 18(600)1152) AD 100825 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 3043-3048, July 5, 1956.

The proton magnetic resonance spectra of a number of monosubstituted benzenes have been studied in an attempt to derive values of the relative electron density from observations of the chemical shifts of the ring protons, and the effect of various functional groups on these shifts. Shifts are assigned to the protons at different ring positions, and these indicate differences in the electron distribution at the o, m, p positions. The observed shifts are compared with data from other expertmental sources, with theoretical calculations of electron densities in substituted benzenes and with the electronic theory of orientation effects in benzene substitutions. In particular, the importance of polarization effects in aromatic substitution reactions is emphasized. (Contractor's abstract)

COU. 03:007

Columbia U. Dept. of Chemistry, New York.

THE ELECTRON WITHDRAWAL POWER OF SUBSTITUENT GROUPS, by B. P. Dailey and J. N. Shoolery. [1955] [5]p. incl. diagrs. tables. [AF 18(600)1152] Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 3977-3981, Aug. 5, 1955.

A study of chemical shifts in the nuclear magnetic resonance spectra of ethyl and methyl dertvatives of a number of organic substituent groups has been made. It was desired to find out how the electronegativity of an atom changes when it forms a part of different substituent groups and to attempt to derive a table of the electron withdrawal power of the substituent groups. A simple relationship between proton "chemical shifts" and the ionic character of the chemical bond to the proton has been established by the regularities existing in the experimental results of this study. It is shown that the electron withdrawal power of a substituent group is largely determined by the electronegativity of the first atom in the group. (Contractor's abstract)

COU. 03:008

Columbia U. [Dept. of Chemistry] New York.

THE IONIC CHARACTER OF DIATOMIC MOLECULES, by B. P. Dailey and C. H. Townes. Jan. 1955 [6]p. incl. diagrs. tables, refs. [AF 18(600)1152] Unclassified

Published in Jour. Chem. Phys., v. 23: 118-123, Jan. 1955.

A relation between the electronegativity difference of two bonded atoms and the ionic character of the bond is obtained for singly bonded diatomic molecules in the gaseous state. The relation is based primarily on the wide variety of nuclear quadrupole coupling constants recently measured by microwave techniques. However, dipole moments of diatomic molecules are also used and discussed. Both quadrupole coupling constants and dipole moments indicate strongly that bonds involving electronegativity differences greater than 2 are almost completely ionic. Certain effects of hybridization, overlap, and polarization on considerations of ionicity are discussed. (Contractor's abstract)

COU. 03:009 - COU. 03:013

COU. 03:009

Columbia U. Dept. of Chemistry, New York.

STRUCTURE AND BARRIER HEIGHT OF METHYL MERCAPTAN FROM MICROWAVE DATA, by N. Solimene and B. P. Dailey. Jan. 1955 [6]p. incl. diagr. tables, refs. [AF 18(600)1152] Unclassified

Published in Jour. Chem. Phys., v. 23: 124-129, Jan. 1955.

The 0_{00} - 1_{01} rotational transitions of several isotopic species of methyl mercaptan were observed. This permitted a complete determination of the structural parameters of this molecule. The torsional energy levels of $C^{12}H_3S^{32}H$ and $C^{12}D_3S^{32}H$ were approximately determined by relative intensity measurements. A sinusoidal barrier height was determined which gave torsional energy levels in agreement with the observed ones. (Contractor's abstract)

COU. 03:010

Columbia U. Dept. of Chemistry, New York.

MICROWAVE SPECTROSCOPY, by B. P. Dailey. [1956] [20]p. incl. diagrs. table, refs. [AF 18(600)-1152] Unclassified

Published in Physical Methods of Chemical Analysis, v. 3, W. G. Berl, ed. Academic Press, Inc., N. Y., 1956, p. 281-301.

The following items are outlined: (1) the theoretical background of microwave spectroscopy; (2) its application to qualitative analysis; (3) problems connected with quantitative analysis; (4) apparatus employed; (5) the determination of electron concentration in flames; and (6) paramagnetic resonance spectra.

COU. 03:011

Columbia U. Dept. of Chemistry, New York.

MICROWAVE SPECTRUM AND STRUCTURE OF FORMIC ACID, by R. G. Lerner, B. P. Dailey, and J. P. Friend. [June 1, 1956] [4]p. incl. tables. (AF 18-(600)1152) Unclassified

Published in Jour. Chem. Phys., v. 26: 680-683, Mar. 1957.

The microwave spectra of five isotopic species of formic acid have been investigated, and values of the rotational constants B and C have been obtained. For $HC^{12}OOH$, B=12,055.1 mc, C=10,416.0 mc; for HC OOD, B=11,762.5 mc, C=9970.1 mc; for DC OOH, B=12,055.6 mc, C=9955.8 mc; for DC OOD, B=11,759.9 mc, C=9534.1 mc; and for $HC^{13}OOH$, B=12,053.7 mc, C=10,378.9 mc. The following structural parameters have been fitted to these rotational constants: r_{C-H}= 1.095 A, $r_{C=O}$= 1.245 A, r_{C-O}= 1.3212 A, r_{O-H}= 0.95 A, $\angle OCO = 124°18'$, $\angle COH = 107°48'$. The C=O bond has been estimated to have 75% double-bond character. The torsional frequency was found to be 667 ± 41 cm^{-1} and a barrier height of roughly 17 kcal/mole is indicated. (Contractor's abstract)

COU. 03:012

Columbia U. Dept. of Chemistry, New York.

THE MICROWAVE SPECTRUM AND STRUCTURE OF PROPIONITRILE, by R. G. Lerner and B. P. Dailey. [June 1, 1956] [3]p. incl. tables, refs. AF 18(600)-1152 Unclassified

Published in Jour. Chem. Phys., v. 26: 678-680, Mar. 1957.

Rotational transitions of several isotopic species of propionitrile have been observed. This has permitted a determination of the structural parameters of the molecule. For $C_2H_5C^{12}N$, B=4714.00 mc, C=4235.07 mc; and for $C_2H_5C^{13}N$, B=4689.77 mc and C=4214.87 mc. For $CD_3CHDC^{12}N$, B=4169.43 mc and C=3736.83 mc. The following model reproduces these constants to within 1.5 mc: r_{C-C}= 1.5479 A (ethyl), r_{C-C}= 1.4735 A (nitrile), $r_{C=N}$= 1.1566 A, r_{C-H}= 1.0914 A, $\angle CCC = 110°32'$, $\angle HCH = 109°19'$. The height of the barrier to internal rotation has been estimated to be 1150 ± 100 cm^{-1} or 3280 ± 290 cal/mole for a torsional frequency of 220 cm^{-1}. (Contractor's abstract)

COU. 03:013

Columbia U. Dept. of Chemistry, New York.

MICROWAVE SPECTRUM OF ETHYL BROMIDE, by R. S. Wagner, N. Solimene, and B. P. Dailey. [July 27, 1956] [4]p. incl. diagr. tables, refs. (AF 18(600)1152) Unclassified

Published in Jour. Chem. Phys., v. 26: 1593-1596, June 1957.

The microwave spectrum of ethyl bromide has been investigated and accurate values for the rotational constants B and C and the asymmetry parameter b have been obtained. For $C_2H_5Br^{79}$, B=3804.5 mc, C=3522.5 mc, b=-0.00487949 and for $C_2H_5Br^{81}$, B=3781.5 mc, C=3503.0 mc, and b=-0.00522977. The following model reproduces these constants to within 2 mc: C-C=1.5495 A, C-H=1.110 A, C-Br=1.9400 A, $\angle$ C-C-H=110°00', $\angle$ C-C-Br=110°30'. Analysis of the quadrupole hyperfine structure indicates that eqQ along the C-Br bond axis is 537.5 mc for $C_2H_5Br^{79}$ and 450.9 mc for $C_2H_5Br^{81}$. Two transitions have not been able to be fitted by first-order or second-order non-degenerate quadrupole theory. The torsional frequency is estimated to be 202 cm^{-1} and the barrier height is 2.80 kcal/mole. (Contractor's abstract)

COU. 03:014

Columbia U. Dept. of Chemistry, New York.

MICROWAVE SPECTRUM OF ETHYL CHLORIDE, by R. S. Wagner and B. P. Dailey. [July 27, 1956] [6]p. diagr. tables, refs. (AF 18(600)1152) Unclassified

Published in Jour. Chem. Phys., v. 26: 1538-1593, June 1957.

The microwave spectrum of ethyl chloride has been investigated and accurate values for the rotational constants B and C for several isotopic species have been obtained. For $C_2H_5Cl^{35}$, B=5493.8 mc, C=4962.3 mc, and for $C_2H_5Cl^{37}$, B=5379.1 mc and C=4867.1 mc. Two deuterated species have been studied. For trans $CH_2DCH_2Cl^{35}$, B=5098.8 mc and C=4637.5 mc. The rotational constants for gauche $CH_2DCH_2Cl^{35}$ are B=5297.6 mc and C=4784.9 mc. The following model reproduces these constants to within 4 mc: dC-C= 1.5495 A, dC-H=1.101 A, dC-D=1.090 A, ∢ HCH=110° 00', ∢ CCCl=110°30', dC-Cl=1.7785 A. From the structural data obtained for the deuterated ethyl chlorides it has been possible to establish the staggered configuration as the equilibrium configuration. The quadrupole analysis shows that eqQ along the C-Cl bond axis is -70.07 mc for Cl^{35} and -55.03 mc, for Cl^{37}, indicating an ionicity of 25%. The torsional frequency has been estimated to be 236 cm^{-1} and the barrier height is 3.4 kcal/mole. (Contractor's abstract)

COU. 03:015

Columbia U. Dept. of Chemistry, New York.

INFLUENCE OF THE SOLVENT ON THE CHEMICAL SHIFTS OF MONOSUBSTITUTED BENZENES, by P. L. Corio and B. P. Dailey. Dec. 1956 [1]p. incl. diagrs. table. (AF 18(600)1152) Unclassified

Published in Jour. Chem. Phys., v. 25: 1291, Dec. 1956.

Study was undertaken of the concentration dependence of the paraproton shift for several monosubstituted benzenes in acetone, acetonitrile, carbon disulfide, carbon tetrachloride, and cyclohexane. Representative plots of the paraproton shifts are presented in graphs.

COU. 04:001

Columbia U. Dept. of Chemistry, New York.

PROTON-DEUTERON HYPERFINE STRUCTURE IN PARAMAGNETIC RESONANCE: A π-σ INTERACTION, by B. Venkataraman and G. K. Fraenkel. July 15, 1955. 11p. refs. (Rept. no. CU-2-55-AF-1390-Chem.) (AFOSR-TN-55-208) (AF 18(600)1390) AD 75141 Unclassified

Also published in Jour. Chem. Phys., v. 24: 737-740, Apr. 1956.

The mechanism of the hyperfine splitting observed in paramagnetic resonance spectra of certain aromatic free radicals containing protons adjacent to the aromatic ring is examined. It is shown that the magnitude of the interaction between an unpaired electron in a π-orbital and a vibrating hydrogen atom is insufficient to account for the observed splitting. Such a vibrational mechanism is untenable: (1) on the basis of quantitative calculations; (2) by the failure to observe lines corresponding to the first excited vibrational state; and (3) by a comparison of the splitting caused by protons and deuterons. It is suggested that the unpaired electron is not in a purely π-state, and that the splitting may be accounted for by configuration interaction between π- and σ- states. (Contractor's abstract)

COU. 04:002

Columbia U. Dept. of Chemistry, New York.

PARAMAGNETIC RESONANCE OF FREE RADICALS, by G. K. Fraenkel. May 15, 1956 [40]p. incl. illus. diagrs. refs. (Rept. no. CU-6-56-AF-1390-Chem.) (AFOSR-TN-56-218) (AF 18(600)1390) AD 88024 Unclassified

Also presented at Conference on Unstable Chemical Species under the auspices of New York Acad. Sciences, May 15-16, 1956.

The elementary principles of paramagnetic resonance absorption spectroscopy are reviewed with respect to detection, identification, and estimation of free radicals. The typical spectra of free radicals in solution reveal a structure caused by nuclear magnetic hyperfine interaction. The interaction is related to the unpaired electron density in the molecule. The structure provides a means for the qualitative identification of the radical species. The identification is useful for determining the nature of the intermediates in many radical reactions. Equilibrium concentrations of radicals can be obtained. The rate of the production of radicals can be followed either directly or with flow reactors. At present, spectrometers are capable of detecting 10^{-11} mol of radical. When a suitable solvent is employed, an ultimate sensitivity of 10^{-10} mol/l is estimated.

COU. 05:001

Columbia U. [Dept. of Mathematical Statistics] New York.

COMPOUND GROUP EXTENSIONS. 1. CONTINUATIONS OF NORMAL HOMOMORPHISMS, by R. L. Taylor. [1953] [30]p. (AF 18(600)135) Unclassified

Published in Trans. Amer. Math. Soc., v. 73: 106-135, July 1953.

COU. 05:002 - COU. 05:004

This question, in the theory of non-commutative groups, arises from topology. For a "normal" homomorphism ϕ: K into G, that is, with image normal in G, a "continuation" is a pair $(E, \bar{\phi})$ where $E \supset K$ and $\bar{\phi}$: E onto G is an extension of ϕ with the same kernel, X. A continuation induces a homomorphism θ: G into A, the group of automorphisms of A carrying X into itself, modulo those inner automorphisms induced by X. Generally, normal ϕ: K into G, and θ: G into A constitute a "pseudo-module" (ϕ, θ) provided $\theta\phi$ is the natural map K into A. A continuation $(E, \bar{\phi})$ that induces θ, provided such exists, is an "extension" of the ps-module (ϕ, θ). A crossed-module (J. H. C. Whitehead, Bull. Amer. Math. Soc., v. 55: 453-496, 1949; Math. Rev. v. 11: 48) is a ps-module for which the kernel X of ϕ lies in the center Z of K. A Q-kernel (Eilenberg and MacLane, Ann. of Math., v. 48: 326-341, 1947; Math. Rev. v. 9: 7) is a ps-module for which ϕ is trivial. The author sets forth carefully the correspondence between $H^2(Q, X)$ and the (isomorphism classes of) extensions of cr-modules and Q-kernels, and the theory of the obstruction. These results are extended to ps-modules by the following device. Let $\tilde{A}$ be the group of automorphisms of K that carry X into itself, with the natural maps c: K into $\tilde{A}$, λ: $\tilde{A}$ into A. The graph (cf. Baer, Math. Z., v. 38: 375-416, 1934) $\Gamma \subset G \oplus A$ is the group of all (g, α) with $\theta g = \lambda\alpha$. The exact sequence O, X, K, G, Q, O leads to an exact sequence O, $X \cap Z$, K, Γ, Q, O. For ϕ' the induced map K into Γ, and $\theta'(g, \alpha) = \alpha$, this yields a cr-module (ϕ', θ') whose extension theory is equivalent to that of the original ps-module (ϕ, θ). In fact, it is shown that the concept of ps-module is equivalent to that of a pair formed by a cr-module together with a suitably related subgroup of K. An additional result states that (ϕ, θ) admits a splitting extension $(E, \bar{\phi})$ just in case G splits over the image of ϕ. (Math. Rev. abstract)

COU. 05:002

Columbia U. [Dept. of Mathematical Statistics] New York.

COMPOUND GROUP EXTENSIONS. II, by R. L. Taylor. [1953] [7]p. (AF 18(600)135) Unclassified

Published in Trans. Amer. Math. Soc., v. 75: 304-310, Sept. 1953.

Let $\{\rho_\nu: R_\nu \to R_{\nu+1}\}$ and $\{\sigma_\nu: S_\nu \to S_{\nu+1}\}$ be two (infinite) exact sequences, and $\{\beta_\nu: R_\nu \to S_\nu\}$ a commuting sequence of homomorphisms; throughout, the additional hypothesis is made that $\sigma_1\beta_1 R_1 = \sigma_1 S_1$. Call this figure F, and F′ the figure obtained by deleting R_2, ρ_1, ρ_2, and β_2. This paper characterizes the set of (isomorphism classes of) "completions" F of a given figure F′. Replacing R_1 by a factor group and R_3 by a subgroup reduces the problem to the case where R_0, S_0, R_4 and S_4 are all trivial, as we may assume henceforth. If β_1 is an isomorphism of R_1 onto S_1, there is a unique solution with R_2 the appropriate graph $\Gamma \subset R_3 \oplus S_1$. With reference to this case, for S_1 in place of R_1, the general problem is now shown to reduce to that for continuations (in the sense of part I, reviewed above) of the naturally induced normal homomorphism $R_1 \to S_1 \to \Gamma$. Finally, if θ is given constituting, together with β_1, a pseudo-module, there corresponds naturally a pseudo-module (β_1', θ') with β_1': $R_1 \to \Gamma$, and the completions of F′ correspond one-to-one with the extensions of (β_1', θ'). (Math. Rev. abstract)

COU. 05:003

Columbia U. [Dept. of Mathematical Statistics] New York.

COVERINGS OF NON-CONNECTED GROUPS, by R. L. Taylor. [1954] [16]p. (AF 18(600)135) Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 753-768, Oct. 1954.

The results of item no. COU. 05:001 are applied to give a classification of the covering groups of a non-connected topological group G, assuming that the arcwise components of G admit universal covering spaces. Examples show that even if G is a compact 1-dimensional Lie group, G may admit several non-isomorphic universal coverings, or no universal coverings at all; G may also admit non-trivial coverings which cannot be obtained by factorization from any universal covering. Given any covering, there is a natural homomorphism $\pi_1(N) \to K$, where N is the arcwise component of the identity in G and X is the kernel of the covering. The kernel of $\pi_1(N) \to X$ is called the type of the covering. In particular, the universal coverings are the coverings of type O. A subgroup of $\pi_1(N)$ is called stable if it is mapped onto itself by every element of $Q = G/N$ under the natural operation of Q on $\pi_1(N)$. Let ρ be an arbitrary subgroup of $\pi_1(N)$. We show: (1) if ρ is unstable, there are no coverings of type ρ; (2) if ρ is stable, it has an "obstruction" in $H^3[Q, \pi_1(N)/\rho]$ whose vanishing is a necessary and sufficient condition for the existence of a covering of type ρ; (3) if ρ is stable, $H^2[Q, \pi_1(N)/\rho]$ operates simply transitively on the set of all isomorphism-classes of coverings of type ρ. These results are generalized to a classification of all topological group extensions of a topological group G by a topological group X provided X (the kernel) is discrete and the arcwise components of G (the factor group) admit universal covering spaces. This essentially reduces the topological group extension problem to the case where both subgroup and factor group are connected. (Contractor's abstract)

COU. 05:004

Columbia U. Dept. of Mathematical Statistics, New York.

COMPOUND GROUP EXTENSIONS, III, by R. L. Taylor. [1955] [31]p. (AF 18(600)135) Unclassified

Published in Trans. Amer. Math. Soc., v. 79: 490-520, July 1955.

In this paper the author continues the work of parts I

and II. The results obtained are quite technical in nature and difficult to state without introducing a good deal of notation. (Math. Rev. abstract)

COU. 06:001

Columbia U. [Dept. of Mathematical Statistics] New York.

ERGODIC THEORY OF MARKOV CHAINS ADMITTING AN INFINITE INVARIANT MEASURE, by T. E. Harris and H. Robbins. [1953] [5]p. [Technical rept. no. 1] (AF 18(600)442) Unclassified

Published in Proc. Nat'l. Acad. Sciences, v. 39: 860-864, Aug. 1953.

The authors show how to apply the point-ergodic theorem for spaces of infinite measure to (integer-valued parameter) Markov processes possessing infinite-valued stationary absolute "probability distributions." As an application, they prove that, if s_n is the sum of n mutually independent random variables with a common distribution, and if the sequence $\{s_n, n \geq 1\}$ is everywhere dense with probability 1, then, if h and k are Lebesgue integrable over $(-\infty, \infty)$, with integrals $\bar{h}$, $\bar{k}$, $\bar{k} \neq 0$, it follows that

$\lim_{n \to \infty} \sum_1^n h(a + s_j) \; / \; \sum_1^n k(a + s_j) = \bar{h}/\bar{k}$ with

probability 1, for almost all a (Lebesgue measure). Moreover, for every a, this limit equation is true with probability 1 simultaneously for every h, k under the additional restriction that these functions be Riemann integrable and vanish in a neighborhood of infinity. If the s_j's are integer-valued, an analogous result is obtained, in which the Lebesgue measure of a linear set is replaced by the cardinal number of a set of integers. (Math. Rev. abstract)

COU. 06:002

Columbia U. [Dept. of Mathematical Statistics] New York.

A SOLUTION OF A SET OF FUNDAMENTAL EQUATIONS IN MARKOV CHAINS, by C. Derman. [1953] [3]p. Technical rept. no. 2 AF 18(600)442] Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 332-334, Apr. 1954.

Consider a discrete Markov chain, with an infinite number of possible states E_i ($i = 0, 1, 2, \ldots$), homogeneous, irreducible, with a transition matrix $P = (p_{ij})$, p_{ij}^n indicating the elements of P^n; let $\Pi_j^n = \sum_{r=0}^{n} p_{ij}^r$, an easily interpreted quantity; K. L. Chung (Jour. Res. N.B.S. Bu. Standards, v. 50: 203-208, 1953; Math. Rev., v. 14: 1099, 1953) has shown that if E_i and E_j are recurrent states, then $\lim_{n \to \infty} \Pi_j^n / \Pi_i^n$ exists. If all E_i states are recurrent, the author concludes that a system and a unique value v_k exists, such as (a) $v_o = 1$, (b) $v_j > 0$ ($j = 1, 2, \ldots$), (c) $v_j = \sum_{i=0}^{\infty} v_i p_{ij}$, i.e. the numbers $v_k = \lim_{n \to +\infty} \Pi_k^n / \Pi_o^n$. (Math. Rev abstract)

COU. 06:003

Columbia U. [Dept. of Mathematical Statistics] New York.

DISTRIBUTIONS OF SOME INTEGRALS OF CERTAIN STOCHASTIC PROCESSES AND LIMITING DISTRIBUTIONS OF SOME "GOODNESS OF FIT" CRITERIA, by T. W. Anderson. [1953] 43p. (Technical rept. no. 4) (AF 18(600)442) AD 36729 Unclassified

To test the hypothesis that a sample of N observations has been drawn from a population with a specified cumulative distrioution function F(x), one can compare the empirical cumulative distribution function $F_N(x)$ with F(x) by using $W_N = N \int \left[F_N(x) - F(x) \right]^2 \psi \left[F(x) \right] dF(x)$ or $V_N = N \iint 1\left[F(x), F(y) \right] \left[F_N(x) - F(x) \right] \left[F_N(y) - F(y) \right] dF(x) dF(y)$, where $1(u, v) = 1(v, u)$ is continuous in both variables ($0 \leq u, v \leq 1$). The characteristic function of $V = \iint 1(u, v) X(u) X(v) du\, dv$, where X(u) ($0 \leq u \leq 1$) is a Gaussian stochastic process with $\varepsilon X(u) = 0$, is found in terms of the eigenvalues of a certain function, and it is shown that the asymptotic distribution of V_N is that of V when X(u) has a certain covariance function. The characteristic functions of $T = \int \left[X(u) + k(u) \right]^2 du$ and $S = \iint 1(u, v) \left[X(u) + k(u) \right] \left[X(v) + k(v) \right] du\, dv$ are found, and it is shown that the limiting distribution of V_N is that of T for a certain k(u) when the sample of N is drawn from $H_N(x)$ such that $\lim_{N \to \infty} H_N(x) = F(x)$. Some examples of the theory are considered. (Contractor's summary)

COU. 06:004

Columbia U. [Dept. of Mathematical Statistics] New York.

SOME CONTRIBUTIONS TO THE THEORY OF MARKOV CHAINS, by C. Derman. Mar. 1954, 63p. incl. refs. (Technical rept. no. 7) ([AF]OSR-TN-54-66) (AF 18(600)442) AD 31552 Unclassified

Also published in Trans. Amer. Math. Soc., v. 79: 541-555, July 1955.

Consideration is given to the statistical regularity properties of a denumberable number of particles, all moving about the states of a Markov chain according to the same transition probabilities. Treatment is given to the related problem of solving a familiar system of equations occurring in the theory of Markov chains. An investigation was made of the problem of obtaining

COU. 06:005 - COU. 06:008

sharper versions of a strong limit theorem that was proved independently by Harris (Tran. Am. Math. Soc., v. 75, 1952) and Levy (Ann. Sci. Ecole Norm., v. 68, Sup. 3, 1951). Proofs are presented of some multivartate central-ltmit theorems applicable to the development of asymptotic distrtbution theory which is useful in treating statistical problems involving Markov chains with denumerably many states. The results are essentially an extension of Bartlett's results (Proc. Cambridge Phil. Soc., v. 47, part 1, 1951) to denumerable chains. The assumption is made that the Markov chain under consideration is irreducible and recurrent.

COU. 06:005

Columbia U. [Dept. of Mathematical Statistics] New York.

ON CHAINS OF INFINITE ORDER, by T. E. Harris. Mar. 1954, 46p. incl. refs. (Technical rept. no. 5) ([AF]OSR-TN-54-67) (AF 18(600)442) AD 32466 Unclasstfied

Studies are made of stationary stochastic processes with a finite number of states by means of an equivalent stationary real-valued Markov process. Conditions are stated for the existence of an ergodic stationary process with assigned conditional probabilities. The distribution of the equivalent Markov chain variable is studied and is found in general to be continuous and purely singular. Applications are made to a special type of stationary process where the random variable is a function of the states of a Markov chain with a finite number of states; such processes are generally not Markovian. (ASTIA abstract)

COU. 06:006

Columbia U. [Dept. of Mathematical Statistics] New York.

A TEST OF GOODNESS OF FIT, by T. W. Anderson and D. A. Darling. May 1954, 7p. (In cooperation with Michigan U., Ann Arbor) ([AF]OSR-TN-54-113) (AF 18(600)442) AD 39348 Unclassified

Also published in Jour. Amer. Stat. Assoc., v. 49: 765-769, Dec. 1954.

Asymptotic significance points are given for a distribution-free test of goodness of fit previously introduced (Ann. Math. Stat., v. 23: 193-212, 1952). The test criterion is given by

$W_n^2 = n \int_{-\infty}^{\infty} [F_n(x) - F(x)]^2 \psi[F(x)]\, dF(x)$, where

$\psi(u)$ is some nonnegative weight function chosen to accentuate the values of $F_n(x) - F(x)$ where the test is desired to have sensitivity. $F(x)$ is compared with an empirical distribution function $F_n(x)$ equal to the number of $x_i \leq x$ divided by n. The null hypothesis $H(x) = F(x)$ is rejected if W_n^2 is sufficiently large. The sampling error is equalized over the entire range of x by using $\psi(u) = \frac{1}{u(1-u)}$ as the weight function. The 1, 5, and 10% asymptotic significance points of W_n^2 are presented, and the test is illustrated by a numerical example used previously by Birnbaum (Jour. Amer. Stat. Assoc., v. 47: 425-441, 1952) in illustrating the Kolmogorov test.

COU. 06:007

Columbia U. [Dept. of Mathematical Statistics] New York.

ON AGE-DEPENDENT BRANCHING STOCHASTIC PROCESSES IN CASCADE THEORY, by A. T. Reid. May 1954 [7]p. (Rept. no. CU-15-54) ([AF]OSR-TN-54-126) (AF 18(600)442) AD 67328 Unclassified

Also published in Phys. Rev., v. 96: 751-753, Nov. 1, 1954.

A brief introduction to the recent Bellman-Harris theory of branchtng stochastic processes (Ann. Math., v. 55: 280, 1953) is given tn the nomenclature of cascade theory; a simple model in cascade theory formulated as an age-dependent branching process is given. (Contractor's abstract)

COU. 06:008

Columbia U. Dept. of Mathematical Statistics, New York.

ERGODIC PROPERTY OF THE BROWNIAN MOTION PROCESS, by C. Derman. July 1954, 6p. (Rept. no. CU-16-54) ([AF]OSR-TN-54-160) (AF 18(600)442) AD 67372 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 40: 1155-1158, Dec. 1954.

Let X(t), $0 \leq t < \infty$, denote a one-dimensional separable Brownian motion process. The following theorem is provided: If $f(x)$ and $g(x)$ are any two real valued Borel measurable functions, summable over the real line $-\infty < x < \infty$, and if $\bar{g} \neq 0$, then with probability 1

$$\lim_{T\to\infty} \frac{\int_0^T f(X(t))dt}{\int_0^T g(X(t))dt} = \bar{f}/\bar{g}$$

where $\bar{f} = \int_{-\infty}^{\infty} f(x)dx$ and $\bar{g} = \int_{-\infty}^{\infty} g(x)dx$. (Contractor's abstract)

COU. 06:009

Columbia U. [Dept. of Mathematical Statistics] New York.

MULTIPLE POINTS OF PATHS OF BROWNIAN MOTION IN THE PLANE, by A. Dvoretzky, P. Erdös, and S. Kakutani. [1954] [18]p. (Technical rept. no. 6) (AF 18(600)442) AD 36740 Unclassified

Also published in Bull. Res. Council of Israel, v. 3: 364-371, Mar. 1954.

The following notation is used: a probability space $(\Omega, \mathcal{E}, Pr)$ is given where $\Omega = \{\omega\}$ is a set of elements ω, $\mathcal{E} = \{E\}$ is a Borel field of subsets of Ω called events, and Pr is a countably additive measure defined on $\mathcal{E}$ and satisfying $Pr(\Omega) = 1$. Pr(E) is called the probability of the event E. For any point z in the plane, for any $\omega \in \Omega$, and for any real numbers a, b with $0 \leq a < b < \infty$ the following paths are defined: $L_{a,b}(z';\omega) = \{z' + z(t,\omega) \mid a \leq t \leq b\}$; $L_a(z';\omega) = \{z' + z(t,\omega) \mid a \leq t < \infty\}$; $L(z';\omega) = L_0(z';\omega) = \{z' + z(t,\omega) \mid 0 \leq t < \infty\}$ where the + sign refers to vector addition in the plane. When z' coincides with the origin, the abbreviation $L(\omega) = L(0;\omega)$ is used; $L_{a,b}(z';\omega)$ is called the (a, b)-path of the plane Brownian motion starting from z', and $L(z';\omega)$ is called the path of the plane Brownian motion starting from z'. A point z_0 in the plane is called a k-multiple point ($k = 2, 3, \ldots$) of $L_{a,b}(z';\omega)$ if there exist k real number $t_1, \ldots, t_k$ with $a \leq t_1 < \ldots < t_k \leq b$ for which $z_0 = z' + z(t_i;\omega)$, $i = 1, \ldots, k$. The main result is given by the following: Theorem: let M be the set of all ω for which $L(\omega)$ contains k-multiple points for every $k = 2, 3, \ldots$, then $Pr(M) = 1$. These additional results are given. Theorem: let a, b be any positive numbers with $0 \leq a < b < \infty$. Then with probability 1, the (a, b)-path $L_{a,b}(\omega)$ has multiple points of arbitrarily high (finite) multiplicity. Theorem: for almost all ω the set of k-multiple points of $L(\omega)$ is dense everywhere in the plane for all $k = 2, 3, \ldots$.

COU. 06:010

Columbia U. [Dept. of Mathematical Statistics] New York.

THE SEQUENCE OF SUMS OF INDEPENDENT RANDOM VARIABLES, by G. Kallianpur and H. Robbins. [June 1954] [23]p. [Technical rept. no. 5] (AF 18(600)-442) Unclassified

Published in Duke Math. Jour., v. 21: 285-307, June 1954.

Let S_n be the sums of n independent random variables with a common distribution $F(x)$ and $M_n(a)$ be the number of S_j's for $j = 1, \ldots, n$ such that $|S_j| < a$. The limit distribution of $M_n(a)$ was obtained by Chung and Kac (Mem. Amer. Math. Soc., no. 6, 1951) when F is a symmetrical stable distribution. Let $b(x)$ be Riemann integrable in a finite interval and 0 outside. Limit distributions for $\sum_1^n h(S_j)$ are obtained assuming asymptotic forms for $Pr(a < S_n < b)$. These forms hold for certain absolutely continuous $F(x)$ belonging to the domains of attractions of symmetrical stable distributions, according to a slight modification of an argument of Gnedenko and Kolmogorov (Limit distributions for sums of independent random variables, Gostehizdat, Moscow-Leningrad, 1949; translation reviewed in Math. Rev., v. 16: 52, Jan. 1955). (Math. Rev. abstract)

COU. 06:011

Columbia U. [Dept. of Mathematical Statistics] New York.

ON STRONG BOUNDS FOR SUMS OF INDEPENDENT RANDOM VARIABLES WHICH TEND TO A STABLE DISTRIBUTION, by M. Ltpschutz. [1955] 25p. refs. [AFOSR-TN-55-105] (AF 18(600)442) AD 79614 Unclassified

Also published in Trans. Amer. Math. Soc., v. 81: 135-154, Jan. 1956.

Strong bounds are given for the sums S_n of independent random variables X_k, $k = 1, 2, \ldots$. Strong upper bounds were derived by Feller (Trans. Amer. Math. Soc., v. 67: 98, 1949) and Levy (Studia Math., v. 3: 117, 1931), but lower bounds were unknown except in the special case for $\gamma = 1/2$. Proofs are presented for the following strong lower bounds. (1) Let $0 < \gamma < 1$, and let $\psi(n) \uparrow \infty$ such that $\psi(n)/n \downarrow 0$; then $P(\psi) = P(S_n < b_n \psi(b_n)^{1/\gamma} \text{ i.o.}) = 0$ or 1 as $I_1(\psi) = \int_1^\infty \left[\psi(x)^{\frac{1}{2}\frac{1}{1-\gamma}}/x\right] \exp -k_\gamma \psi(x)^{\frac{1}{1-\gamma}} dx < \infty$ or $= \infty$. (2) Let $1 < \gamma < 2$, and let $\psi(n) \uparrow \infty$ such that $\psi(n)/n \downarrow 0$; then $P(\psi) = P(S_n - np < -b_n \psi(b_n) \text{ i.o.}) = 0$ or 1 as $I_2(\psi) = \int_1^\infty \frac{\psi(x)^{\frac{1}{2}\frac{1}{\gamma-1}}}{x} \exp -k_\gamma \psi(x)^{\frac{1}{\gamma-1}} dx < \infty$ or $= \infty$. The following theorem presents strong upper bounds. Let $\psi(n) \uparrow \infty$ and $\psi(n)/n \downarrow 0$; then for $0 < \gamma < 1$, $P(S_n > b_n \psi(S_n)^{\frac{1}{\gamma}} \text{ i.o.}) = 0$ or 1

$1 < \gamma < 2$, $P(W_n - np > b_n \psi(b_n)^{\frac{1}{\gamma}} \text{ i.o.}) = 0$ or 1 as $I_3(\psi) = \int_1^\infty dx/x\psi(x) < \infty$ or $= \infty$. The notation $P(\ldots \text{ i.o.})$ denotes that $(\ldots)$ occurs for infinitely many n.

COU. 06:012 - COU. 06:015

COU. 06:012

Columbia U. [Dept. of Mathematical Statistics] New York.

ON STOCHASTIC APPROXIMATION, by A. Dvoretzky. [1954] 41p. (Rept. no. CU-29-55) ([AF]OSR-TN-55-385) (AF 18(600)442) AD 91538 Unclassified

Also published in Proc. Third Berkeley Symposium on Mathematical Statistics and Probability, Calif. U., Dec. 1954, and June and July 1955: 39-55.

A stochastic approximation is presented for a general situation which considers the random element as noise superimposed on a convergent deterministic scheme. The main result is as follows: Let α_n, β_n, and γ_n, $n = 1, 2, \ldots$, be nonnegative real numbers satisfying (1) $\lim_{n\to\infty} \alpha_n = 0$; (2) $\sum_{n=1}^{\infty} \beta_n < \infty$; and (3) $\sum_{n=1}^{\infty} \gamma_n = \infty$. Let ϑ be a real number and T_n, $n=1, 2, \ldots$, be measurable transformations satisfying $|T_n(r_1, \ldots, r_n) - \vartheta| \leq \max[\alpha_n, (1+\beta_n)|r_n - \vartheta| - \gamma_n]$ for all real $r_1, \ldots, r_n$. Let X_1 and Y_n, $n=1, 2, \ldots$, be random variables and define $X_{n+1}(\omega) = T_n(X_1(\omega), \ldots, X_n(\omega)) + Y_n(\omega)$ for $n \geq 1$. Then the conditions $E\{X_1^2\} < \infty$, $\sum_{n=1}^{\infty} E\{Y_n^2\} < \infty$, and $E\{Y_n | x_1, \ldots, x_n\} = 0$ with probability 1 for all n, imply $\lim_{n\to\infty} E\{(x_n - \vartheta)^2\} = 0$ and $P\{\lim_{n\to\infty} X_n = \vartheta\} = 1$. Five extensions or generalizations are given in which one or more of the assumptions are relaxed. The Robbins-Monro and Kiefer-Wolfowitz procedures for weaker conditions are included in the results as special cases. Some remarks are made on extensions to nonreal random variables. (ASTIA abstract)

COU. 06:013

Columbia U. [Dept. of Mathematical Statistics] New York.

AN EMPIRICAL BAYES APPROACH TO STATISTICS, by H. Robbins. [1954] [11]p. (Rept. no. CU-27-55) ([AF]OSR-TN-55-387) (AF 18(600)442) AD 77464 Unclassified

Also published in Proc. Third Berkeley Symposium on Mathematical Statistics and Probability, Calif. U., Dec. 1954, and June and July 1955: 157-163.

The following problem is considered: from an approximate value of $p_n(x)$ equal to (the number of terms $X_1, \ldots, X_n$ which equal x) divided by n of the integral $p_G(x) = \int p(x|\lambda)\, dG(\lambda)$, where $p(x|\lambda)$ is a known kernel, obtain an approximation to the unknown distribution function G or to the value of the Bayes function $\phi_G(x) = \int \frac{p(x|\lambda)\,\lambda\, dG(\lambda)}{p(x|\lambda)\, d\, G(\lambda)}$ which depends on G. The X_n are discrete random variables and for any fixed x, $p_n(x)$ tends with probability 1 to $p_G(x)$ as $n\to\infty$. The analysis depends on the nature of $p(x|\lambda)$ and on the class g to which the unknown G is assumed to belong. The following special cases are considered: (1) the Poisson kernel $p(x|\lambda) = e^{-\lambda}\frac{\lambda^x}{x!}$, $x = 0, 1, \ldots$, $\lambda > 0$, and g is the class of all distribution functions on the positive real axis; (2) the geometric kernel $p(x|\lambda) = (1-\lambda)\lambda^x$, $x = 0, 1, \ldots$, $0 < \lambda < 1$; (3) the binomial kernel $p_r(x|\lambda) = \binom{r}{x}\lambda^x(1-\lambda)^{r-x}$, $x = 0, 1, \ldots, r$, $0 \leq \lambda \leq 1$; r is a fixed positive integer representing the number of trials, x is the number of successes in each trial, and G is the class of all distribution functions on the unit interval; and (4) a Laplacian type kernel $p(x|\lambda) = e^{\lambda x} f(x)h(\lambda)$. The problem for the general case when X is not restricted to discrete values is discussed.

COU. 06:014

Columbia U. [Dept. of Mathematical Statistics] New York.

COMPLETE CLASS THEOREMS IN EXPERIMENTAL DESIGN, by S. Ehrenfeld. [1955] 20p. incl. diagrs. (Rept. no. CU-30-55) ([AF]OSR-TN-55-388) (AF 18(600)442) AD 77463 Unclassified

The problems of experimental design are classified as (1) the practical problem of deciding which experiments are relevant to the problems under consideration; (2) the analysis of the particular experimental design chosen; and (3) the decision as to which of the relevant experiments to perform. This mathematical study is devoted to a consideration of the third problem.

COU. 06:015

Columbia U. [Dept. of Mathematical Statistics] New York.

ON COVERING A CIRCLE BY RANDOMLY PLACED ARCS, by A. Dvoretzky. [1955] [9]p. (Rept. no. CU-32-55) ([AF]OSR-TN-55-449) (AF 18(600)442) AD 91258 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 199-203, Apr. 1956.

A negative answer is given to the query of whether or not the condition $\sum_{i=1}^{\infty} a_i = \infty$ assures that the whole of C is covered with probability 1, where C denotes a circle of unit circumference, and a_i, $i=1, 2, \ldots$ is a sequence of positive numbers smaller than 1. A proof

is presented that sequences $\{a_i\}$ exist satisfying $\sum_{i=1}^{\infty} a_i = \infty$ for which the probability that the whole of C is covered by arcs A_i of length a_i is less than 1; the formal statement is $P\{C \subset \bigcup_{i=1}^{\infty} A_i\} < 1$ or equivalently, $P\{\text{all of C covered infinitely often}\} = 0$. The centers of the arcs A_i are assumed to be uniformly and independently distributed on C.

COU. 06:016

Columbia U. [Dept. of Mathematical Statistics] New York.

THE CRAMÉR-SMIRNOV TEST IN THE PARAMETRIC CASE, by D. A. Darling. [1955] 20p. incl. refs. [Technical rept. no. 3] (AF 18(600)442) Unclassified

Published in Ann. Math. Stat., v. 26: 1-20, Mar. 1955.

Let $X_1, X_2, \cdots, X_n$ be n independent identically distributed random variables having an absolutely continuous distribution function G(x). Let I be a nondegenerate interval on the real axis and suppose, for each θ contained in the interior of I, that $F(x;\theta)$ is a distribution function. The problem is to test the hypothesis H, i.e. H: $G(x) = F(x;\theta)$ for some unspecified $\theta \in I$. Let $F_n(x)$ be the empirical distribution function based on a random sample of size n. The following test function C_n^2 is considered where

$$C_n^2 = n \int_{-\infty}^{\infty} [F(x) - F(x;\hat{\theta}_n)]^2 dF(x;\hat{\theta}_n),$$

and where $\hat{\theta}_n$ denotes a suitable estimator for θ. H will be rejected for C_n^2 suitably large. When the hypothesis completely specifies the distribution function, i.e. a specific value for θ is given, the C_n^2 test function is the ω^2 test function developed by Cramér, Smirnov, and von Mises. This extension of the ω^2-test to include the parametric case is unlike the ω^2-test in that in general this test is not distribution free when H is true. When H is true the characteristic function of the limiting distribution of the C_n^2 test function is investigated for several classes of estimators for θ. In particular, subject to given regularity conditions on $F(x;\theta)$ and subject to conditions on $\hat{\theta}_n$ which include that $nE\{(\hat{\theta}_n - \theta)^4\} \to 0$ as $n \to \infty$ (where $E\{\cdots\}$ is the expectation operator), the asymptotic characteristic function of the test is given in terms of a Fredholm determinant of a specific integral equation when the method of estimation for θ is by the method of maximum likelihood. The results are obtained by reducing the problem to studying a Gaussian stochastic process in a manner similar to that employed in the paper by T. W. Anderson and D. A. Darling (Ann. Math. Stat., v. 23: 193-212, 1955). (Math. Rev. abstract)

COU. 06:017

Columbia U. [Dept. of Mathematical Statistics] New York.

THE STRONG LAW OF LARGE NUMBERS WHEN THE FIRST MOMENT DOES NOT EXIST, by C. Derman and H. Robbins. [1955] 3p. (Rept. no. CU-33-56) (AFOSR-TN-56-21) (AF 18(600)442) AD 89251 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 41: 586-587, Aug. 1955.

In this mathematical study let X be a random variable with distribution function F. It is customary to define $EX = +\infty$ if, and only if, $\int_{-\infty}^{0} |x| dF(x) < \infty$, $\int_{0}^{\infty} x dF(x) = \infty$. (I) It then follows from the strong law of large numbers for finite EX that if $\{X_n\}$ is a sequence of independent random variables with common distribution function F for which (I) holds and if $S_n = \sum_{1}^{n} X_i$, then as $n \to \infty$ $Pr[S_n/n \to +\infty] = 1$ (II) A proof is presented which shows, however, that II can hold even though $\int_{-\infty}^{0} |x| dF(x) = \infty$, $\int_{0}^{\infty} x dF(x) = \infty$. It is presented in the following theorem: If for some constants $0 < \alpha < \beta < 1$ and $c > 0$, $F(x) \leq -C/x^{\alpha}$ for large positive x, which implies that $\int_{0}^{\infty} x^{\alpha} dF(x) = \infty$, while $\int_{-\infty}^{0} |x|^{\beta} dF(x) < \infty$, then II holds.

COU. 06:018

Columbia U. [Dept. of Mathematical Statistics] New York.

SOME ASYMPTOTIC DISTRIBUTION THEORY FOR MARKOV CHAINS WITH A DENUMERABLE NUMBER OF STATES, by C. Derman. [1956] 29p. (Rept. no. CU-34-56) (AFOSR-TN-56-95) (AF 18(600)442) AD 82503 Unclassified

Also published in Biometrika, v. 43: 285-294, Pts. 3 and 4, Dec. 1956.

The joint asymptotic distribution is derived for certain functions of the sample realizations of a Markov chain with denumerably many states, from which the joint asymptotic distribution theory of estimates of the transition probabilities is obtained. Application is made to a goodness of fit test.

COU. 06:019

Columbia U. [Dept. of Mathematical Statistics] New York.

NON-PARAMETRIC UP-AND-DOWN EXPERIMENTATION, by C. Derman. [1956] [6]p. (Rept. no. CU-36-56) (AFOSR-TN-56-220) [AF 18(600)442]

AD 88027 Unclassified

Also published in Ann. Math. Stat., v. 28: 795-798, Sept. 1957.

A nonparametric procedure is proposed for estimating any quantile of F (x) on the basis of quantal response data when x is experimentally restricted to the form a + hn. The procedure is applied to the following conditions: (1) assume a = 0 and h = 1, and estimate the value of $x = \theta$ such that $F(\theta - 0) < \alpha < F(0)$, $1/2 \leq \alpha < 1$. Modifications are given for conditions when $0 < \alpha < 1/2$ or $a \pm 0$ or $h \pm 1$.

COU. 06:020

Columbia U. [Dept. of Mathematical Statistics] New York.

SOME TOPICS ON MARKOFF'S AND DIFFUSION SEMIGROUPS, by J. Neveu. Aug. 22, 1956, 36p. (Rept. no. CU-38-56) (AFOSR-TN-56-401) (AF 18-(600)442) AD 96059 Unclassified

In this mathematical study, a general definition of a Markoff's semigroup is presented. A Markoff's semigroup, $\Phi_s S > O$, is a semigroup of linear transformations on a space of continuous functions induced by a Markoff's process Xs according to the formula: $f \rightarrow \Phi_s f \quad \Phi_s f(x) = E(f(X_s)(X_o = X)) = \int f(\xi) F_s(X, d\xi)$o. With this definition, some new ergodic results and propositions relative to invariant measures are given. This study also contributes to the determination of the most general infinitesimal operator Ω of a Markoff's semigroup. The problem is reduced to a local problem in a terminology introduced by Feller. In addition, the problem is solved for diffusion semigroups on the real line by means of an absorption theory. (Contractor's abstract, modified)

COU. 06:021

Columbia U. [Dept. of Mathematical Statistics] New York.

A SEQUENTIAL DECISION PROBLEM WITH A FINITE MEMORY, by H. Robbins. [1956] 3p. (Rept. no. CU-39-56) [AFOSR-TN-56-593] (AF 18(600)442) AD 116637 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 920-923, Dec. 1956.

We consider the problem of successively choosing one of two ways of action, each of which may lead to success or failure, in such a way as to maximize the long-run proportion of successes obtained, the choice each time being based on the results of a fixed number of the previous trials. (Contractor's summary)

COU. 06:022

Columbia U. [Dept. of Mathematical Statistics] New York.

STOCHASTIC APPROXIMATION, by C. Derman. [1956] 15p. refs. (Rept. no. CU-36-56) (AFOSR-TR-56-15) (AF 18(600)442) AD 86590 Unclassified

Also published in Ann. Math. Stat., v. 27: 879-886, Dec. 1956.

An examination is presented of the Robbins-Monro iterative process for estimating the root of the equation $M(x) = \alpha$ under the hypothesis of a unique root and a real number α. The problem of estimating a root of a given regression equation is discussed in the following context: suppose for every real value x, the random variable Y(x), which denotes the value of a response to an experiment conducted at a controlled level x, has the unknown distribution function $H(y \mid x)$ and the regression function $M(x) = \int_{-\infty}^{\infty} y dH(y \mid x)$. The Robbins-Monro method consists of taking a fixed sequence of positive constants $\{a_n\}$, $(n \geq 1)$, such that $\sum_{n=1}^{\infty} a_n = \infty$, $\sum_{n=1}^{\infty} a_n^2 < \infty$. The level x_1 of the first experiment is arbitrary. Succeeding levels are defined recursively by $x_{n+1} = x_n + a_n(\alpha - y_n)$, where y_n denotes the response at level x_n, a random variable dependent only on x_n and having the distribution function $H(y \mid x_n)$. A more general approach to stochastic approximation is considered which treats the approximation as a convergent determinstic procedure with a superimposed random element.

COU. 07:001

Columbia U. [Dept. of Mathematics] New York.

ON THE HOMOLOGY THEORY OF ABELIAN GROUPS, by S. Eilenberg and S. MacLane. Apr. 1954, 17p. (Rept. no. CU-4-54AF562) ([AF]OSR-TN-54-88) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)562 and Office of Naval Research under Nonr-21800) AD 35963 Unclassified

This report continues the study, by the same authors (Homology theories for multiplicative systems, Trans. Amer. Math. Soc., v. 71: 1951) of the notions of "construction" and "generic acyclicity," and applies them to the homology theory of classes π of abelian groups and their generalizations. For these a "cubical" construction $Q(\pi)$ has been exhibited, and its generic acyclicity proved. Certain gaps in the earlier results are closed in this paper, which defines the construction $A(\pi)$, and establishes its generic acyclicity. (Contractor's abstract)

COU. 07:002

Columbia U. [Dept. of Mathematics] New York.

ALGEBRAS OF COHOMOLOGICALLY FINITE DIMENSION, by S. Eilenberg. May 1954, 16p. (Rept. no. CU-5-54AF562) ([AF]OSR-TN-54-132) (AF 18(600)562) AD 35902 Unclassified

Let Λ be an algebra over a field K with $(\Lambda:K) < \infty$; let N be the radical of Λ; let $\Gamma = \Lambda/N$; let Γ^* be the algebra opposite to Γ; let $\Omega = \Lambda \otimes_K \Gamma^*$. In this paper, the following results are established within the framework of the Cartan-Eilenberg theory (Homological Algebra, Princeton Univ. Press, 1954): Theorem I. Dimension Λ = left global dimension Ω = left dimension $_\Omega\Gamma$. Theorem II. If Γ is separable, then dimension Λ = left dimension $_\Lambda\Gamma$. Theorem III. If dimension Λ is finite then Γ is separable. (All "dimensions" are to be understood in the cohomological sense, as defined in "Homological Algebra.") (Contractor's abstract)

COU. 07:003

Columbia U. [Dept. of Mathematics] New York.

ON THE GROUPS H (π, n), II. METHODS OF COMPUTATION, by S. Eilenberg and S. MacLane. July 1954, 130p. refs. (Rept. no. CU-6-54AF562) (In cooperation with Chicago U., Ill.) ([AF]OSR-TN-54-185) (AF 18(600)562) AD 40838 Unclassified

This is a continuation of previous work by the authors (Ann. Math., v. 58: 55-106, 1953). Methods are established for the group-invariant computation of the integral homology group $H_n\, k(\pi, n)$ regarded as functors of the Abelian group π. The main interest is in the unstable case $k \geq n$ where the functors $H_n + k(\pi, n)$ are not additive such as

$$H_3(\pi_1 + \pi_2, 4) \approx H_3(\pi_1, 4) + H_3(\pi_2, 4) + \pi_1 \otimes \pi_2.$$

The reduction from π finitely generated to π cyclic in the unstable case is achieved by an analysis of cross-effects (the term $\pi_1 \otimes \pi_2$ in the instance above) for arbitrary nonadditive functors. For π cyclic, the complex $\Lambda(\pi, n)$ may be replaced by a simple complex which is finite in each dimension. This guarantees the computability of $H_n + k(\pi, n)$ for π finitely generated. The program is carried out in detail for $k \leq 5$ and $n \geq 2$, except for $H_7(\pi, 2)$. Invariant cohomology results for the groups $H^{n+k}(\pi, n; G)$ are also obtained for $k \leq n$, $k = 2, 3, 4$, and 5.

COU. 07:004

Columbia U. [Dept. of Mathematics] New York.

ON THE VOLUME OF SMOOTH CONVEX BODIES IN HILBERT SPACE, by E. R. Lorch. July 1954, 29p. refs. (Rept. no. CU-7-54AF562) ([AF]OSR-TN-54-194) (AF 18(600)562) AD 47850 Unclassified

A smooth convex body K is defined in a real Hilbert space H, and a class of positive definite self-adjoint transformations is obtained for such a body. These transformations are used to define a fundamental homeomorphism in H which leads to the notion of the adjoint body K*. The volume of K* is expressed by means of an integral of a function of an infinite product of the characteristic values of the self-adjoint transformations. The calculated volume of K* is that of order r = 2; the classical volume corresponds to r = 1. A solution is presented to the problem of finding the volume of ellipsoids in H. (ASTIA abstract)

COU. 07:005

Columbia U. [Dept. of Mathematics] New York.

ON THE DIMENSION OF MODULES AND ALGEBRAS. I, by S. Eilenberg, M. Ikeda, and T. Nakayama. Sept. 1954, 13p. (Rept. no. CU-10-54AF562) [AFOSR-TN-54-269] (AF 18(600)562) AD 67329 Unclassified

A proof is given that the alternative characterizations of algebras of cohomological dimension $\leq n$ which are reported by Ikeda-Nagao-Nakayama (Trans. Amer. Math. Soc.) and Eilenberg (Comment. Math. Helv.) are compatible because the conditions used in stating the principal results of the 2 papers are equivalent. An example of an algebra over an arbitrary ground field is given whose cohomological dimension is infinite but whose Cartan matrix has a determinant equal to -1. The following theorems are proved: (1) if Λ is a K-algebra over a field K, $(\Lambda:K) < \infty$, $\mathcal{N}$ is a 2-sided ideal contained in the radical N of Λ, and $\Lambda' = \Lambda/\mathcal{N}$, then $\dim \Lambda \leq \Lambda' + 1$. $\dim_\Lambda \Lambda'$; and (2) the cohomological dimension of any absolutely primarily decomposable algebra is 0 or ∞.

COU. 07:006

Columbia U. [Dept. of Mathematics] New York.

ON THE DIMENSIONS OF MODULES AND ALGEBRAS. II. FROBENIUS ALGEBRAS AND QUASI-FROBENIUS RINGS, by S. Eilenberg and T. Nakayama. Sept. 1954, 23p. incl. refs. (Rept. no. CU-9-54AF562) [AFOSR-TN-54-270] (AF 18(600)562) AD 67330 Unclassified

The principal results are given by the following theorems: (1) if Λ is Noetherian or satisfies the minimum condition for left or right ideals, then Λ is a quasi-Frobenius ring if and only if it is left self-injective (a ring which when regarded as a left Λ-module is injective; a Λ-module, A, is said to be injective if for each monomorphism ϕ: $A \to C$ of Λ-modules, there exists a Λ-homomorphism ψ: $C \to A$ with $\psi\phi$ = identity); (2) if Λ is a Frobenius algebra and K is quasi-Frobenius (or K is self-injective and Λ is Noetherian), then Λ is a quasi-Frobenius ring; (3) is $\Lambda = K(\pi)$, where π is a finite group of order r, then Λ is symmetric, $\dim \Lambda = 0$ if $r\,K = K$, and $\dim \Lambda = \infty$ if $r\,K = K$.

COU. 07:007 - COU. 09:001

COU. 07:007

Columbia U. [Dept. of Mathematics] New York.

A STUDY OF A CLASS OF STOCHASTIC PROCESSES, PART I, by B. O. Koopman. Oct. 1955, 40p. (Rept. no. CU-54AF562) ([AF]OSR-TN-55-349) (AF 18(600)-562) AD 75271 Unclassified

The stochastic processes studied are the generalized stationary transition birth-and-death processes given by the system (1) $P'_n(t) = R_{n-1}(t) - (R_n + L_n)P_n(t) + L_{n+1} P_{n+1}(t)$ together with the adjoint system (2) $Q'_n(t) = L_n Q_{n-1}(t) - (L_n + R_n)Q_n(t) + R_n Q_{n-1}(t)$; the accents denote t-differentiation. Two cases are studied. In one case, n runs through the nonnegative integers; in the other n runs through all integers, and every R_n and L_n is positive. In both cases, R_n and L_n are independent of t, and attention is confined to nonnegative solutions $P_n(t)$ and $Q_n(t)$. Necessary and sufficient conditions are obtained for the uniqueness of the initial-value problem for (1) and for (2). These conditions are expressed as the divergence of certain triangular series formed from the coefficients R_n and L_n. An analysis is made of the stability and other asymptotic properties of the system [illegible], and on the possible change away from unity of the total probability $\Sigma_n P_n(t)$. Both necessary and sufficient conditions are given for the latter in terms of the coefficients. When the coefficients satisfy both the condition for change away from unity of the total probability and that for nonuniqueness of the initial-value problem, uniqueness can be restored by imposing on the solution the requirement of an unchanging unit total probability.

COU. 07:008

Columbia U. [Dept. of Mathematics] New York.

A STUDY OF A CLASS OF STOCHASTIC PROCESSES. PART II, by B. O. Koopman. Dec. 1955 [26]p. (Rept. no. CU-54AF562) ([AF]OSR-TN-55-448) (AF 18(600)-562) AD 90883 Unclassified

The equations for generalized stationary transition birth-and-death processes previously discussed (AFOSR-TN-55-349) are solved by the application of continued fractions to the Laplace transforms of the original equations. This method is shown to lead to the same solutions as those obtained classically by successive approximations. The utility of this alternate proof is that the formulas are simpler in certain respects than those obtained by the method of successive approximations, and the results throw light on the analytic character of $p_{m,n}(s)$ in the complex variable s, revealing in particular its asymptotic properties for $s \to 0$ and $s \to \infty$, from which, with the aid of Tauberian theorems, those of the minimal $P_{m,n}(t)$ for $t \to \infty$ and $t \to 0$ can be inferred.

COU. 08:001

Columbia U. Dept. of Mechanical Engineering, New York.

ON THE VELOCITY OF SOUND, by H. Dereslewicz and J. H. Weiner. [1956] 3p. (AFOSR-TN-56-422) [AF 18(600)52] AD 96503 Unclassified

A mathematical analysis of Laplace's correction of Newton's theoretical value of the velocity of sound shows that inclusion of the thermal conductivity effect in the equations of motion yields first approximation values which are in accord with Laplace's theory only at relatively low frequencies of motion. As the frequency increases without limit, the equations yield the Newtonian, "isothermal" velocity of propagation. Laplace's hypothesis is correct at low frequencies because condensations and rarefactions are relatively slow, and the long time available for the establishment of thermal equilibrium is counteracted by the large distance between adjacent condensations and rarefactions traversed by the heat; at high frequencies both the time and the distance traversed are short. Analysis of the time and distance effects, by analogy with the problem of heat flow in slab, shows thermal equilibrium to be established rapidly at high frequencies, and slowly at low frequencies when the phase velocity range is bounded from below by the Newtonian value and from above by the Laplacian. The exponential variation of spatial amplitude attenuation as the square of the imposed frequency, indicating an immediate wave decay at very high frequencies, is found true only below a certain bound of the frequency; as the frequency increases without limit the amplitude attenuation tends to a finite value. The processes at high and low frequencies are found to be thermodynamically reversible, since at both limits the specific damping loss tends to zero.

COU. 09:001

Columbia U. [Dept. of Physics] New York.

THE MECHANISM OF ELECTRIC CONDUCTIVITY IN SEMICONDUCTORS, METALS AND SUPERCONDUCTORS, by L. Brillouin and M. Payne. Final rept. Oct. 31, 1952. 18p. incl. diagrs. refs. (Rept. no. CU-4-56AF1606) (AFOSR-TN-56-542) (AF 18(600)-1506) AD 110361 Unclassified

The details of the interaction between the random elastic waves (caused by thermal agitation) in a metal and the conduction electrons were analyzed. The first zone was replaced by a sphere with a radius $R = \sqrt[3]{6\pi^2 N/V} = r_o \sqrt[3]{2}$, where N is the number of atoms in the lattice, V is the lattice volume, and r_o is the radius of the Fermi sphere. To compute the effective number of trapped electrons, the assumptions were made that the trapped electrons do not interact with one another, a given wave may trap many electrons, a given electron may be trapped by many waves, and the curve (α) which represents the correction for the zero-order expression for the electron energy may

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be replaced by a step curve about k_{00} (a constant for a given metal). The criterion for superconductivity was sought in the expression which represents the capacity of the waves for trapping electrons, $\rho_{tr} = n_{tr}/nN$, where n_{tr} is the total effective number of electrons trapped by waves, and n is the number of free electrons per atom. The proposition was examined that $\rho_{tr} > 1$ might imply superconductivity and $\rho_{tr} < 1$ might imply normal behavior. Computations were made on the basis of expressions for n_{tr} and Δn_{tr} (the difference between the number of trapped and antitrapped electrons). The final expression for ρ_{tr} depends on the ratio V/N and on terms in various powers of V. The numerical values of the factors involved in ρ_{tr} failed to discriminate between superconductors and normal metals: the appearance of V made complete numerical calculation impossible. Computations failed to support the hope that ρ_{tr} would decrease through unity at the critical temperature for superconductors. A model of superconductivity is offered which is based on exchange terms. (ASTIA abstract)

COU. 10:001

Columbia U. Electronics Research Labs., New York.

ANALYSIS AND SYNTHESIS OF SAMPLED-DATA CONTROL SYSTEMS, by E. I. Jury. Oct. 20, 1953, iv, incl. diagrs. refs. (Technical rept. no. T-1/B; rept. no. CU-2-53AF677-EE) (AF 18(600)677) AD 20612 Unclassified

The theory of sampled-data systems using the method of the z-transform is extended and clarified. In particular, the equivalence between the z-transform in its closed form and the infinite summation used by some investigators is shown. Important characteristics of the pulsed transfer function and initial and final value theorems are developed for the z-domain. An extensive table of z-transform pairs covering the most important and commonly encountered system functions and input functions is given. The technique for stabilizing and shaping the pulsed transfer locus is demonstrated. In particular, the application of linear compensating networks in the continuous part of the system is investigated. Design criteria are obtained which relate the transient response of sampled-data systems and the frequency response. The effects of pole location and pole dominance are developed. The problem of output ripple is briefly examined insofar as its effect on the transfer loci in the z-domain are concerned. The broad objectives of design of sampled-data systems, including transient response and ripple, are integrated and design procedures are outlined. (Contractor's abstract)

COU. 10:002

Columbia U. Electronics Research Labs., New York.

SAMPLED-DATA PROCESSING TECHNIQUES FOR FEEDBACK CONTROL SYSTEMS, by A. R. Bergen and J. R. Ragazzini. Nov. 19, 1953, 36p. incl. diagrs. tables. (Technical rept. no. T-2/B; rept. no. CU-3-53AF677-EE) (AF 18(600)677) AD 23441 Unclassified

Presented at general meeting of the Amer. Inst. Elec. Engineers, Los Angeles, Calif., June 21-25, 1954.

Also published in Applications and Industry, No. 10: 236-246, Nov. 1954.

Sampled-data feedback control systems are becoming increasingly prominent with the introduction of digital computers as control elements, time-shared data-transmission links, and data-gathering devices such as radars. The plant which is to be controlled is generally represented as a continuous linear device, often having transfer lags. Stabilization and shaping of a feedback control system for such a plant, where the data are sampled at one or more points in the system, is a central problem. Prior methods have utilized linear networks inserted in cascade with the plant which shaped the plant transfer function to give stable and acceptable performance. An alternate method is to process the data samples themselves in a computer or processing unit and to produce an output pulse sequence which has desirable effects in stabilization and shaping of the over-all response of the system. Such a unit is referred to as a Sampled-Data Processing Unit which operates by storing and weighing past input and output samples, and combining them in a linear manner. Using such a device, it is possible to cause the response of a system to conform with desired specifications. Depending on the plant transfer function, certain ideal prototype response functions can be achieved readily in most cases while, in other cases, amplitude limitations and considerations of stability prevent a perfect realization of the ideal prototype response. In any case, dead-beat response to a step or ramp function can always be achieved regardless of the system. Illustrative examples show how the programs for sampled-data processing units can be obtained. The implementation of processing units of this type can be either analog or digital in form but, in either case, a unit will not be required to store more than a finite and generally small number of past data samples to realize stable and desired performance. Its engineering practicality, as well as the relatively superior performance which can be achieved by its use, makes the introduction of sampled-data processing technique desirable even in certain cases where the system is otherwise fully continuous. (Contractor's abstract)

COU. 10:003

Columbia U. Electronics Research Labs., New York.

ANALYSIS OF ERRORS IN SAMPLED-DATA FEEDBACK SYSTEMS, by J. Sklansky and J. R. Ragazzini. Feb. 1, 1954, 15p. incl. illus. (Technical rept. no. T-3/B; rept. no. CU-4-54AF677-EE) [AFOSR-TN-54-18] (AF 18(600)677) AD 26978 Unclassified

Presented at general meeting of the Amer. Inst. Elec.

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COU. 10:004 - COU. 10:007

Engineers, New York, Jan. 31-Feb. 4, 1955.

Also published in Applications and Industry No. 18: 65-71, May 1955.

The system error in sampled-data feedback systems resulting from the application of a test function is an important design parameter. The system error is defined as the difference between the actual output of the system and the desired output. There are two components which contribute to this error: one called organic error is brought about by the system energy storages, and the other called ripple is brought about by the sampling process. Formulation of the system error is obtained by the application of the Laplace and z-transformation. Both the system error time function in intersampling times and the rms system error are formulated in terms of the system parameters. Illustrative examples demonstrate the theory. (Contractor's summary)

COU. 10:004

Columbia U. Electronics Research Labs., New York.

A MATHEMATICAL TECHNIQUE FOR THE ANALYSIS OF LINEAR SYSTEMS, by J. R. Ragazzini and A. R. Bergen. Mar. 15, 1954, 12p. illus. (Technical rept. no. T-4/B; rept. no. CU-5-54AF677-EE) ([AF]OSR-TN-54-43) (AF 18(600)677) AD 30350 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 42: 1645-1651, Nov. 1954.

The z transformation originally developed for the analysis and synthesis of sampled-data systems was applied to numerical solutions of continuous linear systems. The introduction of sampling at some convenient point was incorporated in a model of the continuous linear system. The sampled time function is reconstructed into a polygonal approximation by means of a holding operator. The output of the system is computed as a train of impulses which give the values of the output at sampling instants; both analytical and arbitrary outputs can be handled by this model. The errors in the output, which result by making computations on the sampled model rather than on the actual system, are obtainable by the application of a procedure similar to that of the main computation. Theoretical predictions concerning the error produced by the model were within very close tolerance to the actual error in an example using feedback.

COU. 10:005

Columbia U. Electronics Research Labs., New York.

LINEAR FILTERING OF SAMPLED DATA, by G. Franklin. Dec. 1, 1954, 27p. incl. diagrs. (Technical rept. no. T-5/B; rept. no. CU-7-54AF677-EE) ([AF]OSR-TN-55-21) (AF 18(600)677) AD 57247 Unclassified

An application of least squares filtering theory is made to situations where a time stationary random message and additive noise are sampled before being filtered. Such a situation might possibly occur with a pulsed radar or data link or in a system where an instrument measures only samples. The transfer function of the filter obtained from this application of the theory is usually a product of 2 terms, one of them rational in s and the other rational in e^{sT}, where s is the complex frequency and T is the sampling period. The first term represents a network of lumped R, L, and C elements, while the second term has the form of a linear program on a digital computer. (Contractor's abstract)

COU. 10:006

Columbia U. Electronics Research Labs., New York.

THE OPTIMUM SYNTHESIS OF SAMPLED-DATA SYSTEMS, by [G. Franklin]. May 2, 1955, 81p. incl. diagrs. refs. (Technical rept. no. T-6/B; rept. no. CU-10-55AF677-EE) ([AF]OSR-TN-55-140) (AF 18(600)677) AD 67031 Unclassified

A derivation is presented of the optimum transfer functions in the least squares sense for a particular class of sampled-data systems. These are single-looped, linear, error-sampled, feedback systems. The criterion of performance on which the derivations are based is the mean squared error between the actual output and the desired output at all instants of time. This criterion is applicable to those systems which must produce a continuous signal from sampled data. Two types of inputs were considered: either the input is the sum of a random message and noise, or it is a deterministic signal which is known for all time. The system was considered as a filtering and as a control problem. For the filtering problem, the only restriction on the system was physical realizability, and the solution was the specification of the entire transfer function. For the control problem the system was considered to have a specified continuous component or plant, and the solution specified the transfer function of the optimum controller for this point. An analysis is included of sampled signals with an extension to the analysis of sampled random signals. A method is outlined for the control of plants which are open-loop unstable so that some of the optimum filters which are derived can be realized without approximation. (ASTIA abstract)

COU. 10:007

Columbia U. Electronics Research Labs., New York.

NETWORK COMPENSATION OF ERROR-SAMPLED FEEDBACK CONTROL SYSTEMS, by J. Sklansky. Apr. 1, 1955 [89]p. incl. diagrs. refs. (Technical rept. no. T-7/B; rept. no. CU-11-55AF677-EE) ([AF]OSR-TN-55-162) (AF 18(600)677) AD 72852 Unclassified

Two techniques, believed to be new, for designing lumped parameter networks to compensate error-sampled feedback control systems have been developed. In one technique compensation by means of a network placed in cascade with the fixed part of the system is considered. When this technique is in its simplest form, an approximation is employed in which direct use is made of both the pulsed loop transfer locus of the uncompensated system and the ordinary transfer locus of the compensating network. In addition, there exists a way of making a rough and relatively quick evaluation of the error involved in the approximation. In the other technique, R-C networks form the principal components in some relatively simple circuitry, called "pulsed networks," which perform the same function as more complicated digital computers or "sampled-data processing units;" thus, a pulsed network can act as a c compensating device for a sampled-data feedback system. Some basic building blocks are described with which pulsed R-C networks can be synthesized to realize any rational pulsed transfer function which is at all physically realizable. The theory is substantiated by 3 illustrative examples. (Contractor's abstract)

COU. 10:008

Columbia U. Electronics Research Labs., New York.

FACTORS IN THE DESIGN OF DIGITAL CONTROLLERS FOR SAMPLED-DATA FEEDBACK SYSTEMS, by J. E. Bertram. Aug. 15, 1955, 33p. incl. diagrs. tables. (Technical rept. no. T-8/B; rept. no. CU-12-55AF677-EE) ([AF]OSR-TN-55-360) (AF 18(600)677)
AD 78895 Unclassified

Also published in Trans. Amer. Inst. Elec. Engineers, v. 75: 151-159, July 1956.

This study is an extension of the design procedure proposed by Bergen and Ragazzini for error-sampled control systems ("Sampled-Data Processing Techniques for Feedback Control Systems," Trans. Amer. Inst. Elec. Engineers, v. 73: 1954). Restrictions on the specification of the over-all transmission, $K^*(z)$, caused by steady-state error considerations and the inability to cancel poles perfectly and zeros of the plant on or outside the unit circle are discussed. A design procedure which includes these restrictions is presented. In addition, it is shown that where the input may take different forms it is desirable to have $K^*(z)$ a ratio of polynomials rather than a finite polynomial in z^{-1}. Several examples utilizing the specified design procedure are given. (Contractor's abstract)

COU. 10:009

Columbia U. Electronics Research Labs., New York.

DIGITAL COMPENSATION OF CONTINUOUS-DATA FEEDBACK CONTROL SYSTEMS, by K. K. Maitra and P. E. Sarachik. Aug. 30, 1955, 40p. incl. diagrs. (Technical rept. no. T-9/B; rept. no. CU-15-55AF677-EE) ([AF]OSR-TN-55-377) (AF 18(600)677)
AD 81356 Unclassified

Also published in Trans. Amer. Inst. Elec. Engineers, v. 75: 107-116, May 1956.

Methods are suggested of employing digital computers for compensating continuous data-feedback systems functioning as control systems or as regulators. The term compensating is used to imply that no attempt is made to use the digital compensator to stabilize an inherently unstable system but only to improve the dynamic performance of the system in terms of rise time, maximum overshoot, or settling time. Two classes of systems are considered: duplicators which are control systems with either unity or constant gain in the feedback line and regulators. In the duplicator problem, the system is required to follow the reference input with no steady-state error with the fastest possible rise time and minimum overshoot. In the regulator system, the output to any suddenly applied disturbance is required to decay rapidly with no overshoot.

COU. 10:010

Columbia U. Electronics Research Labs., New York.

THE ANALYSIS OF MULTIPLE-RATE-SAMPLED SYSTEMS, by G. M. Kranc. Nov. 15, 1955, 37p. incl. diagrs. table. (Technical rept. no. T-11/B; rept. no. CU-17-55AF677-EE) ([AF]OSR-TN-56-2) (AF 18(600)677) AD 84868 Unclassified

The analytical technique described in this mathematical study makes it possible to study the behavior of sampled-data systems containing switches which do not operate at the same sampling rate. Once the closed-form Z-transform of the output of such systems is obtained, standard tools of sample data theory can be applied to deal with problems of stability and performance. The amount of necessary computations depends on the actual values of the integers p and q. It is obvious from the general expressions derived that the higher the values the more computational labor is necessary. This becomes especially serious in the general case, treated in the section on "General Case," where it is shown that p or q (whichever is smaller) simultaneous equations have to be solved. Computational labor could be reduced by the use of suitable computers or the use of approximations. Thus, it seems possible to approximate the ratio of p_1/q_1, where p_1 and q_1 are both large integers, by another ratio, p_2/q_2, where p_2 and q_2 are small integers. Such approximations increase the usefulness of the described technique. (Contractor's abstract)

COU. 10:011

Columbia U. Electronics Research Labs., New York.

A TECHNIQUE FOR THE ANALYSIS OF TIME VARYING SAMPLED-DATA SYSTEMS, by B. Friedland. Sept. 15, 1955, 21p. incl. diagrs. table. (Technical

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rept. no. T-10/B; rept. no. CU-16-55AF677-EE) ([AF]OSR-TN-56-4) (AF 18(600)677) AD 89258 Unclassified

Also published in Applications and Industry, No. 28: 407-411, Jan. 1957.

A method of analyzing time-varying sampled-data systems is developed. It is shown that the input-output relation for a component of such systems may be regarded as a matrix equation. The relations for combinations of elements are developed, from which the transmission matrix for an entire system can be found by the simple operations of matrix multiplication and solution of linear algebraic equations. A numerical example illustrating the technique is given. A method for improving the performance of a sampled-data feedback system by means of a time-varying amplifier is given as a further illustration of the technique. A numerical example is presented. (Contractor's abstract)

COU. 10:012

Columbia U. Electronics Research Labs., New York.

MULTIPOLE SAMPLED-DATA CONTROL SYSTEMS, by H. Freeman. Sept. 30, 1955, 42p. incl. diagrs. refs. (Technical rept. no. T-12/B; rept. no. CU-19-55AF677-EE) (AFOSR-TN-56-81) (AF 18(600)677) AD 81534 Unclassified

A detailed discussion is presented of a method for designing a multipole control system so as to permit noninteracting control of any output by its corresponding input. This method eliminates the coupling inherent in such systems to permit application of well-known single-input, single-output system techniques. The treatment is from the sampled-data point of view because of the ease with which complicated transfer functions may be realized with a digital computer. Although the method applies equally well to continuous-data systems, it is not without limitations. Certain restrictions must be placed on the over-all response if the plant determinant (P) has zeros or any of the elements of P have poles in the exterior of the unit circle of the z-plane. An example is presented of the design of a controller for a system having 3 inputs and 2 outputs.

COU. 10:013

Columbia U. Electronics Research Labs., New York.

TRANSFORMATION TECHNIQUES FOR TIME-VARYING SAMPLED-DATA SYSTEMS, by B. Friedland. Jan. 2, 1956, 42p. incl. diagrs. (Technical rept. no. T-13-B; rept. no. CU-20-56AF677-EE) (AFOSR-TN-56-175) (AF 18(600)677) AD 86597 Unclassified

Components of time-varying sampled-data systems are characterized by time-variable transmission functions of the form H (n, z). An operational method for obtaining the response of feedback systems, when the transmission functions for all components are known, is presented. This method leads to a differential or functional equation for the Z-transform of the required response. W-transforms, similar to Z-transforms, are defined and used to obtain the transmission function for a cascade of components. The W-transform method is also used to find the response of feedback systems. Slowly-varying systems are considered, and an approximation which simplifies analysis for such systems is suggested. The final value theorem for fixed systems is extended to systems whose asymptotic behavior is known. It is shown that for a class of systems the asymptotic behavior can be easily determined. Stability of time-varying systems is considered. (Contractor's abstract)

COU. 10:014

Columbia U. Electronics Research Labs., New York.

MULTI-RATE SAMPLED SYSTEMS, by G. M. Kranc. May 7, 1956, 95p. incl. diagrs. tables, refs. (Technical rept. no. T-14/B; rept. no. CU-22-56AF677-EE) (AFOSR-TN-56-242) (AF 18(600)677) AD 88362 Unclassified

The following contributions to the theory of sampled systems are presented: (1) a method for the analysis of multirate sampled systems (defined as systems with switches operating at different sampling rates); and (2) a method of compensation of an error-sampled feedback system by means of a multirate controller. The analysis procedure extends the methods of Z-transforms to multirate systems, and its only theoretical limitation is that the sampling rates of these systems should be constant and related by a rational number. Sampling periods of each switch are first expressed in the form $T/p_1 \ldots T/p_n$, where $p_1 \ldots p_n$ are generally different integers. Each switch is replaced by a system of switches and advance and delay elements, where each switch operates simultaneously and with a period T. This technique, which is referred to as the switch-decomposition method, leads in the general feedback case to a functional equation whose solution is outlined. The phantom switch method which was developed previously for multirate systems with sampling rates related by an integer is extended to cover the general case. Some of the multirate techniques developed for the process of analysis are applied to the synthesis of a multirate controller, a pulsed network which in response to input samples at time $t = 0, T, 2T, \ldots$ produces output samples at time $t = 0, T/n, 2T/n, \ldots$, (n is an integer) any output sample being a linear combination of the past and present inputs and outputs. The multirate controller, which is used to compensate an error-sampled feedback system, has two advantages over its single-rate predecessor; it minimizes the intersampling ripple and improves the rise time of the system.

COU. 10:015

Columbia U. Electronics Research Labs., New York.

A TWO-DIMENSIONAL FEEDBACK CONTROL SYSTEM, by P. [E.] Sarachik and J. R. Ragazzini. Aug. 15, 1956, 24p. incl. diagrs. (Technical rept. no. T-16/B; rept. no. CU-26-56AF677-EE) (AFOSR-TN-56-105) (AF 18(600)677) AD 97369 Unclassified

The class of control systems whose objective is to control and maintain a relationship between several dimensions (time, spatial or both) is discussed in the two dimensional case. The system is synthesized by regulating the movement of the open-cycle system with that of the closed-cycle system. The dimensions, x and y, must maintain such a relationship that an error in y affects x and y, preferrably through a functional relationship obviating programming or externally adjusting the system. The cross-coupling of the outputs aims at slowing the motion in one dimension while speeding it up in the other, when the error tends to become too large for the appropriate two-dimensional space curve. For higher order systems, approximate linear small signal methods with computer studies are recommended for contour cutting tool controls and other applications.

COU. 10:016

Columbia U. Electronics Research Labs., New York.

AN EXTENDED ANGULAR RANGE DIRECT READING PHASEMETER, by S. Bigelow and J. Wuorinen. Sept. 20, 1956, 20p. incl. diagrs, refs. (Technical rept. no. T-17/B; rept. no. CU-27-56AF677-EE) (AFOSR-TN-56-566) (AF 18(600)677) AD 110369 Unclassified

Most commerical phasemeters are designed to measure angles from 360° lagging to 360° leading. This range is usually covered in a number of segments, some sort of switching arrangement providing for a desired segment. A specialized analog computer, the Complex Plane Scanner, was desired to be capable of following slow changes in phase between two 400-cycle per second sinusoids. This meter is developed capable of measuring angles of from 540° lagging to 540° leading (upper limit 720° lagging to 720° leading) in one continuous range without range switching or output ambiguity. The accuracy is ± 1° for the angular range and 0.1 to 100 volts for the input amplitude. Modifications for use at other frequencies are suggested.

COU. 10:017

Columbia U. Electronics Research Labs., New York.

THE SYNTHESIS OF MULTIPOLE CONTROL SYSTEMS, by H. Freeman. Apr. 24, 1956, 74p. incl. diagrs. refs. (Technical rept. no. T-15/B; rept. no. CU-24-56AF677-EE) (AFOSR-TR-56-26) (AF 18(600)677) AD 90006 Unclassified

A method is presented for the direct synthesis of multipole control systems, i.e., control systems having a multiplicity of inputs and controlled outputs. Formerly, the synthesis of such systems had to be carried out by laborious trial-and-error studies on analog computers. The method described here permits the straightforward design of multipole control systems in a manner similar to that presently possible for single-input, single output systems. Only linear systems are considered. The method is presented from the sampled-data point of view, without, however, sacrificing any generality. A canonical form of multipole control system is defined and the basic requirements to achieve control action are established for such a system. An analysis is given of the factors which affect system stability together with a technique for stabilizing systems having plants with unstable elements. It is shown that a system may be synthesized to have any arbitrary input-output transformation and output transient responses, subject only to certain restrictions imposed by the requirements for stability and the use of physically realizable components. The concept of error coefficients is extended to multipole systems by the definition of an error coefficient tensor. This permits the design of systems having steady-state errors of prescribed magnitude for given test-function inputs. Equations are developed which permit the explicit solution for the required controllers in terms of the given plant and the desired over-all responses. A detailed, illustrative example is worked out involving the design of a control system required by a motor manufacturer for the rapid testing of motor-alternator sets coming off a production line.

COU. 11:001

Columbia U. Electronics Research Labs., New York.

SYNTHESIS OF NONLINEAR TRANSFER CHARACTERISTICS WITH PASSIVE RESISTANCE NETWORKS, by R. J. Schwarz. Sept. 15, 1954, 37p. incl. diagrs. tables. (Technical rept. no. T-1/F; rept. no. CU-4-54AF962-EE) (AF 18(600)962) AD 52449 Unclassified

A method is described for obtaining approximately a specified nonlinear characteristic by means of passive resistance ladder networks using nonlinear resistive elements of known characteristic. The method assumes only that the voltage-current characteristic of the nonlinear elements can be reversed. The network parameters are obtained by minimizing the mean square error or the mean square relative error of the required input relative to the ideal input for the desired output. The accuracy and the dynamic range over which the desired characteristic can be obtained depend on the complexity of the network configuration chosen. Ladder structures are considered in which either all elements may be nonlinear, or only the shunt or the series elements are made nonlinear. The input-output relationships for one-, two-, and three-section ladder structures in which the nonlinear elements are thyrite resistors with a current-voltage characteristic $i = ae^n$ are given in a table. These relationships are also given

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for several combinations of numerical values of the exponent n. The method is illustrated by applying the procedure to the synthesis of a logarithmic output-input characteristic for several input dynamic ranges. (Contractor's abstract)

COU. 11:002

Columbia U. Electronics Research Labs., New York.

COMPLEX PLANE SCANNER: AN ANALOG COMPUTER, by G. [M.] Kranc, P. Mauzey, and J. Wuorinen. Aug. 1, 1955, 71p. incl. diagrs. refs. (Technical repl. no. T-2/F; rept. no. CU-8-55AF962-EE) ([AF]OSR-TN-55-261) (AF 18(600)962) AD 72853 Unclassified

This report reviews the theory, indicates the applications, and describes certain specific circuits of a special type of electronic analog computer which uses sinusoidal voltages as analogs of phasors in the complex plane. The circuits which make up the heart of the computer, its central unit, are explained in detail. This unit receives, as inputs, the complex-frequency variable s in addition to the location of each pole and zero of the function, F(s), being investigated. Its outputs are 2 slowly varying voltages, one representing the phase and the other the logarithm of the magnitude of F(s) as s takes various positions in the complex plane. Thus, for example, if s is restricted to the imaginary axis (s = jω) the outputs will be slowly varying voltages representing the phase and the logarithm of the magnitude of F(s) as functions of frequency. Multiplication and division are required to obtain the magnitude of F(s). These operations are converted to addition or subtraction (or summing and sign-changing) by the use of logarithms. Pulse techniques are used to obtain the phase information as a slowly varying voltage. The remainder of the computer consists of the input unit which provides the variable s and the output unit which processes the voltages from the central unit into a convenient form for the type of display desired. Results of performance tests on portions of the system are included. (Contractor's abstract)

COU. 11:003

Columbia U. Electronics Research Labs., New York.

RESEARCH IN DESIGN TECHNIQUES FOR CONTROL SYSTEMS BY ELECTRONIC SIMULATION OF THE COMPLEX PLANE, by S. Fenster and J. Wuorinen. Interim Final rept. (Oct. 1, 1953 - May 31, 1956. June 30, 1956, 23p. incl. diagrs. refs. (Rept. IF/110; rept. no. CU-13-56AF962-EE) (AFOSR TR-56-64) (AF 18(600)962) AD 154426 Unclassified

This report covers research done on the Complex Plane Scanner (CPS). Specifically, study was made of methods of applying the scanning of the complex plane to the solution of various problems occurring in linear systems and of implementation of such scanning in electronic form. Displays useful in engineering design problems were developed. The theory of an electronic analog method of scanning the complex plane is outlined and applications of this theory are indicated. The CPS, an analog computer, the operation of which is based on this method is described. System block diagrams and waveforms are included. (Contractor's abstract, modified)

COU. 12:001

Columbia U. Guggenheim Inst. of Flight Structures, New York.

FATIGUE IN AIRCRAFT STRUCTURES; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE HELD AT COLUMBIA U., JAN. 30, 31 AND FEB. 1, 1956, ed. by A. M. Fruedenthal. 1956, 456p. incl. illus. diagrs. tables, refs. [AF 18(600)898, Task II] TL698.U52 Unclassified

The full text of all papers presented at the International Conference on Fatigue in Flight Structures are offered in this volume. The purpose of the conference was to bring together the physisists and physical metallurgists, the test engineers and aircraft designers concerned with the problem of the effect of metal fatigue on the performance and safety of modern aircraft, both civilian and military, American and foreign, in an attempt to bridge the gaps existing between these groups and to stimulate the work on the various aspects of fatigue by exchange of information and results of recent research between workers in the various groups. Each day of the conference was devoted to one of the three principal aspects of fatigue in aircraft structures: physical theories of fatigue, prediction of fatigue life and fatigue strength, and prevention of fatigue failure. The subject of the papers range from a discussion of the fatigue mechanism on the submicroscopic scale in terms of dislocations, to the presentation and discussion of methods used in the aircraft industry to ensure adequate fatigue performance of structural parts and specific details of aircraft.

COU. 13:001

Columbia U. Inst. of Air Flight Structures, New York.

THREE-DIMENSIONAL AND SHELL THEORY ANALYSIS OF AXIALLY-SYMMETRIC MOTIONS OF CYLINDERS, by G. Herrmann and I. Mirsky. Apr. 1955 [31]p. incl. diagr. refs. (Technical note no. 1; rept. no. CU-3-55AF1247-CE) ([AF]OSR-TN-55-95) (AF 18(600)1247) AD 67034 Unclassified

Also published in Jour. Appl. Mech., v. 23: 563-568, Dec. 1956.

The frequency (or phase velocity) of axially symmetric free vibrations in an elastic, isotropic circular cylinder of medium thickness is studied on the basis of the 3-dimensional linear theory of elasticity, and also on the basis of several different shell theories. To be in good agreement with the solution of the 3-dimensional

equations for short wavelengths, an approximate theory has to include the influence of rotatory inertia and transverse shear deformation for example in a manner similar as in Mindlin's plate theory. A shell theory of this (Timoshenko) type is deduced from the 3-dimensional elasticity theory. From a comparison of phase velocities, it appears that, to a good approximation, membrane and curvature effects on one hand and flexural, rotatory inertia and shear deformation effects, on the other hand, are mutually exclusive in 2 ranges of wavelengths, separated by a "transition" wavelength. Thus, in the full range of wavelengths, the associated lowest phase velocities may be determined on the basis of the membrane shell theory (for wavelengths larger than the transition wavelength) and on the basis of Mindlin's plate theory (for wavelengths smaller than the transition wavelength). (Contractor's abstract)

COU. 13:002

Columbia U. Inst. of Air Flight Structures, New York.

AXIALLY-SYMMETRIC MOTIONS OF THICK SHELLS, by I. Mirsky and G. Herrmann. Nov. 1955 [21]p. incl. diagr. table. (Technical note no. 2; rept. no. CU-C-55AF1247-CE) ([AF]OSR-TN-55-411) (AF 18(600)1247) AD 81126 Unclassified

An approximate theory of axially-symmetric motions of thick, elastic, cylindrical shells, in which the effect of transverse normal stress is retained, is deduced from the 3-dimensional theory of elasticity. The present theory contains, as special cases, a variety of shell plate, and solid cylinder equations. The propagation of free harmonic waves in the shell is studied on the basis of the present theory, and the 3-dimensional theory of elasticity. Excellent agreement is obtained for the phase velocity of the lowest mode of motion for a wide range of the parameters involved. (Contractor's abstract)

COU. 13:003

Columbia U. Inst. of [Air] Flight Structures, New York.

NONAXIALLY-SYMMETRIC MOTIONS OF CYLINDRICAL SHELLS, by I. Mirsky and G. Herrmann. Dec. 1956 [57]p. incl. diagrs. tables. (Technical note no. 3; rept. no. CU-11-56AF1247-CE) (AFOSR-TN-56-591) (AF 18(600)1247) AD 115018 Unclassified

A shell theory containing membrane and bending effects, transverse shear deformation, rotatory inertia and nonaxially-symmetric motions is developed. The propagation of free harmonic waves in the axial direction of a shell of infinite extent and the physical significance of the results are discussed.

COU. 14:001

Columbia U. School of Mines, New York.

X RAY MICROBEAM STUDIES OF BRITTLE FRACTURES OF METALS, by L.-C. Chang. [Mar. 15, 1954] [14]p. incl. diagrs. table. (Bound with its The Nature of Fracture in Metals, by M. Gensamer, J. O. Brittain and others. Quarterly progress rept. no. 2, Dec. 1, 1954-Feb. 28, 1954. Mar. 15, 1954, 3p.; AD 67374; Unclassified) (AF 18(600)898; Task I) AE 67374(a) Unclassified

A back-reflection x-ray microbeam camera was used in the study of brittle fracture of zinc and iron. Strain distribution curves obtained by the experimental procedure are given for zinc specimens fractured in slow tension at 77°, 195°, and 225°K; for an electrolytic iron specimen fractured at 35°K; and for a carbon steel specimen fractured at 38°K. The average plastic strain decreases rapidly within a short distance from the fracture surface and remains more or less constant at larger distances. There is good evidence that uniformly distributed plastic strain precedes the plastic process resulting in brittle fracture. A formula is given for the work done to produce the plastic strain associated with fracture, or the plastic work factor, w. An estimation of this factor was accomplished graphically. The w values for zinc and iron are about two orders of magnitude larger than their respective surface energies, and w decreases slightly with decreasing temperature in the case of zinc.

COU. 14:002

Columbia U. School of Mines, New York.

ENVIRONMENTAL EFFECTS ON FRACTURE, by L. C. Weiner. [Nov. 1955] 2p. ([AF]OSR-TN-55-413) (AF 18(600)898; Task I) Unclassified

The effect of electroplated coatings of copper and gold, 200-20,000 A thick, on the fracture stress of seeded zinc monocrystals, having the orientation $\chi_0 = 3°$ and $\gamma = 28°$, was tested at room temperature where brittle fracture occurs in crystals of this orientation and prefracture deformation is limited to twinning. Results show that normal fracture stress is increased by copper or gold coating. The increase in fracture stress is constant, within experimental accuracy, for thicknesses greater than about 500 A, being raised from a mean of 2280 ± 70 psi for clean crystals to a mean of 3350 ± 130 psi after copper plating and to 3165 ± 95 psi after gold plating. The increase of fracture stress with coatings less than about 500 A appears to follow a steep straight line. The 3% strain due to twinning in clean crystals is not changed by coating but the coating adds a 3% strain due to slip with high strain hardening. Calculations show the fracture stress increase is not attributable to the inherent strength of the copper of gold film, even assuming that the film is only strained elastically. (Contractor's abstract, modified)

COU. 14:003

Columbia U. School of Engineering, New York.

EFFECTS OF SOLID ENVIRONMENTS ON THE

COU. 14:004 - COU. 16:001

BRITTLE FRACTURE OF ZINC SINGLE CRYSTALS, by L. C. Weiner and M. Gensamer. Aug. 24, 1956 [36]p. incl. diagrs. tables, refs. (AFOSR-TN-56-402) (AF 18(600)898; Task I) AD 96060 Unclassified

Also published in Jour. Inst. Metals, v. 85: 441-448, 1956-1957.

In this study, the normal fracture stress of Zn single crystals oriented χ_o = 3° and tested in tension at room temperature, was increased 43% upon applying a surface film of Cu, Au, ZnO, Sn, or Zn greater than about 500 Å. This increase was independent of film thickness above this value. In addition, the total % elongation was increased twofold, the primary mode of deformation being twinning accompanied by parent basal slip both prior to and subsequent to twinning, as well as the basal slip within the twins. Metallographic examination revealed a difference in the internal structure of clean and coated crystals, namely, the number and distribution of twins. There were more twins in the coated crystals, and they were more uniformly distributed. In contrast, the fracture stress of crystals oriented χ_o = 83° was 48% less than the value observed with clean-surfaced crystals. crystals. The presence of preexisting twins produced by precompression caused the fracture stress of both clean and coated crystals to be increased. These results, as well as observations in prestrain, recovery, and film-removal experiments, have been explained by a dislocation model in which twins play an important role, modifying the dislocation path and acting as barriers. (Contractor's abstract)

COU. 14:004

Columbia U. School of Engineering, New York.

A GRIPPING DEVICE TO TEST BRITTLE METAL SINGLE CRYSTALS IN TENSION, by L. C. Weiner. Sept. 5, 1956[4]p. incl. diagr. (AFOSR-TN-56-423) (AF 18(600)898; Task I) AD 96504 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 1081, Dec. 1956.

A brief description is given of a set of grips used successfully at both low and elevated temperatures in the tensile testing of metal single crystals. Their operation is discussed. It is pointed out that they maintain axiality of load, preventing crystal deformation prior to testing. In addition, they allow crystal specimens not having conventional threaded or enlarged ends to be employed. The grips are shown in a diagram.

COU. 15:001

Columbia U. [School of Mines] New York.

CREEP RUPTURE BY VACANCY CONDENSATION, by E. S. Machlin. Nov. 1954, 16p. illus. tables, refs. (Rept. no. CU-7-55AF899 Met.) (AF OSR-TN 54 359) (AF 18(600)899) AD 57328 Unclassified

Also published in Jour. Metals, v. 8: 106-111, Feb. 1956.

The possibility that formation of voids under creep-rupture conditions may take place by the condensation of vacancies has been investigated theoretically. It has been concluded that nucleation of voids under creep-rupture conditions by vacancy condensation is highly improbable; however, growth of pre-existant voids by vacancy condensation is probable. A number of predictions made in this theory have been verified by the data, e. g., the elongation at which voids just become visible has been predicted and found to be in good agreement with experiment. It has been predicted and verified that the product of rupture life and steady-state creep rate for preannealed metals and single phase alloys is an invariant quantity independent of stress, temperature, and atomic number for a given type structure. The direction of the effect of cold work on this product has been predicted and found in agreement with experiment. A number of experiments to further evaluate the vacancy condensation mechanism are described. (Contractor's abstract)

COU. 15:002

Columbia U. [School of Mines] New York.

A THERMAL ETCHING TECHNIQUE FOR REVEALING DISLOCATIONS IN SILVER, by A. A. Hendrickson and E. S. Machlin. July 14, 1954 [6]p. incl. illus. diagrs. tables. (Rept. no. CU-9-55AF899-Met.) ([AF]OSR-TN-55-113) (AF 18(600)899) AD 91252 Unclassified

Also published in Acta Metallurgica, v. 3: 64-69, Jan. 1955.

A thermal etching technique for revealing dislocations in silver has been developed. The technique reveals single dislocations in silver as evidenced by the close agreement between the experimentally measured area density of dislocations in bent single crystals and the area density calculated using the Cottrell formula for the excess density of dislocations as a function of the radius of curvature of the bent crystal. It has been found that the density of dislocations in recrystallized specimens and as solidified crystals is about 2 x 10^6 /cm^2. A new mode of subgrain formation has been found. The type of subgrain morphology obtained is shown to be dependent upon the orientation between the crystal and the tension direction. (Contractor's abstract)

COU. 16:001

Columbia U. School of Mines, New York.

ON THE THEORY OF THE FORMATION OF MARTENSITE, by M. S. Wechsler, D. S. Lieberman, and T. A. Read. 1953 [13]p. incl. diagrs. tables, refs. (AF 18(600)951 Unclassified

Published in Jour. Metals, v. 5: 1503-1515, Nov. 1953.

A theoretical analysis of the austenite-martensite transformation is presented which predicts the habit plane, orientation relationships, and macroscopic distortions from a knowledge only of the crystal structures of the initial and final phases. (Contractor's abstract)

COU. 16:002

Columbia U. [School of Mines] New York.

ON THE FORMATION OF MARTENSITE IN LOW AND MEDIUM CARBON STEELS, by M. S. Wechsler and T. A. Read. [1954] [42]p. incl. diagrs. table. ([AF]OSR-TN-54-157) (AF 18(600)951) Unclassified

The recently proposed theory of the formation of martensite, which postulates that the total transformation is inhomogeneous in such a way as to bring about a plane of zero average distortion, is applied to the austenite-martensite transformation in low and medium C steels. The transformation is considered to take place by an inhomogeneous distortion for which slip occurs on octahedral planes in the austenite. The habit plane, orientation relationship, and macroscopic distortion are derived as functions only of the lattice parameters of the 2 phases. Two habits, one in the region of $\{225\}$ and the other near $\{111\}$, are predicted by the theory, and are in approximate agreement with experimental observation. The calculated orientation relationship and macroscopic distortion also agree with what has been observed. For continuation of this work, see Illinois U. Dept. of Mining and Metallurgical Engineering, Urbana under contract AF 18(600)1311. (Contractor's abstract, modified)

COU. 16:003

Columbia U. [School of Mines] New York.

INVESTIGATION OF THE CRYSTALLOGRAPHY OF DIFFUSIONLESS PHASE CHANGES IN STEELS, by H. M. Otte and T. A. Read. Final rept. [Aug. 1954] [12]p. incl. diagr. (AF 18(600)951) Unclassified

In this study, the theory of the austenite-martensite transformation in steel is reviewed. The theory postulates that of all the ways that a body-centered tetragonal structure can be generated from a face-centered cubic structure, energy considerations demand that the process of formation lead to a plane of zero distortion. In addition, the total transformation must be inhomogeneous for such a plane of zero distortion to exist. This concept of an inhomogeneous distortion allows, however, all of the crystallographic features of the transformation to be derived. In the case of high carbon steels, the type of inhomogeneity considered was one in which slip takes place with elements appropriate to the martensite, namely, slip on (112) martensite planes in the $\langle 11\bar{1} \rangle$ direction. In the case of the analysis of martensite formation in medium and low carbon steels, a different pattern of inhomogeneity was selected, namely, slip on octahedral planes in the austenite. Two treatments of this type were studied, one in which the direction of slip is the $[1\bar{2}1]$ austenite direction, and in the other, $[10\bar{1}]$ austenite direction.

COU. 17:001

Columbia U. School of Mines, New York.

AN INVESTIGATION OF THE EFFECT OF SOLUTES ON THE GRAIN BOUNDARY STRESS RELAXATION PHENOMENON, by S. Weinig and E. S. Machlin. Apr. 15, 1955 [48]p. incl. diagrs. tables, refs. ([AF]OSR-TN-55-106) (AF 18(600)965) Unclassified

Also published in Jour. Metals, v. 9: 32-41, Jan. 1957.

In this study, an investigation of the effect of solutes on the grain boundary stress relaxation phenomenon in high purity Cu was performed by means of a high vacuum torsion pendulum. It was found that the magnitude of the relaxation peak decreased, and that the energy of activation increased with increased solute content. With the progressive decrease in the first peak with solute content, a second peak appeared which increased in magnitude until a saturation value was attained. The mechanisms of Kê and Mott were investigated and found to be nonapplicable. A 2-step process is propsed in which the first step is rate limiting for the Cu peak, and the second step is rate limiting for the solute peak. The variation of the activation energy for the initial grain boundary stress relaxation phenomenon with concentration is shown to be a measure of the relative interface adsorption of the alloying elements. (Contractor's abstract)

COU. 17:002

Columbia U. School of Mines, New York.

HIGH-VACUUM TORSION PENDULUM FOR ANELASTIC STUDIES, by S. Weinig. Aug. 18, 1954 [1]p incl. diagr. tables. (Rept. no. CU-7-55AF965) ([AF]OSR-TN-55-107) (AF 18(600)965) AD 62015 Unclassified

Also published in Rev. Scient. Instruments, v. 26: 91-92, Jan. 1955.

A design for a high-vacuum torsion pendulum is presented. It allows a complete internal friction study of a single wire specimen to be made without manual manipulation or exposure of the specimen to the atmosphere from a time prior to annealing until completion of the test.

COU. 17:003

Columbia U. School of Mines, New York.

LOW FREQUENCY STUDIES OF DISLOCATION INTERACTIONS WITH SOLUTE ATOMS, by S. Weinig and E. S. Machlin. June 3, 1955. 17 p. incl. diagrs. tables.

COU. 17:004 - COA: 01:001

([AF]OSR-TN-55-160) (AF 18(600)965) Unclassified

Also published in Acta Metallurgica, v. 4: 262-267, May 1956.

A strain amplitude dependent logarithmic decrement and modulus have been found in high purity Cu at 1 cps and 40°C. The effect of various solutes upon the internal friction at this temperature was studied; it was observed that the ability to diminish the decrement was a function of the alloy content, and of the total interaction energy between a solute atom and a Taylor dislocation. Electrical interactions between solute atoms and edge dislocations are shown to be significant in their effect upon dislocation pinning. The experimental results are compared with the theoretical computations and are found to be in good agreement. (Contractor's abstract)

COU. 17:004

Columbia U. School of Mines, New York.

STRAIN-AMPLITUDE DEPENDENT INTERNAL FRICTION STUDIES OF DILUTE ALLOYS OF COPPER, by S. Weinig and E. S. Machlin. [Jan. 27, 1956] [5]p. incl. diagrs. (AF 18(600)965) Unclassified

Published in Jour. Appl. Phys., v. 27: 734-738, July 1956.

An investigation is described of the room-temperature decrement in dilute polycrystalline alloys of Cu as a function of strain amplitude and annealing at a frequency of about 1 cps. The characteristics of the internal friction measured are: (1) the internal friction and strain-amplitude dependence of the internal friction decreases with increasing solute content; (2) the internal friction is reversibly dependent upon the preanneal temperature; and (3) the internal friction is hysteretic with strain amplitude. From the effect of the solute concentration and annealing temperatures on the decrement, values for the binding energy for Al and Si solute atoms to dislocations in Cu were calculated. These values are compared to theoretical values calculated on the basis of strain and electrical interaction energies. The experimental binding energy is in good enough agreement with the theoretical values to conclude that the onset of a strain amplitude dependence of the internal friction is caused by the freeing of sufficient dislocations from their pinning solute atoms. (Contractor's abstract)

Committee on Math. Biophysics, Chicago Ill. see Chicago U. Committee on Math. Biophysics, Ill.

CON. 01:001

Connecticut U., Storrs.

SOME CONTRIBUTIONS TO THE PROBLEM OF THE EXTENSION OF POSITIVE DEFINITE FUNCTIONS. PART I. ON INFINITELY DIFFERENTIABLE POSITIVE DEFINITE FUNCTIONS. PART II, by A. Devinatz. Oct. 1955, 1v. refs. ([AF]OSR-TN-55-421) (AF 18(600)1223) AD 95891 Unclassified

Part II also published in Proc. Amer. Math. Soc., v. 8: 3-10, Feb. 1957.

In Part I, the following problem is considered: Let Q be an open symmetric neighborhood of the origin in the 2-dimensional Euclidean vector space E_2. Let $f(\mathbf{x})$ be a continuous function defined on Q^2 (i.e., the set of all vectors $\mathbf{x} + \mathbf{y}$, where $\mathbf{x}, \mathbf{y} \in Q$) such that for any finite set $\{\zeta_k\}_1^n$ of complex numbers and points $\{x^k\}_1^n \subset Q$ there is

$$\sum_{r=1}^{n} \sum_{s=1}^{n} \zeta_r \bar{\zeta}_s f(x^r - x^s) \geq 0.$$

Is it possible to extend $f(\mathbf{x})$ to all of E_2 so as to retain this positive definite character? It is shown that this may be done in a number of special cases. The results indicate that the general question has an affirmative answer. In Part II, an infinitely differential function is considered, defined on the open interval $\langle -a, b \rangle$, $a, b > 0$. Sufficient conditions are given, in terms of the derivatives of $f(\mathbf{x})$, in order that $f(\mathbf{x})$ may be extended to the whole axis and be positive definite there.

COA. 01:001

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THERMODYNAMIC CHARTS FOR HIGH TEMPERATURE AIR CALCULATIONS (2,000°K TO 9,000°K), by J. G. Logan, Jr. July 1956, 25p. incl. diagrs. (Rept. no. AD-1052-A-3) (AFOSR TN-56-342) (Sponsored jointly by Arnold Engineering Development Center under AF 40(600)6 and Air Force Office of Scientific Research under AF 18(603)10) AD 95218 Unclassified

A compilation is presented of 20 thermodynamic charts useful for shock wave and isentropic flow calculations. The charts were based primarily upon National Bureau of Standards results (NBS rept. no. 3991, Apr. 1, 1955). Density and speed of sound ratios are based on reference values at 273.16°K and 1 atm pressure. Nine charts show variation of density with absolute enthalpy for constant values of pressure over the ranges: pressure ratio (P/P_0), 1000-0.0001; density ratio (ρ/ρ_0), 100-0.000093; and absolute enthalpy (H), 600-9400 cal/g. Three charts show variation of entropy with pressure for constant values of temperature over the ranges: temperature, 100°-9000°K; pressure ratio, 1000-0.00001; entropy (s), 1.0-5.2 cal/g°K. Two charts give variation of entropy with pressure for constant values of absolute enthalpy for

the ranges: absolute enthaly, 150-7000 cal/g; pressure ratio, 1000-0.00001; entropy, 1.4-4.1 cal/g°K. Three charts present variation of absolute enthalpy with entropy for constant temperatures in the ranges: temperature, 0°-10,000°K; absolute enthalpy, 0-14,600 cal/g; and entropy, 1.85-4.8 cal/g°K. Two charts show variation of entropy with density for constant values of absolute enthalpy over the ranges: absolute enthalpy, 1000-7000 cal/g; density ratio, 40-0.00000631; and entropy, 1.4-3.9 cal/g°K. The final chart presents the variation of speed of sound with entropy for constant values of temperature and density for the ranges: speed of sound ratio (a/a_0), 2.6-7.9; entropy, 1.6-4.9 cal/g° K; temperature, 2000-9000°K; and density ratio, 100-0.0001.

COA. 01:002

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

TABLES OF THERMODYNAMIC PROPERTIES OF AIR FROM 3000°K TO 10,000°K, by C. E. Treanor and J. G. Logan, Jr. June 1956, 39p. incl. diagrs. tables, refs. (Rept. no. AD-1052-A-2) (AFOSR-TN-56-343) (Sponsored jointly by Arnold Engineering Development Center under AD 40(600)6 and Air Force Office of Scientific Research under AD 18(603)10) AD 95219 Unclassified

Tables are presented giving partition functions for components (O_2, O_2^+, O, O^+, O^-, NO, NO^+, N_2, N_2^+, N, N^+, e^-, A) of high-temperature air, temperature derivatives of partition functions, equilibrtum constants for the high-temperature air reactions, mole fraction concentrations of the constituents, and pressure, entropy and enthalpy of the air. These calculations were performed at 1000° tntervals form 3000° to 10,000°K and for densities of 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}, 10^{-2}, 10^{-1}, 10, 20, 30 and 40 atm. Three charts are given showing good agreement of the present calculations, those of the latest available National Bureau of Standards calculations, for the compressibility factor Z, entropy, and enthalpy. (Contractor's abstract, modified)

COA. 01:003

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THE CALCULATION OF THE THERMODYNAMIC PROPERTIES OF AIR AT HIGH TEMPERATURES, by J. G. Logan, Jr. May 1956, 68p. incl. diagrs. tables, refs. (Rept. no. AD-1052-A-1) (AFOSR-TN-56-344) (Sponsored jointly by Arnotd Engineering Development Center under AF 40(600)6 and Air Force Office of Scientific Research under AF 18(603)10) AD 95220 Unclassified

Procedures for the calculation, for air, of the equilibrium concentration and the thermodynamic quantities, energy, enthalphy, entropy, pressure, specific heat, molecular weight, and the speed of sound in the temperature range 1,000°K to 20,000°K are described. Complete tables of constants derived from spectroscopic data for the various components are included, and are corrected as far as possible using the latest available data in the literature. In cases where the values have not been determined, approximate values are given. It is suggested that all partition functions be calculated directly from spectroscopic data; however, an approximate procedure of Bethe is presented in an appendix. The calculations for N are based on the dissociation energy value 9.756 ev. All calculations are based on the composition of dry air at NACA (National Advisory Committee for Aeronautics) standard sea-level conditions. The air in the temperature range of 1,000°K to 20,000°K is assumed to have the components O_2, O, N, O^+, N^+, e, NO, NO^+, N_2, O^-, N_2^+, O_2^+, and A. Chemical equilibrium is assumed at all temperatures and densities, and it is also assumed that the perfect gas law is valid. It is suggested that all quantities such as entropy, energy, and enthalpy be calculated in terms of the absolute values, including contributions of the lowest energy states of the molecules at each temperature and density as well as nuclear spin contributions. (Contractor's abstract)

COA. 01:004

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THE APPLICATION OF THE SHOCK TUBE TO THE STUDY OF THE PROBLEMS OF HYPERSONIC FLIGHT, by A. Hertzberg. [1956] [7]p. incl. illus. diagrs. refs. (AF 18(603)10) Unclassified

Published in Jet Propulsion, v. 26: 549-554, 565, July 1956.

This paper discusses some of the new scientific and technical problems introduced by the high temperature conditions encountered in hypersonic flight. Modifications of the shock tube which have been studied at this laboratory for the investigation of these problems are presented. The shock tube is one of the few laboratory instruments capable of generating the high temperature conditions in air encountered in hypersonic flight studied. The conventional shock tube is limited since the maximum flow Mach number that can be achieved behind a normal shock wave in air is approximately 3. When the conventional shock tube is terminated by an expansion nozzle, high Mach number flows can be achieved as well as high stagnation temperatures. Actual flow conditions can therefore be closely simulated for the investigation of heat transfer rates and other aerodynamic problems. The application of the shock tube to other areas of high temperature research is briefly discussed. In particular, a technique for the study of high temperature chemical reaction rates is described. (Contractor's abstract)

COA. 02:001

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A NEW METHOD FOR PROVIDING CONTINUOUS

COR. 01:001 - COR. 01:003

HIGH-TEMPERATURE AIR FLOW FOR HYPERSONIC RESEARCH, by A. H. Flax, A. Hertzberg, and W. E. Smith. May 1956 [34]p. incl. diagrs. table, refs. (Rept. no. CAL-79) (AFOSR-TN-56-236) (AF 18(603)-19) AD 68356 Declassified

The problem of providing a facility capable of producing the high stagnation temperatures required for hypersonic testing is discussed briefly. Existing facilities are reviewed, and the requirements of future facilities for high temperature testing are outlined. Since existing facilities are found to be limited as to maximum available temperature or allowed testing time, a new type of machine is proposed. This machine, called the "wave superheater," involves an extension of the shock tube principle whereby a group of shock tubes is mounted at the periphery of a cylindrical drum and brought successively into play by a rapid rotation of this drum so that a continuous stream of high temperature air useful for hypersonic testing is available. The results of preliminary performance calculations of the wave superheater, as well as the description of a possible arrangement of test apparatus, is discussed. It appears that by using orthodox engineering techniques it will be possible to obtain continuous gas flows in air with approximate stagnation temperatures of 5000°K (9000°R). An outline of high-temperature research is included concerning materials and structures problems to which the proposed technique could be applied. (Contractor's abstract)

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

N6ori-10503 and N6ori-11901, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:026 - PRI. 11:064.

COR. 01:001

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

THE APPLICATION OF POLARIZED MERCURY POOL ELECTRODES TO POLAROGRAPHY, by C. A. Streuli and W. D. Cooke. [1953] [3]p. incl. diagrs. [AF 18-(600)486] Unclassified

Published in Jour. Phys. Chem., v. 57: 824-826, Nov. 1953.

The use of mercury pool electrodes is proposed for extending the range of polarographic analysis. This electrode retains many of the advantages of conventional procedures and has a considerably greater sensitivity. The current-voltage curves obtained are fundamentally different from conventional polarograms. Current peaks are obtained which can be predicted within 10% by the equations of oscillographic polarography. The mercury pool electrode compares favorably with the dropping mercury electrode. The peak currents are linear with concentrations, particular metals can be identified by their half peak potentials, and the electrode has a low charging current and high hydrogen overvoltage. The polarograms follow a predictable curve and conventional equipment can be used. Furthermore, the mercury pool electrode has some inherent advantages as compared to the dropping mercury electrode. The area of the electrode can be varied over wide limits and charging current densities are much smaller. The dropping mercury electrode, however, has a surface which is renewed during the recording of a polarogram. In most cases this appears to be unimportant but this fact may cause difficulties with some metals. Polarograms have been obtained for zinc, lead, copper, cadmium, thallium, bismuth and indium. The sensitivity of the method is about twenty millimicrograms per milliliter. (Contractor's abstract)

COR. 01:002

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

DEVELOPMENT OF ELECTROCHEMICAL METHODS OF SEPARATION AND ANALYSIS FOR MILLIMICROGRAM AMOUNTS OF TRACE METALS, by C. A. Streuli and W. D. Cooke. [1953] [18]p. incl. diagrs. tables. [Technical note no. 1] (AF 18(600)486) Unclassified

Determinations of zinc, lead, and chromium in concentration from approximately 10^{-6} molar to 5×10^{-5} molar have been made using a polarized mercury pool electrode, and the height of the current maxima has been shown to be linearly proportional to the concentration of the ion. Half wave potentials for these three ions have been calculated, and appear to be in agreement with those obtained from dropping mercury electrodes. The diffusion current has been shown to vary with polarization rate, and the diffusion current and half wave potential have been shown to vary with external resistance in series with the cell. The height of the zinc wave appears to be generally independent of the lead content of a solution if the lead content is as much as 20 times the zinc content. The diffusion wave height varies with gelatin content of the solution, and in the case of chromic ion the maxima is eliminated. The maxima is not entirely eliminated for the lead wave. The reduction of chromic ion in potassium chloride and in the presence of 0.005% gelatin appears to be reversible. (Contractor's abstract)

COR. 01:003

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

MERCURY POOL POLAROGRAPHY: ION-AMALGAM REDUCTIONS OCCURING AT SURFACE OF A LARGE STATIONARY MERCURY POOL, by C. A. Streuli and W. D. Cooke. [1953] [6]p. incl. diagrs. tables. (Technical note no. 2) (AF 18(600)486) Unclassified

Published in Anal. Chem., v. 25: 1691-1696, Nov. 1953.

In order to extend the range of polarographic methods, possible analytical applications of a large polarized mercury pool electrode were investigated. The polarographic waves obtained have distinct current

maxima whose heights vary in a linear fashion with the concentration of the reducible ion. The halfpeak potentials are independent of concentration and correspond, within 0.05 volt, to the halfwave potentials associated with the dropping mercury electrode. Thallous, lead, copper, cadmium, zinc, bismuth, and indium ions have been studied. The polarized pool electrode has been found to be applicable to the determination of ions at lower concentrations than the more conventional polarographic methods, while retaining many of the advantages of the dropping electrode. The currents are proportional to concentration, the ions can be identified by their reduction potentials, and the electrode has a high hydrogen overvoltage. The area of the electrode can be varied over wide limits, the charging current density is much smaller, and conventional equipment can be used. The polarograms obtained are theoretically predictable within 5% by the equations applicable to oscillographic polarography. (Contractor's abstract)

COR. 01:004

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

RELATION OF MERCURY POOL POLAROGRAPHY TO OSCILLOGRAPHIC POLAROGRAPHY, by C. A. Streuli and W. D. Cooke. [1953] [13]p. incl. diagrs. tables. (Technical rept. no. 3) (AF 18(600)486) Unclassified

Polarographic waves obtained by the use of a polarized mercury pool and relatively slow scanning rates have been shown to be similar to those obtained through the use of oscillographic polarography. The heights of the current maxima are predictable with the exception of zinc and indium within 10 percent by the Sevcik equation derived for use with oscillographic techniques. Experimental results from pool polarography give a constant in good agreement with that derived by Sevcik for the equation. The experimental value from this data is 217 ± 10. The scope of both oscillographic and pool polarography appears to be capable of great extension to more dilute solutions by the use of the more rapid scanning procedures of oscillography and the larger area of the pool. Through the use of the pool no synchronization of drop size and wave pulse are necessary for oscillographic techniques and studies embracing the use of oscillographic methods are contemplated. (Contractor's abstract)

COR. 01:005

Cornell U. Dept. of Chemistry, Ithaca, N. Y.

A NEW APPROACH TO ORGANIC POLAROGRAPHY, by C. A. Streuli and W. D. Cooke. Nov. 4, 1953, 1v. incl. diagrs. tables, refs. (Technical rept. no. 4) (AF 18(600)486) AD 20674 Unclassified

Organic molecules were analyzed using a polarizable Hg-pool electrode. The results are compared with those obtained with a conventional dropping Hg electrode. The increased sensitivity of the electrode permitted determination of smaller quantities of organic materials. The half-peak potentials were reproducible to 10 mv. The potentials in the quiet pool were sometimes negative and sometimes positive when they were compared to the dropping electrode values. A correlation existed between the I_{max}/concentration (c) values and the probable number of electrons transferred in the reduction. $PhNO_2$, the first wave of m-dinitrobenzene, Ph_2CO, and Bz_2, which are probably reduced with 4-electron transfers, showed I_{max}/C values of 0.64, 0.69, 0.60, and 0.68 amp/mol, respectively; cystine and a 1,6-anthraquinone disulfonate, which are probably 2-electron reductions, gave values of 0.33 and 0.31 amp/mol, respectively. In using the pool electrode, the H wave occurred at a potential of 0.2 to 0.3 v more positive than it appeared at the dropping electrode (for most supporting electrolytes). Conjugated double bonds and the aldehyde groups were reduced at a value close to that of H evolution and could not be determined by this procedure. (ASTIA abstract)

COR. 01:003

Cornell U. Dept. of Chemistry, Ithaca, N. Y.

THE DETERMINATION OF THE GAMMA ISOMER OF HEXACHLOROCYCLOHEXANE IN THE PRESENCE OF OTHER ISOMERS AND HIGHER CHLORINATED MATERIAL, by C. A. Streuli and W. D. Cooke. Nov. 4, 1953, 9p. diagrs. tables. refs. (Technical rept. no. 5) (AF 18(600)486) AD 37488 Unclassified

Also published in Anal. Chem., v. 26: 970-972, June 1954.

A more sensitive method than the conventional polarographic method was developed for the analysis of the γ-isomer of hexachlorocyclohexane. Replacement of the dropping-Hg electrode by an Hg-pool electrode resulted in a shifting of the reduction potentials in such a way that interference from other compounds was eliminated. The proposed method was applied to pure lindane, natural isomeric mixtures, concentrates, dusts, and α-β cakes. (ASTIA abstract)

COR. 01:007

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

ELECTROLYTIC DECOMPOSITION OF DILUTE AMALGAMS, by J. T. Porter, II and W. D. Cooke. July 1, 1954 [6]p. incl. diagrs. tables, refs. [Technical note no. 6] [AFOSR-TN-54-158] (AF 18-(600)486) AD 63419 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 1481-1486, Mar. 20, 1955.

A study has been made of the anodic decomposition of dilute amalgams and of the general behavior of amalgam electrodes when the decomposition is achieved by:

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(a) discharge through a resistance at constant applied potential; (b) under the influence of an intermittent constant current; or (c) under conditions of constant anode potential. It was found that amalgams of cadmium and thallium can be completely decomposed and that a general insight into the phenomena of decomposition under conditions of constant anode potential, or through a resistance, can be found in the application of the Nernst equation, Ohm's law, and Faraday's law with the conventional concentration polarization corrections. It was found, however, that cadmium is not reversible in this type of experiment in that there is a nonpolarization contribution to the overpotential. It was also found that the efficiency of the constant current decomposition was much greater than could be explained in view of the calculated effect of polarization. It is proposed that this efficiency is due to the formation of an adherent film which acts as an intermediate for the storage and transfer of electrons. Studies of bismuth, cobalt, and nickel indicate that the deposited metals cannot be anodically oxidized without decomposing mercury. (Contractor's abstract)

COR. 01:008

Cornell U. Dept. of Chemistry, Ithaca, N. Y.

POLAROGRAPHY AT A STIRRED MERCURY POOL CATHODE, by D. J. Rosie and W. D. Cooke. Sept. 9, 1954 [19]p. incl. diagrs. tables. (Technical note no. 7) (AFOSR-TN-54-291) (AF 18(600)486) Unclassified

Also published in Anal. Chem., v. 27: 1360-1363, Sept. 1955.

As part of a general program for the development of analytical procedures for trace components, various attempts have been made to increase the sensitivity of polarographic methods. A large Hg pool cathode in a stirred solution was found to be adaptable to such work. Because of the low charging current of such an electrode, it is possible to obtain polarograms of solutions in the micromolar range. The polarograms have the same general shape as those obtained at a dropping Hg electrode but no maxima are obtained and current fluctuations caused by the drop growth are absent. Studies have been made for various types of electrolytic processes including ion-amalgam, ion-metal, ion-ion, and molecule-molecule reductions. Various aspects of each of these systems are discussed. A rapid, simple method requiring no special apparatus, is proposed for the determination of polarographic n-values. (Contractor's abstract)

COR. 01:009

Cornell U. [Dept. of Chemistry] Ithaca, N. Y.

POLAROGRAPHIC BEHAVIOR OF ORGANIC COMPOUNDS AT THE MERCURY POOL ELECTRODE, by C. A. Streuli and W. D. Cooke. [1954] [8]p. incl. diagrs. tables, refs. (Technical note no. 4) (AF 18(600)-486) Unclassified

Published in Anal. Chem., v. 26: 963-970, June 1954.

The study of the mercury pool cathode for the polarography of organic compounds leads to significant differences, although the polarograms are qualitatively similar to those obtained for ion-metal reductions. In contrast to the behavior exhibited by metallic ions, the reduction potentials are often different from those obtained at the conventional dropping electrode and at times the number of waves is different. In general, the reproducibility of the mercury pool cathode is not as good as that of the dropping mercury electrode; half-peak potentials are precise to 10 mv, and current values, within 7% of their relative values. The groups which have been studied are: nitro, dinitro, keto, diketo, azo, hydrazo, nitroso, disulfide, and quinone. The new electrode extends the range of polarographic methods to more dilute solutions. It is sometimes possible, in the analysis of mixtures of organic compounds, to take advantage of the shift in the reduction potentials. (Contractor's abstract)

COR. 01:010

Cornell U. Dept. of Chemistry, Ithaca, N. Y.

AMPEROMETRIC TITRATIONS OF MICROMOLAR SOLUTIONS, by J. G. Nikelly and W. D. Cooke. June 28, 1955 [12]p. incl. diagrs. table. (Technical note no. 8) [AFOSR-TN-55-196] (AF 18(600)486) Unclassified

Published in Anal. Chem., v. 28: 243-245, Feb. 1956.

Amperometric titrations of dilute solutions of metal ions with disodium ethylenediaminetetraacetate have been carried out using a Hg-pool indicator electrode. Some of the problems of Hg-pool polarography, such as the reproducibility of the electrode area and the constancy of stirring, have been eliminated by this technique. The area of the electrode used was 1 to 2 sq cm and stirring was accomplished by bubbling N through the solution. Cd, Cu, Pb, Ni, and Zn have been titrated at concentrations well below the range of conventional amperometric methods which employe the dropping Hg electrode. In favorable cases, titrations were feasible at dilutions approaching 10^{-7}M. For example, solutions containing 0.02 γ of Cd/ml can be titrated with an average error of 0.0001 γ. It was also found possible to titrate solutions of ions which could not be polarographically determined with a Hg-pool cathode. (Contractor's abstract)

COR. 01:011

Cornell U. Dept. of Chemistry, Ithaca, N. Y.

APPLICATION OF COULOMETRIC TITRATIONS TO MICROVOLUMES OF SOLUTION, by H. Schreiber and W. D. Cooke. [Sept. 1955] [2]p. incl. diagr. table. [AF 18(600)486] Unclassified

Published in Anal. Chem., v. 27: 1475-1476, Sept. 1955.

The coulometric generation of titrants was found to be applicable to microvolumes of solution. Ten microliters of hydrochloric acid, sodium hydroxide, and arsenite were titrated with coulometrically generated reagents with an accuracy comparable to that obtained using conventional methods. Thin platinum probes could be used as generating electrodes, and the expertmental arrangement was both compact and versatile. The technique is tllustrated by typtcat redox and acidimetric titrations, but ts not llmited to these particular examples. The method is general in nature and can be applied to a vartety of titrations involving small volumes of sotution. (Contractor's abstract, modified)

COR. 01:012

Cornelt U. Dept. of Chemistry, Ithaca, N. Y.

ANODIC STRIPPING POLAROGRAPHY, by J. G. Niketty and W. D. Cooke. May 15, 1956 [22]p. tnct. diagrs. tabtes. (Technicat note no. 9) [AFOSR-TN-56-215] (AF 18(600)486) AD 87260 Unclassified

Also published in Anal. Chem., v. 29: 933-939, June 1957.

Anodic stripping polarography is a method of analysis by which a metal is deposited on an etectrode and anodically removed under controlled conditions. The magnitude of the anodic current peak is proportional to the concentration of metallic ion. The applicability of various etectrodes to this method has been investigated and the use of a small Hg electrode has been found to be significantly advantageous. Metallic lons at concentrations as low as 10^{-4} Y/mt were detected, and Pb and Cd in spectrographicalty pure Zn were determined. tn contrast to other electrodes, no pretreatment is necessary and no change in calibration values was observed over a period of 8 mo. There is no interaction in mixtures of deposited metals and 100 times as much metal with a more positive half-wave potential has no influence on the anodic peaks. Half-peak potentiats are independent of concentration and agree ctosely with the half-wave potentiats obtained at a dropping Hg etectrode. Analyses have been carried out on solutions of Cu^{++}, Pb^{++}, Cd^{++} and Tt^{+} from 2×10^{-4} to 2×10^{-8} motar. The method is only applicable to those metals which can be deposited in Hg and anodically removed. (Contractor's abstract)

COR. 02:001

Cornell U. [Dept. of Engineering Physics] Ithaca, N. Y.

AN INVESTIGATION OF THE TEMPERATURE DEPENDENCE OF INTERNAL FRICTION IN COPPER SINGLE CRYSTALS FROM 4.2°K TO 300°K, by N. W. Briggs. Sept. 1955, 45p. incl. diagrs. refs. ([AF] OSR-TN-55-393) (AF 18(600)1000) Unclassified

In thts study, the decrement of 2 Cu stngte crystals was determined as a function of temperature from liquid He temperature to room temperature. One of the crystals was examined only in an annealed state, while the other was examined in both annealed and somewhat cold-worked states. Curves of the losses vs temperature are given, and show a gradual decrease from room temperature to 4°K. The loss peaks observed by Bordoni at about 80°K for polycrystalline material, tf present at att, are so small as to be practicalty unobservabte in the stngte crystals studied here. Activation energies are calcutated from graphs of the logarithm of the decrement vs the reciprocat of the absolute temperature. A value of a few tenths of 1 kcal/mol ts found from about 40°K to room temperature. This is exptained as being the energy required to initiate the motion of a distocation. What appears to be a very small activation energy is found at very low temperatures, but this is explained as being the residual support tosses, observable at these temperatures because the actuat dislocation tosses are so small.

COR. 02:002

Cornelt U. Dept. of Engineering Physics, Ithaca, N. Y.

A STUDY OF THE tNTERNAL FRICTION AND YOUNG'S MODULUS OF PURE COPPER SINGLE CRYSTALS IN THE TEMPERATURE RANGE 25°C TO 750°C, by L. A. Kamentsky. Sept. 1, t956, 1v. incl. illus. diagrs. tables, refs. (Technical rept. no. 1) (AFOSR-TN-56-425) (Sponsored jointty by Air Force Office of Scientific Research under AF 18(600)1000 and Office of Naval Research under N6ori-9t02) AD 96507 Unclassified

Measurements were made of the internal friction and Young's modulus of pure single Cu crystals in transverse vibration from 25° to 750°C at strain amplitudes of 10^{-8} to 10^{-5} and frequencies of 700 to 7600 cps. These data are compared with those of other authors, and the theories of dislocations are reviewed. Good agreement between experimental results and the theory of Granate and Lucke (Jour. Appt. Phys., v. 27: 583, 789, 1956) was shown for the strain dependent portions of the data up to 300°C. A summary of what is believed to be the behavior of the internal friction and Young's modutus of single Cu crystats is formulated for the higher temperature range. (ASTtA abstract)

COR. 02:003

Cornell U. Dept. of Engineering Physics, Ithaca, N. Y.

INTERNAL FRICTION IN SINGLE COPPER CRYSTALS (Abstract), by H. S. Sack. 1956, 1p. (AF 18(600)1000) Unclassified

Presented at Conference on Ultrasonic Energy Losses in Crystalline Materials, Brown U., Sept. 4-6, 1956.

The internat friction of high purity copper stngle crystals was studied tn the temperature range of 4°K to t000°K, in a frequency range of 600 to 7000 cps, and in a range of strain amplitudes of 10^{-8} to 10^{-5}. Lateral vibrations were used. The ranges were

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covered by experimsnting with identical specimens so that the well known variations from one sample to the other were eliminated in comparing results under different conditions. A few measurements wsre also made at 40 kcpe at low temperatures, again using the same samples that served for the expertmente with transverse vibrations. The phenomena in this low frequency range are very similar to those observed by other authors tn the high frequency range, where most studies, however, sncompass only a limtted range of temperatures, strain amplitudee or frequenctes. At low temperatures, (approximately 70° K) the Bordoni peak ts not observed for well annealed single crystals. A slight peak superimposed on a broad background appears when the crystal ts slightly cold worked. Very pronounced and sharp peaks ars obsarved in polycrystalline samplee which were subject to a great amount of cold work (15% reduction). Annealing of these polycrystalline samples reduces the hetght of the peak by a factor of 10 or more. Ths annealing was done in such a way that the grain size remained unchanged. The peak shifts only very little tn going from a frequency of 800 to 40,000 cps. The peak doee not seem to be very amplitude sensitive. The background, however, ts both sensitive to amplitude of vibration and to slight amounts of cold work, as ts also obeerved at room temperature. (Contractor's abstract)

COR. 03:001

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

CONTRIBUTIONS TO RENEWAL THEORY AND MARKOV CHAINS, by K. L. Chung. June 15, 1952, 25p. ([AF 18(600)100] continued by AF 18(600)330) Unclassified

In part I the following ts proved: for any sequence of tndependent r-dtmensional identically distributed chance vartables $V_1, V_2, \ldots$ with $r > 1$, any bounded set C of r-space and any vector U tn r-space, the expected number of sums $V_1 + \ldots V_n$ lying in C + U, the set C translated by U, approaches zero as $|U| \to \infty$. In part II a classification of recurrent states and classes ts given and a central limit theorem for Markov chains ts proved. Some results concerning the mean recurrence and first passage times are included. (Contractor's summary, modified)

COR. 04:001

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

LIMIT DISTRIBUTIONS FOR SUMS OF INDEPENDENT RANDOM VARIABLES, by B. V. Gnedenko and A. N. Kolmogorov, trans. by K. L. Chung. Cambridge, Mass., Addison-Wesley Publishing Co., Inc., 1954, 264p. tncl. refs. (AF 18(600)330; continuation of AF t8(600)100) Unclassified

Thts ts a translation of the Russian mathematical text Predel'nye Raspredeleniĭa Dlĭa Summ Nezavisimykh Slucha̧inykh Velichin (1949). The account presenteds combines generality with simplicity, explaining some of the moet tmportant and difficult aspects of t s theory of probability. The following subjects are treated: (1) probability distributions, random variablee, and mathematical expectations; (2) distributions in R^1 and their characteristic functions; (3) infinitely divisible distributions; (4) gensral limit theorems for sums of independent summands; (5) convergence to normal, Poteson, and unitary distributions; (6) limit theorems for cumulative sums; (7) fundamental limit theorems; (8) tmprovement of theorems about the convergencs to the normal law; and (9) local limit theorems for lattice dtstributione.

COR. 04:002

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

CONTRIBUTIONS TO THE THEORY OF MARKOV CHAINS, II, by K. L. Chung. [1954] [23]p. incl. refs. (AF 18(600)330) Unclassified

Published in Trans. Amer. Math. Soc., v. 76: 397-419, May 1954.

The random variables X_n, $n = 0, 1, \ldots$, form a Markov chain with denumerable states and temporally homogeneous transition probabilities $P_{ij}^{(n)} = P(X_{m+n} = j \mid X_m = t)$; $i, j = 0, 1, \ldots$. All states are in the eame recurrent class. Let

$$F_{ij}^{(n)} = P(X_n = j,\ X_v \neq j,\ 1 \leq v < n \mid X_0 = i),$$

$$m_{ij}^{(p)} = \sum_{n=1}^{\infty} n^p F_{ij}^{(n)},\ p > 0.$$

Theorem: $m_{ij}^{(p)} < \infty$ and $m_{ji}^{(p)} < \infty$ for some pair t, j implies $m_{kl}^{(p)}$ every k, I. A partial version for integral p, was proved by Hodges and Rosenblatt [Pacific J. Math. v. 3: 127-136 (1953); Math. Rev. v. 14: 886]. Let

$$E_{ij} = \lim_{n \to \infty} \sum_{v=0} P_{jj}^{(v)} \Big/ \sum_{v=0}^{n} P_{ii}^{(v)}.$$

For a real function f set $I(f) = \sum_j E_{ij} f(j)$. If $I(|f|) < \infty$, $I(|g|) < \infty$, $I(g) \neq 0$ (the choice of t here and later ts tmmaterial), it ts shown

$$P\left\{\lim_{n \to \infty} \sum_{v=0}^{n} f(X_v) \Big/ \sum_{v=0}^{n} g(X_v) = I(f)/I(g)\right\} = 1.$$

A proof using ergodic theory was given tndependently for certain general-state Markov processes by Harris and Robbins [Proc. Nat'l. Acad. Sciences, U. S. A. v. 39: 860-864 (1953); Math. Rev., v. 15: 140]. Let $Y = f(X_{v_1}) + \ldots + f(X_{v_2})$, where $X_{v_1} = i$ and v_2 is the time of first return to t after v_1. If $E(|Y|) < \infty$ and

$m_{ii}^{(1)} < \infty$, the weak law of large numbers holds for $S_n = f(X_0) + \ldots + f(X_n)$. This is not sufficient for the strong law, as an example shows, but $m_{ii}^{(1)} < \infty$ and $\sum_{j=0}^{\infty} |f(j)| / m_{jj}^{(1)} < \infty$ together imply the strong law. Doeblin's central limit theorem is treated; if $m_{ii}^{(2)} < \infty$, then $E(Y^2) < \infty$ implies the central limit theorem, but an example shows $\sum_{j=0}^{\infty} (f(j))^2 / m_{jj}^{(1)} < \infty$ does not. The law of the iterated logarithm and the distribution of the maximum partial sum are treated. (Math. Rev. abstract)

COR. 04:003

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

[RESEARCH ON MARKOV CHAINS] by K. L. Chung. Final rept. [1954] 2p. (AF 18(600)330) Unclassified

Progress on the publication of a translated version of Limit Theorems For Sums of Independent Random Variables, by Gnedenko and Kolmogorov is reported, as well as research on Markov chains regarding theory of the chains with discrete time and space.

COR. 05:001

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

PROBABILITY METHODS AND THE DIRICHLET PROBLEMS, by G. A. Hunt and M. Kac. Sept. 15, 1953, 4p. (Technical rept. no. 1) (AF 18(600)685) AD 18944 Unclassified

Progress is reported on a book being written on the application of probability methods to the Dirichlet problem. The book is intended to show the pedagogical and scientific advantages of treating purely analytic problems by methods of modern probability theory. Chapter 1 is devoted to the presentation of the theory of the Wiener process and those of its properties which are used in the sequel. Chapter 2 is devoted to the solution of the generalized Dirichlet problem and the closely related types of harmonic measure, capacitory potential, Green's function, and regularity of boundary points. The following result is given in connection with the work on chapter 2. If F is a plane closed set of positive capacity and P is a point not in F, then the probability that a Brownian motion curve originating at P will not hit F up to time t is asymptotically (for large t) $\frac{U(P)}{\log \sqrt{t}}$ where U(P) is the solution (generalized) of Robin's problem. The considerations of chapter 2 are based on the study of the event that a Brownian motion curve hits a set F. (ASTIA abstract)

COR. 05:002

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

THEOREMS ON FOURIER TRANSFORMS, by W. H. J. Fuchs. Sept. 15, 1953, 13p. (Technical rept. no. 2) (AF 18(600)685) AD 18945 Unclassified

Theorems are proved which confirm the heuristic principle that if a set where a function is large is concentrated near a point, then large values of its Fourier transform cannot be concentrated near a point. The following terminology is used: let E be an n-dimensional Euclidean space, where $t = (t_2, \ldots, t_n)$, and $x = (x_1, \ldots, x_n)$ are points of E, $(t_x) = t_1 x_1 + \ldots + t_n x_n$, and $dt = dt_1 dt_2 \ldots dt_n$. For any set U of finite n-dimensional measure in E, write $k(t;U) = (2\pi)^{-n} \int_U e^{-i(tx)} dx$. If S and T are sets of finite measure, define $\lambda(S, T)$ as the largest eigenvalue of the integral equation $\lambda y(t) = \int_T y(s) k(t-s;S) ds$, where $t \in T$. Theorem 1: Let $g(t) \in L^2(E)$; $\int_E |g(t)|^2 dt = 1$; and let $G(x) = (2\pi)^{-\frac{n}{2}} \int_E g(t) e^{i(tx)} dt$ be the Fourier transform of g. If S and T are 2 sets of finite measure, and if $\int_T |g(t)|^2 dt = A$, then $\int_S |G(x)|^2 dx \leq \mu^2(A)$, where $\mu(A) = 1$ for $A \leq \lambda(T, S)$, and $\mu(A) = [A\lambda(T, S)]^{1/2} + [(1-A)(1-\lambda(T-S))]^{1/2}$ for $A > \lambda(T, S)$. The bound $\mu(A)$ is attained in all cases. The concentration function Q(1) of F(t) is defined by $Q(1) = \max [F(l + 1 + 0) - F(t-0)]$; $\rho(f)$ is defined as $\sup |f(x)^t|$. Theorem 2: If $Q(21) = 1$ for a finite $|x|>a$ value of 1, then $\rho(f) \geq (\cosh al)^{-1}$. This bound cannot be replaced by a larger one. Theorem 3: If the characteristic function f(x) vanishes for $|x| > a$, then $Q(1) \leq \lambda(T, S)$ where $A < \lambda(T, S)$ T is the interval $|t| < 1/2$ 1, and S is the interval $|x| < 1/2$ a. This bound cannot be replaced by a smaller one. (ASTIA abstract)

COR. 05:003

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ESTIMATION BY THE MINIMUM DISTANCE METHOD IN NON-PARAMETRIC STOCHASTIC DIFFERENCE EQUATIONS, by J. Wolfowitz. June 1954 [27]p. [AFOSR-TN-54-4] (AF 18(600)685) AD 30391 Unclassified

Also published in Ann. Math. Stat., v. 25: 203-217, June 1954.

The method of estimation (J. Wolfowitz. Skandinavisk Aktuarietidskrift, 1952, p. 132-151) is characterized by the fact that the estimators are always such as to

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minimize the distance between suitabty chosen distribution functions. Problems are treated which provide examptes of superconsistent estimators (estimators which converge with probabtlity one to the quantities being estimated). Previous resutts obtained by the minimum distance method are presented. Three new problems tn nonparametric stochastic difference equations are formulated, and minimum distance estimators are exhibtted for these problems. A proof of the superconsistency ls presented for 2 of the estimators. The minimum distance method ls said to be of interest because it enabtes a ctass of probtems to be solved which cannot be solved by ctassical methods. The problems need not be solety probtems of estimation, but may be probtems of testing hypotheses. The minimum distance method ls said to be useful in the sotution of many identification problems. (ASTIA abstract)

COR. 05:004

Cornetl U. Dept. of Mathematics, Ithaca, N. Y.

THE BERNSTEIN APPROXIMATtON PROBLEM, by H. Potlard. Aug. 1954 [17]p. (Rept. no. 11) ([AF]OSR-TN-54-202) (AF 18(600)685; continuation of DA 30-115-ORD-439) AD 44128 Unclasstfied

Also published in Proc. Amer. Math. Soc., v. 6: 402-4t1, June 1955.

A former solution of the Bernstein problem (Proc. Amer. Math. Soc., v. 4: 869-875, t953) ls given in a simplified form. The main result ls the following theorem: For the set of functions $x^n/\Phi(x)$, $n = 0, 1, \ldots$, subject to the conditions that

$$\lim x^n/\Phi(x) = 0, \quad x \to \pm\infty, \quad n = 0, 1, \ldots,$$
$$\Phi(x) > 0, \quad -\infty < x < \infty,$$

to be fundamental in the real space C_0, it is necessary and sufficient that (i) the upper bound (u. b.) $\int \frac{\log^+ p(x)}{1+x^2}\,dx = \infty$, where the u. b. is taken over all real polynomials p for which $|p(x)| < \Phi(x)$, $-\infty < x < \infty$. The result is extended to L^p spaces $p \geq 1$ by the following theorem: For the set of functions $x^n/\Phi(x)$, $n = 0, 1, \ldots$, subject to the conditions that $\Phi(x) > 0$ almost everywhere in $(-\infty, \infty)$,

$$x^n/\Phi(x) \in L^p, \quad n = 0, 1, \ldots,$$

to be fundamental in L^p, it is necessary and sufficient that (i) hold where the u. b. is taken over all real polynomials p such that $\left\| \frac{p}{\Phi} \right\| < 1$. A set S in a Banach space B is called fundamental if the set of finite linear combinations of the elements of S is dense in B. The problem is also solved for the semi-infinite interval $(0, \infty)$. (ASTIA abstract)

COR. 05:005

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

GLOBAL VERSIONS OF THE CENTRAL LIMIT THEOREM, by R. P. Agnew. Aug. 1954, 8p. (Rept. no. 12) ([AF]OSR-TN-54-210) (AF 18(600)685) AD 44130 Unclassified

Also published in Proc. Nat't. Acad. Sciences, v. 40: 800-804, Sept. 1954.

Let $F_n(x)$ be the distribution function of the combination $(F_1 + F_2 + \ldots + F_n)n^{1/2}$ where $F_1, F_2, \ldots$ are equally distributed random variables having mean 0 and standard deviation 1. The central limit theorem implies that (*)$\lim F_n(x) = \Phi$, $-\infty < x < \infty$, where $\Phi(x)$ is the Gaussian distribution function. It is shown that if $p > 1/2$, then (**)$\lim_{n\to\infty} \int_{-\infty}^{\infty} |F_n(x) - \Phi(x)|^p dx = 0$. (Contractor's abstract)

COR. 05:006

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

POSITIVE TRANSFORMATIONS ON GROUP SPACES, t, by G. A. tlunt. Aug. 1954, 34p. (Rept. no. 13) ([AF]OSR-TN-54-211) (AF 18(600)685) AD 44127 Unctassified

Results of Lévy and Khinchin on an explicit representation of the characteristic function of an infinitely divisible probability distribution on the additive group of the real numbers are extended to semigroups of probability distributions on arbitrary Lie groups. The rote of the characteristic function is taken over by the infinitesimal generator of a semigroup of transformations associated with the prohability distributions. The principal resutt is the foltowing theorem. Let S_t be a probability semigroup on a Lie group $\mathcal{G}$. The infinitesimal generator M of S_t is defined at least on ζ^2 and has the expression

(1) $Mf.(\tau) = \sum a_i X^i f.(\tau) + \sum a_{ij} X^i X^j f.(\tau) +$

$$\int_{\mathcal{G}-e} \left\{ f(\tau\sigma) - f(\tau) - \sum X^i f.(\tau) x_i(\sigma) \right\} G(d\sigma);$$ where (2)

$x_1, \ldots, x_n \in \zeta^2$, $x_i(e) = 0$, $X^i x_j.(e) = \delta_{ij}$;

(3) $a_{ij} = a_{ji}$, $\sum a_{ij}\lambda_i\lambda_j \geq 0$ for all λ_t; and (4) $G(E) = \int_E \frac{1}{\varphi(\sigma)} F(d\sigma)$, where F is a bounded positive measure on $\mathcal{G}-e$ and φ is in ζ^2 with $\varphi(e) = X^i\varphi.(e) = 0$, $X^iX^j\varphi.(e) = \delta_{ij}$, $\varphi(\tau) > 0$ for $\tau \in \mathcal{G}-e$. The measure G and the operator $\sum a_{ij}X^iX^j$ are determined by S_t independently of the choice of X^i and x_i. The restriction of M to ζ^2 determines S_t. Conversely, if $M: \zeta^2 \to \zeta$

is defined by (1) and if (2), (3), and (4) are satisfied, then M is the restriction to ζ^{-2} of the infinitesimal generator of exactly 1 probability semigroup. In the notation, $\bar{\mathcal{G}}$ is the 1-point compactification of $\mathcal{G}$, and ζ is the Banach space of continuous functions on $\bar{\mathcal{G}}$. (ASTIA abstract)

COR. 05:007

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON TESTS OF NORMALITY AND OTHER TESTS OF GOODNESS OF FIT BASED ON DISTANCE METHODS, by M. Kac, J. Kiefer, and J. Wolfowitz. Aug. 1954, 38p. incl. tables, refs. (Rept. no. 14) ([AF]OSR-TN-54-212) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)685 and Office of Naval Research under [N6onr-26405]) AD 44129 Unclassified

Also published in Ann. Math. Stat., v. 26: 189-211, June 1955.

The problem tested is that of whether the distribution function (df) of observed independent chance variables $x_1, \ldots, x_n$ is a member of a given class. The notation is as follows: F(y) and G(y) are any 2 df's, and $\delta(F, G) = \sup_y |F(y)-G(y)|$; $G_n^*(y)$ is the empiric df of $x_1, \ldots, x_n$. Tests of normality are based on $v_n = \delta(G_n^*(y), N(y|\bar{x}, s^2))$ and on $w_n = \int (G_n^*(y) - N(y|x, s^2))^2 dy N(y|\bar{x}, s^2)$. The analysis reveals that the asymptotic power of these tests is greater than that of the optimum X^2 test. The covariance function of a Gaussian process Z(t), $0 \leq t \leq 1$, is obtained. A demonstration is given that the sample functions of Z(1) are continuous with probability 1, and that, as $n \to \infty$, $\lim P\left\{nw_n < a\right\} = P\left\{W < a\right\}$, where $W = \int_0^1 [z(1)]^2 dt$. Tables are presented of the distribution of W and of the limiting distribution of $\sqrt{n}\, v_n$. The role of the various metrics is discussed. (ASTIA abstract)

COR. 05:008

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

EQUICONVERGENCE OF CESÀRO AND RIESZ TRANSFORMS OF SERIES, by R. P. Agnew. Aug. 1954 [12]p. (Repl. no. 15) ([AF]OSR-TN-54-213) (AF 18(600)685) AD 44122 Unclassified

Also published in Duke Math. Jour., v. 22: 451-460, Sept. 1955.

Let $C_r(n)$ and $R_r(n)$ denote, respectively, the well known Cesàro and Riesz transforms of a series Σu_n of real or complex terms. More general results are obtained which imply the following. If $r > 0$ and if Σu_n is a series for which $\lim u_n = 0$, or if the partial sums of Σu_n are bounded, then the Cesàro and Riesz transforms, whether they be convergent or divergent, are equiconvergent in the sense that $\lim_{n\to\infty} [C_r(n) - R_r(n)] = 0$. (Contractor's abstract)

COR. 05:009

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ESTIMATES FOR GLOBAL LIMIT THEOREMS, by R. P. Agnew. Aug. 1954, 23p. (Rept. no. 16) ([AF]OSR-TN-54-214) (AF 18(600)685) AD 44124 Unclassified

Also published in Ann. Math. Stat., v. 28: 26-42, Mar. 1957.

Let $F_1, F_2, \ldots$ be random variables having the same df (distribution function) F(x) with mean 0 and standard deviation 1. Let $F_n(x)$ be the df of the combination $(F_1 + F_2 + \ldots + F_n)/n^{1/2}$, let $\varphi(x)$ be the Gaussian df, and let $C_n = \int_{-\infty}^{\infty} |F_n(x) - \varphi(x)|^2 dx$. Various questions about the numbers C_n are considered. A formula giving C_n in terms of the characteristic function is obtained and studied. Close appraisals of the C_n are given when F(x) is the symmetric binomial df and when the F_k are uniformly distributed over a finite interval. (Contractor's abstract)

COR. 05:010

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON A THEOREM OF ELIE CARTAN, by G. A. Hunt. Aug. 1954, 2p. (Rept. no. 17) ([AF]OSR-TN-54-215) (AF 18(600)685) AD 44123 Unclassified

A metric proof is presented of the following theorem: all maximal Abelian subgroups of a compact connected Lie group $\mathcal{G}$ are conjugate within $\mathcal{G}$. The proof uses the following lemma: if x and y are any elements of the Lie algebra $\mathcal{J}$ of $\mathcal{G}$, then $[x, A_j y] = 0$ for some inner automorphism A_j of $\mathcal{G}$. (ASTIA abstract)

COR. 05:011

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON A PROBLEM OF ADDITIVE NUMBER THEORY, by P. Erdös and W. H. J. Fuchs. Aug. 1954, 8p. (Rept. no. 18) ([AF]OSR-TN-54-216) (AF 18(600)-685) AD 44125 Unclassified

Also published in Jour. London Math. Soc., v. 31: 67-73, 1956.

Let $a_1 < a_2 \ldots$ be a sequence of non-negative numbers, let r(n) = number of solutions of $a_i + a_j < n$. Then

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$r(n) = cn + O(n^{1/4}\log^{-1/2-\varepsilon} n)$ ($\varepsilon > 0$) cannot hold for any $c > 0$. In the case $a_k = k^2$, the estimation of $r(n)$ is the classical problem about the number of lattice points in a circle. In this case, it is known that $r(n) = \pi/4\, n + R(n)$, where $R(n)$ is not $o(n^{1/4}\log^{1/4} n)$. Our error term in the general case is not much worse, and the proof is much simpler. (Contractor's abstract)

COR. 05:012

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A LIMIT THEOREM FOR THE MAXIMUM OF NORMALIZED SUMS OF INDEPENDENT RANDOM VARIABLES, by D. A. Darling and P. Erdös. Nov. 1954, 16p. (Rept. no. 20) ([AF]OSR-TN-54-313) (AF 18(600)685) AD 47968 Unclassified

Also published in Duke Math. Jour., v. 23: 143-155, Mar. 1956.

The following theorem is proved: Let $X_1, X_2 \ldots$ be independent random variables with a uniformly bounded third absolute moment. Put $S_n = X_1 + X_2 + \ldots + X_n$, and let $U_n = \max_{1\le k\le n} S_k/\sqrt{k}$.

Then $\lim_{n\to\infty} P_r \left\{ U_n < (2\log\log n)^{1/2} + \frac{1}{2}(\log\log\log n)(2\log\log n)^{-\frac{1}{2}} + t(2\log\log n)^{-\frac{1}{2}} \right\} = \exp\left(-\frac{1}{2\sqrt{\pi}}\exp(-t)\right)$, $-\infty < t < \infty$. A similar theorem is proved for $U'_n = \max_{1<k\le n} |S_k|/\sqrt{k}$ and two strong theorems for the sequence U_n are indicated. The method of proof consists in finding an interpolatory stochastic process for the sequence $S_k/\sqrt{k}$, obtaining a limit theorem for its maximum and then an application of the invariance principle of Erdös-Kac. (Contractor's abstract)

COR. 05:013

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

FOUNDATIONS OF KINETIC THEORY, by M. Kac. Nov. 1954 [46]p. (Repl. no. 19) ([AF]OSR-TN-54-314) (AF 18(600)685) AD 47967 Unclassified

Also published in Proc. Third Berkeley Symposium on Mathematical Statistics and Probability, Calif. U. Statistical Lab., (Dec. 1954, and June and July 1955), Berkeley, Univ. Calif. Press, 1956, p. 171-179.

A detailed analysis is made of the assumptions underlying the derivation of Boltzmann's basic nonlinear integro-differential equation of the kinetic theory of dilute monoatomic gases. The derivation is based on a probabilistic master equation, and the classical theory is illustrated on the basis of a simplified mathematical model. (ASTIA abstract)

COR. 05:014

Cornell U., Dept. of Mathematics, Ithaca, N. Y.

ON A CHARACTERIZATION OF THE NORMAL LAW, by G. E. Baxter. Dec. 1954, 5p. (Rept. no. 21) ([AF]OSR-TN-54-362) (AF 18(600)685) AD 53316 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 41: 383-385, June 1955.

Two proofs are presented of the following theorem (Linnik's): let X_1 ($\neq 0$) and X_2 be independent, identically distributed random variables and suppose that there exists a pair of real numbers (a, b) with $0 < a \le b < 1$, $a^2 + b^2 = 1$, for which $aX_1 + bX_2$ has the same distribution as X_1; then X_1 is Gaussian with mean zero. A counterexample is given of the conjecture that if X_1 and X_2 are independent, identically distributed (perhaps symmetric) random variables and if there exists a pair of real numbers (a, b) with $0 < a \le b < 1$, $a^\alpha + b^\alpha = 1$, for which $aX_1 + bX_2$ has the same distribution as X_1, then X_1 is stable with parameter α. (ASTIA abstract)

COR. 05:015

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

TOPOLOGICAL PROPERTIES OF HOMOMORPHISMS BETWEEN BANACH ALGEBRAS, by B. Yood. Jan. 1954 [13]p. incl. refs. [AF 18(600)685] Unclassified

Published in Amer. Jour. Math., v. 76: 155-167, Jan. 1954.

Let B be a real Banach algebra. An involution on B is a mapping $x \to x^*$ for which $(x + \lambda y)^* = x^* + \lambda y^*$ for λ real, $x^{**} = x$, and either $(xy)^* = x^*y^*$ or $(xy)^* = y^*x^*$. Call B a ρ^*-algebra if B has an involution and a non-negative subadditive function $||$ which vanishes only at 0 and satisfies $|x| < \rho(x)$ for x self-adjoint or skew ($\rho(x)$ is the spectral radius of x in the complexification of B). If moreover $||$ can be chosen so that B is an (F)-space (in the sense of Banach) under the metric $|x - y|$, then B is a ρ_c^*-algebra. The A^*-algebras of Rickart (Ann. of Math. (2), v. 51: 615-628 (1950); Math Rev., v. 11:670 (1954)) are ρ^*-algebras. The involution in a ρ^*-algebra is continuous. ρ^*-algebras are semi-simple and have unique norm. A homomorphism of a Banach algebra onto a self-adjoint subalgebra of a ρ^*-algebra is continuous. If B is a ρ_c^*-algebra for which each self-adjoint element has a real spectrum and T is an isomorphism of B into a Banach algebra, then T preserves the spectral radius of self-adjoint and skew elements; if moreover there is a $c > 0$ such that $||T(x^*)|| \le c||T(x)||$ for all x, then T^{-1} is continuous on T(B). Now let B (B_1) be a complex commutative Banach algebra with radical R (R_1)

and let $\mathfrak{M}'(\mathfrak{N}')$ be its set of maximal regular ideals (including B (B_1) itself). Let T be a homomorphism of B into B_1. For $N \in \mathfrak{N}'$ let $T^*(N)$ be the unique $M \in \mathfrak{M}$ determined by the rule $x[T^*(N)] = T(x)(N)$ for $x \in B$. If B is regular, in the sense of Silov (Trav. Inst. Math. Stekloff, v. 21 (1947); Math. Rev., v. 9: 596, 1954), then $T^*(\mathfrak{N}')$ consists of the maximal regular ideals containing $T^{-1}(R_1)$ $(T^{-1}[\overline{T(R)}])$; for R = 0 and T one-to-one the second result reduces to one due to Rickart (Proc. Amer. Math. Soc., v. 4: 191-196 (1953); thm. 1; Math. Rev., v. 14: 860, 1954). If B is regular and is closed under uniform limits when considered as an algebra of functions on the set of maximal regular ideals containing $T^{-1}(0)$ and if $T^{-1}(0)$ is the intersection of the maximal regular ideals containing it, then the closure of T(B) is $T(B) \oplus R_1$ and the canonical isomorphism of $B/T^{-1}(0)$ onto T(B) has a continuous inverse. The paper contains other results and most of the above results are proved in a more general setting. (Math. Rev. abstract)

COR. 05:016

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

TOEPLITZ MATRICES, TRANSLATION KERNELS AND A RELATED PROBLEM IN PROBABILITY THEORY, by M. Kac. Sept. 1954 [10]p. [AF 18(600)685] AD 26900 Unclassified

Also published in Duke Math. Jour., v. 21: 501-510, Sept. 1954.

Theorem: Let F be the Fourier transform of an even function ρ such that $\rho(x) \geq 0$, $\int_{-\infty}^{\infty} \rho(x)dx = 1$, and suppose that $|x|\rho(x)$ and F belong to $L^1(-\infty, \infty)$. Let $D_a(\lambda)$ denote the Fredholm determinant of the integral equation $\int_{-a}^{a} \rho(x-y)\rho(y)dy = \lambda\rho(x)$. Then for sufficiently small real λ, $\lim D_a(\lambda) \exp\left\{-\frac{a}{\pi}\int_0^{\infty} \log[1-\lambda F(\eta)]d\eta\right\} = \exp\left\{\int_0^{\infty} x\left|\frac{1}{2\pi}\int_{-\infty}^{\infty} \log[1-\lambda F(\eta)]e^{i\eta x}d\eta\right|^2 dx\right\}$. This theorem is an analogue of a result which Szegö recently proved for Fourier series (Comm. Sém. Math. Univ. Lund [Medd. Lunds Univ. Mat. Sem.] Tome Supplémentaire, 228-238, (1952); these Rev. 14, 553). An interesting account of the way in which the theorem was discovered is included. Szegö's result is reinterpreted in probabilistic terms, and it is shown that both Szegö's result and the above analogue are consequences of the following combinatorial identity: Let $s = (s_1, \ldots, s_n)$ be a permutation of $(1, \ldots, n)$, let $a_1, \ldots, a_n$ be real numbers, and let N(s) be the number of non-negative terms in the sequence a_{s_1}, $a_{s_1} + a_{s_2}$, $\ldots$, $a_{s_1} + a_{s_n}$, whose largest is M(s). Then $\sum \max(0, M(s)) = \sum N(s)a_{s_t}$, the summations being extended over all permutations of $(1, \ldots, n)$. The reviewer noticed one minor oversight: Szegö's result is proved by him under the assumption that f' satisfies a Lipschitz condition of order α $(0 < \alpha \leq 1)$, and is proved in the present paper under the assumption that f' has an absolutely convergent Fourier series: it is claimed that the second condition is weaker than the first; but this is so only if $\alpha > \frac{1}{2}$. (Math. Rev. abstract)

COR. 05:017

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON THE VIRIAL SERIES OF THE IDEAL BOSE-EINSTEIN GAS, by W. H. J. Fuchs. Jan. 1955, 10p. (Rept. no. 22) ([AF]OSR-TN-55-13) (AF 18(600)685) AD 53138 Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 4: 647-652, Sept. 1955.

The radius of the Virial expansion of the ideal Bose-Einstein gas was shown to lie between 4π and $\sum_{n=1}^{\infty} n^{-3/2} + 8\pi$. The result shows that no close connection exists between the singularities of the Virial expansion and the phenomenon of condensation. (Contractor's abstract)

COR. 05:018

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ASYMPTOTIC MINIMAX CHARACTER OF THE SAMPLE DISTRIBUTION FUNCTION AND OF THE CLASSICAL MULTINOMIAL ESTIMATOR, by A. Dvoretzky, J. Kiefer, and J. Wolfowitz. May 1955, 50p. (Repl. no. 23) ([AF]OSR-TN-55-137) (AF 18(600)685) AD 63414 Unclassified

Also published in Ann. Math. Stat., v. 27: 642-669, Sept. 1956.

This study is concerned with proving the asymptotic minimax character of the sample distribution function (df) for estimating an unknown df in $\mathcal{F}$ or $\mathcal{F}_c$ for a wide variety of weight functions. Section 1 contains definitions and a discussion of measurability considerations. Section 2 includes a statement of 2 lemmas, and a corollary of the second, which are important tools in the proofs and are of interest per se. For example, Lemma 2 implies the convergence of the moment generating function of G_n to that of G. A proof of Lemma 2 is given in Section 2; Lemma 1 was proved by Anderson in Proc. Amer. Math. Soc., v. 6: 170-176, 1955. In Section 3, the asymptotic minimax character is proved for a fundamental class of weight functions which are functions of the maximum deviation between estimating and true df. In Section 4, a device (of more general applicability in decision theory) is employed which yields the asymptotic minimax result for a wide class of weight functions of this character as a consequence of the results of Section 3 for weight functions of the fundamental class. The asymptotic minimax character is proved for a class of integrated weight functions in Section 5. A more general class of weight functions for which the asymptotic minimax character holds is discussed in Section 6. This

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include weight functions for which the risk function of the sample df is not a constant over $\mathfrak{F}_c$. Most weight functions of practical interest are included in the considerations of Sections 3 to 6. Section 6 also presents a discussion of multinomial estimation problems for which the asymptotic minimax character of the classical estimator is contained in the results. Finally, Section 7 includes a general discussion of minimization of symmetric convex or monotone functionals of symmetric random elements, with special consideration of the "tied-down" Wiener process, and with a heuristic proof of the results of Sections 3, 4, 5 and much of Section 6. (Contractor's abstract)

COR. 05:019

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON THE REPRESENTATION OF A FUNCTION BY A POISSON TRANSFORM, by C. Standish. July 1955, 13p. (Rept. no. 24) ([AF]OSR-TN-55-209) (AF 18-(600)685) AD 87254 Unclassified

Also published in Mich. Math. Jour., v. 3: 95-104, 1955.

In a recent study, Pollard ("The Poisson Transform," Trans. Amer. Math. Soc., v. 78: 541-550, 1955) obtained a real inversion formula for the convolution transforms

$$(1)\quad f(x) = 1/\pi \int_{-\infty}^{\infty} \frac{d\alpha(y)}{1 + (x-y)^2}$$

with $\alpha(y)$ of bounded variation on every finite interval, and

$$(2)\quad f(x) = 1/\pi \int_{-\infty}^{\infty} \frac{g(y)dy}{1 + (x-y)^2}$$

with $g(y)$ integrable on every finite interval. The integrals are interpreted in the sense

$$\int_{-\infty}^{\infty} = \lim_{\substack{R\to\infty \\ S\to\infty}} \int_{-S}^{R}$$

In this study, necessary and sufficient conditions will be obtained for $f(x)$ to be representable in the form (1) with (I) $\alpha(y)$ of bounded variation on $(-\infty, \infty)$ or (II) $\alpha(y)$ nondecreasing and bounded on $(-\infty, \infty)$ and in the form (2) with (III) $g(y)$ integrable on $(-\infty, \infty)$ or (IV) $g(y)$ bounded on $(-\infty, \infty)$ or (V) $g(y) \in L_p(-\infty, \infty)$ $p > 1$.

COR. 05:020

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A NOTE ON THE NORMAL DISTRIBUTION, by J. R. Blum. July 1955, 4p. (Rept. no. 25) ([AF]OSR-TN 55-210) (AF 18(600)685) AD 87253 Unclassified

Let $\varphi(t)$, $\psi(t)$, and $M(t)$ be characteristic functions of distributions with zero means and unit variances. The following theorems are proved: Theorem I. Let $n > 1$ be an integer, and let m be an integer with $0 \leq m \leq n$. Suppose:

$\varphi(t)\,\psi(t) = \varphi^m(\frac{t}{n^{1/2}})\ \ m(\frac{-t}{n^{1/2}})\ \varphi^{n-m}(\frac{-t}{n^{1/2}})\ \ \psi^{n-m}(\frac{-t}{n^{1/2}})$ for all t. Then $\varphi(t) = \psi(t) = e^{\frac{-t^2}{2}}$. Theorem II. Suppose for every $\alpha > 0$ that: $\varphi(\alpha t)\,\psi(t) = M[\alpha^2 + 1)^{1/2} t]$. Then $\varphi(t) = \psi(t) = M(t) = e^{\frac{-t^2}{2}}$. (Contractor's abstract)

COR. 05:021

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON THE STRUCTURE OF CERTAIN DECISION RULES, by J. R. Blum and L. Weiss. Aug. 1955, 3p. (Rept. no. 27) ([AF]OSR-TN-55-229) (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)685 and Office of Naval Research under [Nonr-40103]) AD 87251 Unclassified

This study is concerned with decision problems where the possible distributions fall into a finite number of parametric families, while the loss incurred depends only on which family the true distribution belongs to and not on the values of the parameters, and a set of statistics sufficient for all the parametric family exists. Under these circumstances, a complete class of decision rules is characterized by means of Bayes' solutions for the conditional decision problems, given the values of the sufficient statistics.

COR. 05:022

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON NONPARAMETRIC MULTISAMPLE TESTS, by J. R. Blum and L. Weiss. Aug. 1955, 8p. (Rept. no. 28) ([AF]OSR-TN-55-254) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)685 and Office of Naval Research under [Norr-40103]) AD 87110 Unclassified

Let $X_{0,1}, \ldots, X_{0,n_0}; \ldots; X_{k,1}, \ldots, X_{k,n_k}$ be $k+1$ samples with distribution functions $F_0, \ldots, F_k$. The multisample hypothesis H is that $F_0 = F_1 = \ldots = F_k$. Rank tests for this hypothesis are developed from a slightly different set of statistics which, although equivalent to ranks, are somewhat more amenable to mathematical manipulation. All distributions are considered to be continuous to exclude the possibility of tied observations. Certain optimum 2-sample tests are discussed. A simple method is given for obtaining multisample tests. (ASTIA abstract)

COR. 05:023

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON OCCUPATION TIMES FOR MARKOFF PROCESSES, by D. A. Darling and M. Kac. Aug. 1955, 20p. (Rept. no. 26) ([AF]OSR-TN-55-255) (AF 18(600)685) AD 87252 Unclassified

Also published in Trans. Amer. Math. Soc., v. 84: 444-458, Mar. 1957.

Let $\{x_t \quad t \geq 0\}$ be an abstract-valued Markov process with the stationary transition probability $p(x, E;t)$. Let $p_s(x, E) = \int_0^\infty e^{-st}P(x, E;t)dt$; $V(x)$ be measurable and ≥ 0. Assumption: There exists $h(s) \to \infty$ as $s \to 0$ and $C > 0$ such that

$$(h(s))^{-1} \int V(y)p_s(x, dy) \to C \quad (s \to 0)$$

uniformly in $x \in \{\xi | V(\xi) > 0\}$. Then if $h(s) = L(s^{-1})s^{-\alpha}$ $(0 \leq \alpha < 1)$ and $L(s^{-1})$ is slowly varying as $s \to 0$,

$$(Ch(t^{-1}))^{-1} \int_0^t V(x(\tau))d\tau$$

has as limit the Mittag-Leffler distribution of index α. Conversely, if the above has a nondegenerate limit distribution after $Ch(t^{-1})$ is replaced by some $u(t) > 0$, then $u(t)$ is indeed $Ch(t^{-1})$, where h is given in the assumption and must be of the stated form. There is a discrete analogue. The connexion with Karamata's Tauberian theorem is discussed. Applications to sums of independent random variables unify some known results but under more restrictive conditions than otherwise obtainable. (Math. Rev. abstract)

COR. 05:024

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

THE MAXIMUM OF SUMS OF STABLE RANDOM VARIABLES, by D. A. Darling. Aug. 1955, 8p. (Rept. no. 30) ([AF]OSR-TN-55-262) (AF 18(600)685) AD 87108 Unclassified

Also published in Trans. Amer. Math. Soc., v. 83: 164-169, Sept. 1956.

Let $X_1, X_2, \ldots$ be identically distributed independent random variables having a common stable distribution of index γ, $0 < \gamma \leq 2$. In this paper the limiting distribution of $n^{-1/\gamma} \max(S_1, S_2, \ldots, S_n)$, where $S_n = X_1 + X_2 + \ldots + X_n$, is deduced. (Contractor's abstract)

COR. 05:025

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A COMBINATORIAL LEMMA AND ITS APPLICATION TO PROBABILITY THEORY, by F. Spitzer. Aug. 1955, 24p. (Rept. no. 29(([AF]OSR-TN-55-270) (AF 18(600)685) AD 87109 Unclassified

By combinatorial methods the following result is established. If $X_1, X_2, \ldots$ is a sequence of identically distributed independent random variables, $S_k = X_1 + \ldots + X_k$, $\theta_0(\lambda) = 1$, and if $\theta_n(\lambda)$ and $\psi_k(\lambda)$ are the characteristic functions of the random variables $\max[0, S_1, \ldots, S_n]$ and $\max[0, S_k]$, then, for $|t| < 1$,

$$\sum_{n=0}^{\infty} \theta n(\lambda)t^n = \exp\left[\sum_{k=1}^{\infty} \frac{\psi k(\lambda)}{k} t^k\right].$$

A few theoretical applications of this result are treated. (Contractor's abstract)

COR. 05:026

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

CONSISTENCY OF THE MAXIMUM LIKELIHOOD ESTIMATOR IN THE PRESENCE OF INFINITELY MANY INCIDENTAL PARAMETERS, by J. Kiefer and J. Wolfowitz. Sept. 1955 [37]p. refs. (Rept. no. 34) ([AF]OSR-TN-55-290) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)685 and Office of Naval Research under [Nonr-40103] AD 87106 Unclassified

Also published in Ann. Math. Stat., v. 27: 887-906, Dec. 1956.

It is shown that, under usual regularity conditions, the maximum likelihood estimator of a structural parameter is strongly consistent, when the (infinitely many) incidental parameters are independently distributed chance variables with a common unknown distribution function. The latter is also consistently estimated although it is not assumed to belong to a parametric class. Application is made to several problems, in particular to the problem of extimating a straight line with both variables subject to error, which, thus, after all has a maximum likelihood solution. (Contractor's summary)

COR. 05:027

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

N-DIMENSIONAL DISTRIBUTIONS CONTAINING A NORMAL COMPONENT, by C. Standish. Sept. 1955 [8]p. (Rept. no. 32) ([AF]OSR-TN-55-302) (AF 18-(600)685) AD 87107 Unclassified

Also published in Ann. Math. Stat., v. 27: 1161-1165, Dec. 1956.

In this study, necessary and sufficient conditions are obtained for an n-dimensional distribution function $F(x_1, \ldots, x_n)$ to contain as a factor the distribution

COR. 05:028 - COR. 05:032

function of n independent normal random variables having common mean zero and variance 1. That ts, conditions are obtained for $F(x_1, \ldots, x_n)$ to be of the form

$$F(x_1, \ldots, x_n) = \int_{-\infty}^{\infty} \cdots \int_{-\infty}^{\infty} G(x_1 - u_1, \ldots, x_n - u_n) dP(u_1, \ldots, u_n),$$

where $P(u_1, \ldots, u_n)$ is a distribution function and

$$G(x_1, \ldots, x_n) = \left(\frac{1}{\sqrt{\pi}}\right)^n \int_{-\infty}^{x_1} \cdots \int_{-\infty}^{x_n} \exp -(u_1^2 + \ldots + u_n^2) du_1 \ldots du_n$$

(Contractor's abstract)

COR. 05:028

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

DISTRIBUTION OF EIGENVALUES OF CERTAIN INTEGRAL OPERATORS, by M. Kac. Sept. 1955 [11]p. (Rept. no. 33) ([AF]OSR-TN-55-303) (AF 18(600)685) AD 87398 Unclassified

Also published in Mich. Math. Jour., v. 3: 141-148, 1955-56.

The asymptotic distribution of eigenvalues of the integral equation $\int_{-a}^{a} \frac{V(y)}{|x-y|^{\alpha}} \varphi(y)dy = \lambda \varphi(x)$, $0 < \alpha < 1$, where

V(y) te continuous and bounded away from 0, ts determtned. The method ts based on a study of certain functionals of a process with independent incremente obeying the symmetrtc stable distribution of exponent α. (Contractor's abstract)

COR. 05:029

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

PRESENTATION AS A POISSON TRANSFORM, by H. Pollard. May 1956 [13]p. (Rept. no. 35) ([AF]OSR-TN-55-329) (AF 18(600)685) AD 140602 Unclassifted

Also published tn Trans. Amer. Math. Soc., v. 85: 174-180, May 1957.

For the ftrst time, neceesary and euffictent conditions were obtained for the representation of a function tn the form $f(x) = \frac{t}{\pi} \int_{-\infty}^{\infty} \frac{d\alpha(y)}{(x-y)^2+t}$, $d\alpha \geq 0$, the so-called

Poisson transform. The proofs depend upon Harry Pollard's tnversion operator [Trans. Amer. Math. Soc., v. 78: 541-550 (1955)] and a new formula for functione harmonic in a half-plane, with anatytic boundary values. (Contractor's abstract)

COR. 05:030

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

CONVOLUTIONS WITH RATIONAL KERNELS, by J. Blackman. Oct. 1955 [10]p. (Rept. no. 35) ([AF]OSR-TN-55-330) (AF 18(600)685) AD 87105 Unclassified

Consider the equation

(1) $f(x) = \int_{-\infty}^{\infty} k(x-u)d\alpha(u)$

under the conditions A

(i) $k(x) = \frac{p(x)}{q(x)}$, where p(x) and q(x) are polynomials of degree p and q, respectively, with $p - q = n > 0$;
(ti) the distance d from the set of zeros of q(x) to the real axis ts positive;
(iii) $\alpha(x)$ ts locally of bounded variation, and $\alpha(0) = \frac{\alpha(0+) + \alpha(0-)}{2} = 0$;

(iv) $\hat{k}(x) = \int_{-\infty}^{\infty} e^{ixt} k(t)dt \neq 0$ for real x;

(v) for some x_0, $|\mathrm{Im} x_0| < d$

$$\lim_{A,B \to \infty} \int_{-A}^{B} k(x_0 - u)d\alpha(u) \text{ exists.}$$

If the conditione A are satisfied, tt te shown that the eolution of (1) ts unique, and the eolution ts obtained. (Contractor's abetract)

COR. 05:031

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

DOMAINS OF METHODS FOR EVALUATION OF SEQUENCES, by R. P. Agnew. Dec. 1955 [24]p. (Rept. no. 38) ([AF]OSR-TN-55-356) (AF 18(600)-685) AD 87261 Unclassified

When A ts a regular matrix method for evaluation of sequences and x_n^{-1} ie a bounded divergent sequence evaluable A, an explictt conetruction of an extensive class of sequences evaluable ts obtained. The latter class always contains an extensive class of unbounded sequences. Other resulte of this nature and consequences of them are obtained, and thetr relations to published results in the fteld are set forth. (Contractor'e abstract)

COR. 05:032

Cornell U. Dept. of Mathematice, Ithaca, N. Y.

RIEMANN METHODS FOR EVALUATION OF SERIES, by R. P. Agnew. Dec. 1955 [37]p. refs. (Rept. no. 39) ([AF]OSR-TN-55-357) (AF 18(600)685) AD 87262 Unclassifted

An investigation is made of the behavior of the R(p) and R_p transforms of series Σu_n satisfying the Tauberian condition $\limsup_{n\to\infty} |nu_n| \leq M < \infty$. The series is said to be evaluable R(p) to L if the series in $\sigma_1(p,t) = \sum_{k=0}^{\infty} \left(\frac{\sin kt}{kt}\right)^p u_k$ converges over some interval $0 < t < t_0$ and $\sigma_1(p,t) \to L$ as $t \to 0$, and the series is said to be evaluable R_p to L if the series in $\sigma_2(p,t) = c_p t \sum_{k=0}^{\infty} \left(\frac{\sin kt}{kt}\right)^p s_k$ converges over some interval $0 < t < t_0$ and $\sigma_2(p,t) \to L$ as $t \to 0$; s_k is the k^{th} partial sum of the series Σu_n. Precise optimal relations are obtained between (1) the R(p) transform of Σu_n and the partial sums of Σu_n; (2) the R_p transform of Σu_n and the partial sums of Σu_n; and (3) the R(p) and R_p transforms of Σu_n. A simple Tauberian argument is used to prove that the product transformation $R(p)C_r$ and R_pC_r are regular when $r \geq 1$; C_r is the Cesaro transformation of order r. (ASTIA abstract)

COR. 05:033

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

RIEMANN SUMMABILITY OF CAUCHY PRODUCTS AND TRANSLATES OF SERIES, by R. P. Agnew. Dec. 1955, 16p. (Rept. no. 40) ([AF]OSR-TN-55-358) (AF 18-(600)685) AD 87263 Unclassifted

For each positive integer p, let R(p) denote the Riemann method of order p for evaluation of series. It is shown that to each positive integer p there corresponds an extensive class of series Σu_n such that, for each series Σu_n in the class, the series $u_0 + u_1 + \ldots$ is evaluable R(p) while both of the translates $0 + u_0 + u_1 + \ldots$ and $u_1 + u_2 + \ldots$ are nonevaluable R(p). For the case p = 2, the result has previously been given without details of proofs. One service of the results is to establish the falsity of a published theorem on R(p) evaluability of Cauchy products of series. (Contractor's abstract)

COR. 05:034

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

INVERSION OF CLASS OF DISCRETE CONVOLUTION TRANSFORMS, by H. Pollard and C. Standish. Oct. 1955 [17]p. (Rept. no. 37) ([AF]OSR-TN-55-367) (AF 18(600)685) AD 87104 Unclassifted

An inversion formula is obtained for the discrete convolution transforms

$$f(n) = \sum_{-\infty}^{\infty} k(n-m)g(m)$$

with kernels k(n) defined by the property

$$\sum_{-\infty}^{\infty} k(n)z^n = \prod_{j=1}^{\infty}(1-a_j)(1-b_j)/\prod_{j=1}^{\infty}(1-a_jz)(1-b_jz),$$

where $1 > a_1 \geq a_2 \geq \ldots > 0$; $1 > b_1 \geq b_2 \geq \ldots > 0$, and, $\Sigma (a_j + b_j) < \infty$.

The inversion formula is the following. Define operation δ, $1/\delta$, and $P_N(\delta)$

$$\delta F(n) = F(n+1) \quad [1/\delta]F(n) = F(n-1)$$

$$[P_N(\delta)F(n) = (1/K_1)\prod_{1}^{N}(1-a_k\delta)(1-b_k|\delta)F(n) \text{ then}$$

$$K_1 = \prod_{j=1}^{\infty}(1-a_j)(1-b_j)$$

$\lim_{N\to\infty}[P_N(\delta)]F(n) = g(n)$. (Contractor's abstract)

COR. 05:035

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

SOME THEOREMS CONCERNING BROWNIAN MOTION, by G. A. Hunt. July 20, 1955 [26]p. [AFOSR-TN-55-368] [AF 18(600)685] Unclassified

Published in Trans. Amer. Math. Soc., v. 81: 294-319, Mar. 1956.

Given a Markov process with stationary transition probabilities, this mathematical study is concerned with certain random times such that, when the associated state is known, the future is a new Markov process which is governed by the original transition probabilities, and is independent of the past. A somewhat special version of these statements is reported. Consider a Brownian motion with state space R^n and continuous sample functions $X = (X(t): t \geq 0)$, built over the probability field (Ω, F, P), let T be a (P) measurable random time, and let $\Omega' = (T < +\infty)$, have positive P measure, let $F' = (B: B = A \cap \Omega', A \in F)$ and $P'(.) = P(./\Omega')$, and call T a Markov time if, over the new probability field (Ω', F', P'), $Z = (X(t+T) - X(T): t \geq 0)$ is a Brownian motion, independent of the stopped process $X^* = (X(\min(t,T)): t \geq 0)$. The theorem is stated as: T is a Markov time provided either that it be Borel measurable in X^* or that it be the limit of Markov times S such that $(S = +\infty) = (T = +\infty)$. Let E be closed in R^n, and let E' be the points of E which are regular for the associated Dirichlet problem. It is remarked that $T = \inf(t: X(t) \in E, t > 0) \cup (t = +\infty)$ is a Markov time and uses this to indicate that $q(t,r,s) = P(T > t, X(t) \in ds/ds/X(0) = r/ds$ is the elementary solution for the heat equation $v_t = (1/2)\Delta v$ on $R^n - E$, $v = 0$ on E', and that $G(r,s) = \int_0^{+\infty} q(t,r,s)dt$ is the Green function

COR. 05:036 - COR. 05:040

for the Poisson equation $(1/2)\Delta v = -u$ on $R^n - E$, $v = 0$ on E'. When $n = 2$ and E has positive logarithmic capacity, these expressions are used to estimate the speed at which the solution $v(t, s)$ of $v_t = (1/2)\Delta v$, $v(0, \cdot) = 0$ on Rn-E, $v(t, \cdot)$ prescribed on E', converges to the corresponding solution $v(s)$ of $\Delta v = 0$. The result is $[v(s) - v(t, s)] \log t \longrightarrow 2\pi G(s, \infty)v(\infty)$, as $t \uparrow +\infty$, and it follows that $P(T > t / X(0) = s) \sim 2\pi G(s, \infty)/\log t$, as $t \uparrow +\infty$, which has been conjectured by M. Kac.

COR. 05:036

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

SPECTRAL SYNTHESIS FOR THE CANTOR SET, by C. S. Herz. Oct. 1955 [3]p. (Rept. no. 42) ([AF]-OSR-TN-55-386) (AF 18(600)685) AD 87264 Unclassified

If I is a closed ideal in the L^1 convolution algebra over the reals and the Cantor set is the set of zeros common to the Fourier transforms of functions in I, then $f \in L^1$ has Fourier transforms vanishing on the Cantor Set, $f \in I$. (Contractor's abstract)

COR. 05:037

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

CONSISTENCY AND OPTIMUM PROPERTIES OF SOME TWO-SAMPLE TESTS, by J. R. Blum and L. Weiss. Dec. 1955, 10p. (Rept. no. 4) ([AF]OSR-TN-55-403) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)685 and Office of Naval Research under [Nonr-40103]) AD 87395 Unclassified

The problem is stated as follows: $X_1, \ldots, X_m$ is a sample from the uniform distribution on the unit interval and $Y_1, \ldots, Y_n$ is a sample with density g(y) on the unit interval. $Z_0 = 0$, $Z_{n+1} = 1$, and $Z_1 < \ldots < Z_n$ are the order statistics corresponding to $Y_1, \ldots, Y_n$. For each $i = 1, \ldots, n+1$, S_i is the number of X's in the interval $[Z_{i-1}, Z_i]$, and for each nonnegative r, $Q_n(r)$ is the proportion among $S_1, \ldots, S_{n+1}$ which is equal to r. Define $a = m/n$, and for each r, set

$Q(r) = a^r \int_0^1 \frac{g^2(y)dy}{[a+g(y)]^{r+1}}$. A proof is given, under mild restrictions on g(y), that

$P\left\{\limsup_{n\to\infty} \sqrt{n}\left|Q_n(r) - Q(r)\right| = 0\right\} = 1$. This is applied to prove the consistency of such 2-sample tests as that of the Wald-Wolfowitz run-test (Ann. Math. Stat., v. 2: 147-162, 1940). (Contractor's abstract, modified)

COR. 05:038

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON A CONJECTURE OF TEICHMÜLLER, by W. H. J. Fuchs. Feb. 1956 [11]p. (Rept. no. 43) ([AF]OSR-TN-55-418) (AF 18(600)685) AD 87396 Unclassified

It is proved that for an entire function, f(z), of order ρ there is a number $A(\rho)$ depending only on ρ such that

$$\Sigma (\delta(a))^{1/2} < A(\rho) < \infty$$

where the summation is over all finite deficient values of f(z). (Contractor's abstract)

COR. 05:039

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

SOME REMARKS ON THE USE OF PROBABILITY IN CLASSICAL STATISTICAL MECHANICS, by M. Kac. Feb. 1956, 7p. (Rept. no. 45) ([AF]OSR-TN-56-22) (AF 18(600)685) AD 87394 Unclassified

Also published in Bull. Acad. Roy. de Belgique, Cl. Sci., v. 42: 356-361, 1956.

A simple artifical model is constructed to explain the role of probabilistic notions in establishing the irreversibility of reversible systems. The model consists of n equidistant points on a circle, m of which are marked and form a set S. The complementary set of n-m points is $\bar{S}$. Each of the n points is a site of a ball which can be either white or black. During an elementary time interval each ball moves counterclockwise to the nearest site under these conditions: if the ball is in S it changes color when the move is completed, but if the ball is in $\bar{S}$ the move is made without a color change. Analysis of the model shows that the Boltzmann approach can be justified in a manner similar to that employed by P. and T. Ehrenfest. An analysis of the model for the case when S is completely specified, but the initial arrangement of white and black balls is subject to a probability distribution, was unsuccessful. (ASTIA abstract)

COR. 05:040

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

ON STOCHASTIC APPROXIMATION METHODS, by J. Wolfowitz. Dec. 1955, 9p. (Rept. no. 46) (AFOSR-TN-56-58) (AF 18(600)685) AD 81050 Unclassified

Also published in Ann. Math. Stat., v. 27: 1151-1156, Dec. 1956.

A simple proof is given of the following theorem on the convergence of stochastic approximation procedures by Dvoretzky. a_n, b_n, and Y_n, $n = 1, 2, \ldots$ are

nonnegative real numbers that satisfy these conditions:

(1) $\lim_{n\to\infty} \alpha_n = 0$; (2) $\sum_{n=1}^{\infty} \beta_n < \infty$; and

(3) $\sum_{n=1}^{\infty} \gamma_n = \infty$. θ is a real number and T_n, n=1, 2, ..., are measurable transformations that satisfy $|T_n(r_1, \ldots, r_n) - \theta| \leqq \max [\alpha_n, (1+\beta_n)|r_n - \theta| - \gamma_n]$ for all real $r_1, \ldots, r_n$. X_1 and Y_n, n=1, 2, ..., are random variables, and $X_{n+1}(\omega) = T_n(X_1(\omega), \ldots, X_n(\omega)) + Y_n(\omega)$ is defined for $n \geqq 1$. Then the conditions $E\{X_t^2\} < \infty$, $\sum_{n=1}^{\infty} E\{Y_n^2\} < \infty$, and $E\{Y_n | x_1, \ldots, x_n\} = 0$ with probability 1 for all n imply $\lim_{n\to\infty} E\{X_n - \theta^2\} = 0$ and $P\{\lim_{n\to\infty} X_n = \theta\} = 1$. (ASTIA abstract)

COR. 05:041

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A CLASS OF LIMIT THEOREMS, by M. Kac. Apr. 1956 [20]p. (Rept. no. 47) (AFOSR-TN-56-153) (AF 18(600)685) AD 86313 Unclassified

Also published in Trans. Amer. Math. Soc., v. 84: 459-471, Mar. 1957.

Let $x_1, x_2, \ldots$ be identically distributed, independent random variables having a symmetric density function $\rho(x)$, whose characteristic function $\varphi(\xi)$ is absolutely integrable in $(-\infty, \infty)$. Let Ω be a bounded measurable set and denote by $P_n(1, \Omega)$, the probability that exactly 1 among the first n partial sums $s_k = x_1 + \ldots + x_k$ fall within Ω. Under certain additional conditions on $\varphi(\xi)$ the exact asymptotic behavior of $P_n(1, \Omega)$ is determined. (Contractor's abstract)

COR. 05:042

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A NOTE ON THE SPAN OF TRANSLATIONS IN L^p, by C. S. Herz. June 1956, 6p. (Rept. no. 49) (AF-OSR-TN 56-264) (AF 18(600)685) AD 88984 Unclassified

The relation between the Wiener closure property, c, (A. Beurling, Arkiv für Mat., v. 1: 301-303, 1951) of the set of translations of a function in L^p and the uniqueness property of $Z(f)$ of the set of zeros of the Fourier transform are considered. Some sufficient conditions for closure are given.

COR. 05:043

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

THE LOTOCKII (OR LOTOTSKY) METHOD FOR EVALUATION OF SERIES, by R. P. Agnew. July 1956 [37]p. (Rept. no. 50) ([AF]OSR-TN-[56]-297) (AF 18(600)685) AD 90009 Unclassified

Also published in Mich. Math. Jour., v. 4: 105-128, 1957.

A. V. Lotockii (On a linear transformation of sequences and series. In Russian. Ivanov. Gos. Ped. Inst. Uc. Zap. Fiz.-Mal. Nauki, v. 4: 61-91, 1953) has introduced a triangular matrix method for evaluation of series. This method seems to be new and to have fundamental significance which may make it rival in importance the classic methods of Cesàro, Abel, Euler-Knopp, Borel and others. Numerous properties of this method are obtained, and it is found to be exceptionally effective. (Contractor's abstract)

COR. 05:044

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

THE L_p CONVERGENCE OF FOURIER-BESSEL SERIES FOR $0 < p < 1$, by C. Standish. July 1956 [4]p. (Rept. no. 51) (AFOSR-TN-56-305) (AF 18-(600)685) AD 90019 Unclassified

The object of this mathematical study is to extend to Fourier Bessel series a theorem of M. Riesz on L_p convergence of trigonometric series. The following theorem is proved. If $f(x) \in L(0, 1)$ then

$$\lim_{N\to\infty} \int_0^1 |f(x) - S_N(x)|^p dx = 0 \quad \text{e}$$

$$S_N(x) \quad \sum_1^N b_n (ax)^{1/2} J_V(u_n x) / J_{U+1}(u_n)$$

$$J_{V+1}(u_n) b_n = 2^{1/2} \int_0^1 t^{1/2} J_V(u_n t) f(t) dt.$$ (Contractor's abstract)

COR. 05:045

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

FURTHER REMARKS ON USE OF PROBABILITY IN CLASSICAL STATISTICAL MECHANICS, by M. Kac. July 1956, 7p. (Rept. no. 52) (AFOSR-TN-56-321) (AF 18(600)685) AD 94857 Unclassified

Previous work on the use of probability in classical statistical methods is continued. The model is modified so that the number of elements in the set is not fixed but is a random variable with a mean. The

COR. 05:046 - COR. 05:050

treatment is analogous to a treatment by means of a grand-canonical ensemble. A purely probabilistic approach is introduced and justified on the basis of the Liouville equation, with a restriction to symmetric initial distributions. Symmetrization is explained, and an analogy is made with kinetic theory. (ASTIA abstract)

COR. 05:046

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

SUMMABILITY METHODS AND SPECTRAL ANALYSIS, by C. S. Herz. Aug. 1956 [3]p. (Rept. no. 53) ([AF]OSR-TN-56-345) (AF 18(600)685) AD 95431 Unclassified

It is shown that the spectrum of a bounded measurable function on the real line may be defined in terms of any of a large variety of summability methods. Known theorems in this connection for Abel and (R, 2) summability can be extended quite generally. In addition, a new, sharp theorem on summability of formal products is given.

COR. 05:047

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

GENERALIZATIONS OF A THEOREM OF WALD ON MONOTONE SEQUENCES, by R. P. Agnew. Aug. 1956 [17]p. (Rept. no. 54) (AFOSR-TN-56-355) (AF 18(600)685) AD 95441 Unclassified

The following theorem of Wald is strengthened and generalized in several ways: If n is an even integer, if $\lambda(n) = n/2$, and if $q(k) = k$, then

$$\liminf_{n\to\infty} \sum_{1 \le k < \lambda(n)} \left(\frac{a_k}{a_n}\right)^{q(k)} = 0, \text{ whenever}$$

$0 < a_1 \le a_2 \dots$ and $a_n \to \infty$. It is found that if $0 < \lambda < 1$, $\lambda(n) = \lambda n$, and $\epsilon > 0$, then $g(k)$ can be $(\log k)^{2+\epsilon}$ when $k > 1$. When $\lambda(n) = n - 1$ and $\epsilon > 0$, $g(k)$ can be $k(\log k)^{2+\epsilon}$ when $k > 1$. Some of the generalizations involve monotone functions instead of sequences. (Contractor's abstract, modified)

COR. 05:048

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

ON THE DEVIATIONS OF THE EMPIRIC DISTRIBUTION FUNCTION OF VECTOR CHANCE VARIABLES, by J. Kiefer and J. Wolfowitz. Aug. 1956, 20p (Rept. no. 54) (AFOSR-TN-56-379) (AF 18(600)685) AD 95815 Unclassified

The following two theorems are proven in this paper: Theorem 1. $1 - G_n(r) < C_0 e^{-cr^2}$ for all $r > 0$, where C_0 and C are absolute positive constants; and

Theorem 2. There exists a distribution function $(d..f..)$ G (depending on F) such that, at every point of continuity of G, $\lim_n G_n = G$. Also

$\lim_{k\to\infty} \lim_{n\to\infty} H_{n,k} = G$ at every point of continuity of G. Similar results to those of these theorems hold for the joint df of the signed deviations, and also when F is not continuous.

COR. 05:049

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON SIMILARITY, REDUCING MANIFOLDS, AND UNITARY EQUIVALENCE OF CERTAIN VOLTERRA OPERATORS, by G. K. Kalisch. Oct. 1956, 19p. (Rept. no. 54) ([AF]OSR-TN-56-513) (AF 18(600)-685) AD 110328 Unclassified

Also published in Ann. Math., v. 66: 481-494, Nov. 1957.

The investigation is concerned with Volterra Operators T_F where $T_F f(x) = \int_0^1 F(x,y)dy$ mapping $L_p[0,1]$ into itself $(1 < p < \infty)$. The following three topics are discussed: Similarity, reducing manifolds, (i.e., subspaced S such that $F_F S \subset S$), and in the case $p = 2$ unitary equivalence. In addition to certain regularity conditions, the kernels satisfy the following: $F(x,y) = (y-x)^{n-1}G(x,y)$ where $G(x,x)$ is real and different from 0; otherwise, the kernels may be complex-valued. The integer n in the foregoing equation is to be positive: it is called the order of F. The principal results concerning similarity may be stated as follows: Under suitable regularity conditions imposed on F, every T_F is similar to a unique operator cT_E^n where c is real number, E is the function identically equal to 1, and n is the order of F. The principal results concerning reducing manifolds are these: The only reducing subspaces of the operators T_F considered are the spaces $L_p[0,\mu]$ for all $\mu \in [0,1]$. The principal results concerning the unitary equivalence of the operators T_F (acting on $L_2^*[0,1]$) are these: Every T_F is unitarily equivalent to a unique operator T_G where $G(x,y) = (y-x)^{n-1}H(x,y)$ such that $H(x,x) = c$ (a real number) and $1M\ 11_x(x,x) = 1M\ 11_y(x,x) = 0$. The operators used to implement the similarity and unitary equivalence relations are of three kinds: multiplication by measurable functions, change of measure of the unit interval, and operators of the form $1 + T_m$ for suitable $m(x,y)$. (Contractor's abstract)

COR. 05:050

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ASYMPTOTIC EXPANSIONS IN GLOBAL CENTRAL LIMIT THEOREMS, by R. P. Agnew. Dec. 1956 [33]p. (Rept. no. 63) ([AF]OSR-TN-56-514) (AF 18(600)685) AD 110329 Unclassified

Let $\xi_1, \xi_2, \ldots$ be random variables having the same df (distribution function) F (x) with mean 0 and standard deviation 1. By the central limit theorem, the df F_n of the normalized sum $(\xi_1 + \xi_2 + \ldots + \xi_n)/n^{1/2}$ then converges pointwise to the Gaussian df Φ. Let

$$C_n = \int_{-\infty}^{\infty} | F_n(x) - \Phi(x) |^2 dx.$$

A principal problem of the paper is to give conditions under which there exist constants $D_1, D_2, D_3, \ldots$ such that the expansion

$$C_n = \frac{D_1}{n} + \frac{D_2}{n^2} + \ldots + \frac{D_k}{n^k} + 0\left(\frac{1}{n^{k+1}}\right)$$

is valid for a fixed $k \geq 1$ or for each $k = 1, 2, 3, \ldots$, and to give explicit expressions for D_1 and D_2. The above problem is solved for random variables $\xi_1, \xi_2, \ldots$ having distribution functions belonging to important classes. Characteristic functions are employed in the proofs and in the determination of D_1 and D_2. (Contractor's introduction, modified)

COR. 05:051

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

ON THE REGULARITY OF THE GROWTH OF MEROMORPHIC FUNCTIONS WITH HIGHLY DEFICIENT ZEROS AND POLES, by A. Edrei and W. H. J. Fuchs. Nov. 1956, 16p. (Rept. no. 59) ([AF]OSR-TN-56-515) (AF 18(600)685) AD 110330; PB 136420 Unclassified

The authors consider a meromorphic function f(z) and show that if its zeros and poles are highly deficient, the lower order of f(z) is close to its order. In particular, if $\delta(0) + \delta(\infty) = 2$, the increase of f(z) is regular, that is the order and lower order coincide. (For functions of infinite order this is to be interpreted as meaning that the lower order is infinite.) (Contractor's abstract)

COR. 05:052

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

GAP PROPERTIES OF ENTIRE FUNCTIONS POSSESSING DEFICIENT VALUES, by A. Edrei. Nov. 1956, 2p. (Rept. no. 58) ([AF]OSR-TN-56-516]) (AF 18-(600)685) AD 110331 Unclassified

The author investigates the influence of deficient values on the gaps of the Taylor expansion of an entire function. (Contractor's abstract)

COR. 05:053

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

A REPRESENTATION THEOREM FOR A ONE-SIDED CONVOLUTION TRANSFORM, by C. Standish. Aug. 1956 8[]p (Rept. no. 56) ([AF]OSR-TN-56-517) (AF 18(600)685) AD 110332 Unclassified

The following theorem is proved. Necessary and sufficient conditions for f(x) to be representable in the form

$$f(x) = \int_0^{\omega} G(x-t)g(t)dt \qquad x \geq 0$$

where g(t) is integrable over every finite subinterval of $(0, \omega)$ and

$$\int_{-\infty}^{\infty} e^{-st} G(t)dt = \frac{1}{\prod_{k=1}^{N}(s-a_k) \prod_{j=1}^{M}(s+b_j)}$$

b_j, a_k all distinct $a_k > 0$, $b_j > 0$ $N \geq 1$ are

(1) $f^{M+N-1}(x)$ exists and is absolutely continuous on finite intervals; (2) $f^{M+N-1}(x) = o(e^{ax})$ $x \to \infty$ $a = \min(a_1, \ldots, a_N)$; and (3) $\prod_{j=1}^{\ell}(D+b_j)\prod_{k=1}^{N}(D-a_k)f(x) = 0$ at $x = 0$ $(D=\frac{d}{dx})$ $\ell = 0, 1, 2, \ldots, M-1$. (Contractor's abstract)

COR. 05:054

Cornell U. [Dept. of Mathematics] Ithaca, N. Y.

SEMI-GROUPS OF MEASURES ON LIE GROUPS, by G. A. Hunt. [1956] [30]p. [AF 18(600)685] Unclassified

Published in Trans. Amer. Math. Soc., v. 81: 264-293, Mar. 1956.

Let G be a Lie group and let G_c be its one-point compactification. Let $\{p_t\}$ $(0 < t < \infty)$ be a family of probability measures on the Borel subsets of G_c which forms a semi-group under convolution and satisfies the continuity condition $\lim_{t \downarrow 0} p_t(E) = 1$ for any neighborhood of the identity e of G. Such a semi-group $\{p_t\}$ gives rise to a strongly continuous semi-group of linear operators $\{S_t\}$ on the Banach space $C = C(G_c)$ to C: $(S_t f)(g) = \int_{G_c} f(gh)p_t(dh)$. The Theorem 5.1 gives a characterization of the infinitesimal generator M of such semi-group $\{S_t\}$: M is defined at least on $C^2(G_c)$ and has there the representation $(Mf)(g) = \sum a_i X_i f(g) + \sum a_{ij} X_i X_j f(g) + \int_{G_c - \{e\}} [f(gh) - f(g) - \sum X_i f(g) x_i(g)] \bar{G}(dh)$. Here the symmetric positive semi-definite matrix (a_{ij}) is such that $\sum a_{ij} X_i X_j$ is independent of the choice of the basis $X_1, X_2, \ldots, X_d$ of the infinitesimal transformations of G; the positive measure $\bar{G}$ is such that $\int k(g)\bar{G}(dg)$ is finite for C^2

COR. 05:055 - COR. 05:057

function k(g) strictly positive on $G_c - \{e\}$ and behaves near e like Σx_1^2, $x_1(g)$, $x_2(g)$, ..., $x_d(g)$ denoting the local coordinates of $g \in G$ near e such that $x_i(e) = 0$ and $X_i x_j(e) = \delta_{ij}$. It is proved in §6, that the Lévy formula concerning the characteristic function of the infinitely divisible law may be obtained from the Theorem 5.1. In later g's, the case where the continuity condition for $\{p_t\}$ is not satisfied is discussed in some detail. In such a case, p_t converges, as t decreases to 0, weakly to the Haar measure of a compact subgroup K of G, and an analogue of Theorem 5.1 pertaining to the homogeneous space G/K is sketched. (Math. Rev. abstract)

COR. 05:055

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

BOUNDARIES INDUCED BY NON-NEGATIVE MATRICES, by W. Feller. Jan. 25, 1956 [36]p. incl. refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)685 and Office of Ordnance Research under DA 36-034-ord-1296)
Unclassified

Published in Trans. Amer. Math. Soc., v. 83: 19-54, Sept. 1956.

Let E be the set of positive integers, and let $\prod$ be a matrix with non-negative elements and row sums ≤ 1. The author immerses E in a Hausdorff space, depending on $\prod$, to obtain a boundary for E. A second boundary is also obtained, adjoint to the first and in no relationship to the first except by way of $\prod$. The boundaries are to be applied in a subsequent paper to the theory of the Kolmogorov differential equations for the transition probabilities of a continuous parameter Markov process with countably many states. Let $\mathfrak{M}$ be the class of vectors z with $z \geq 0$ and $\prod z \leq z$. Let $\mathfrak{B}$ be the subclass of $\mathfrak{M}$ with $z \leq 1$. The class $\mathfrak{B}$ is a convex set, and a lattice. The extremals of this convex set, called sojourn solutions, form a lattice also. If A is a subset of E, and if $S_A(i)$ is the probability that the random walk starting from i, with transition probability matrix $\prod$, will enter A and remain there indefinitely, S_A is a sojourn solution, and every sojourn solution can be obtained in this way. (A sojourn solution is an element of $\mathfrak{B}$ for which the limit along successive random walk steps from each initial point has only the possible values 0 and 1.) The author obtains the usual decomposition of E into recurrent and transient states as an application of his study of sojourn solutions. The boundary $\mathfrak{B}$ is the set of maximum ideals in the lattice of sojourn solution, and $E \cup B$ is topologized in such a way that each element $\mathfrak{B}$, considered as a function on E, has continuous boundary values. Each such element can be approximated uniformly by linear combinations of sojourn solutions. If z is a strictly positive element of $\mathfrak{M}$, and if $\prod'$ is defined by $\prod'(i, j) = \prod(i, j)z(j)/z(i)$, then, if $\prod'$ has row sums 1, $\prod'$ has the same property, and $x \in \mathfrak{M}$ if and only if $\prod' x' \leq x'$, for $x(i) = x(i)/z(i)$. Thus a correspondence between $\mathfrak{M}$ and its analogue for $\prod'$ is set up and thereby the above is extended to a larger boundary which includes $\mathfrak{B}$ and every boundary obtained by the above relativization in terms of a specified element of $\mathfrak{M}$. The analogue of this relativization in the context of the first boundary value problem for harmonic functions (when $\mathfrak{M}$ becomes the class of positive barmonic functions on a suitable domain) has been used by Brelot (Jour. Math. Pures Appl., v. 35: 297-335, 1956) for a somewhat different purpose. Finally, replacing $\prod$ by the transition matrix of a corresponding random walk reversed in time, an adjoint boundary is obtained. (Math. Rev. abstract)

COR. 05:056

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

IDEALS IN ABELIAN GROUP ALGEBRAS, by A. P. Calderón. July 1956, 12p. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume 1; AF 18(603)12)
[AF 18(600)685] Unclassified

This paper is concerned with the characterization of intersections of maximal ideals in the L^1 algebra of a locally compact abelian group by means of their hulls. A fairly numerous class of sets which as hulls are characteristic of such ideals is obtained. In the case of vector groups such sets include among others polygonal lines, polygons, polyhedra regions with sufficiently regular (locally starshaped) boundaries, convex sets etc. These results have their counterparts in the problem of spectral synthesis of bounded functions.

COR. 05:057

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

POTENTIAL THEORY AND SPECTRAL ANALYSIS, by C. S. Herz. July 1956, 11p. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume 1; AF 18(603)12)
[AF 18(600)685] Unclassified

The underlying heuristic notion of the spectrum of a function could be formulated this way: the spectrum, $\Lambda(\varphi)$ is the closure of the set of points t at which the formal trigonometric integral $\int \exp(-itx)\varphi(x)dx$ is different from 0. The concept can be made precise for the class L^∞ of essentially bounded measurable functions in three ways which we wish to view as distinct. The first of these involves the application of a summability method to the trigonometric integral. For a suitable kernel k, one forms the absolutely convergent integrals

$$\Phi_h(t) = \int \exp(-itx)k(hx)\varphi(x)dx$$

$h > 0$, and investigates the limiting behavior as $h \to 0$. If $\int_x^{x+1} |\varphi(y)|dy = O(1)$ as $|x| \to \infty$, one may use ordinary convergence, i.e., $k(x) \to 1$ for $|x| \leq 1$, $k(x) = 0$ for

$|x| > 1$. However, for the general case of $\varphi \in L^{\infty}$, ordinary convergence is inappropriate. Fortunately all the other conventional methods of summing trigonometric integrals are suitable; these are accounted for in the rather extensive class of kernels described in this paper.

COR. 05:058

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

TRANSLATION KERNELS. SOME SOLVED AND UNSOLVED PROBLEMS, by M. Kac. July 1956, 9p. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume I; AF 18(603)12) [AF 18(600)685] Unclassified

The present status is reviewed of a complex of problems centering around the general question of the behavior of eigenvalues of integral equations of the form

$$\int_{-a}^{a} \rho(x-y)\varphi(y)dy = \lambda\varphi(x)$$

in the limit $a \to \infty$. Analogous questions for the Toeplitz matrices, i.e. matrices of the form

$$((a_{i-j})) \quad i, j = 0, 1, 2, \ldots, n$$

are also discussed.

COR. 05:059

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

TWO PROBLEMS IN HARMONIC ANALYSIS AND PROBABILITY, by G. A. Hunt. July 1956, 3p. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume I; AF 18(603)12) [AF 18(600)685] Unclassified

Cramer's theorem, that each of two probability distributions must be Gaussian if their convolution is Gaussian, makes sense on any homogeneous space which is the quotient of a Lie group by a compact subgroup. The analogue of Cramer's theorem, which holds true in the hyperbolic plane, is shown not true on compact spaces, specifically for the circle group R/Z. The second problem concerns stochastic processes rather than distribution functions, and their representation in terms of a random additive function of intervals. Questions concerning the independence of this function for increments of the interval are discussed.

COR. 06:001

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

SYMPOSIUM ON HARMONIC ANALYSIS AND RELATED INTEGRAL TRANSFORMS, Volume I, July 23-27, 1956, 1v. incl. refs. (Final tech. rept.) (AF 18(603)12) Unclassified

Texts are presented of the following papers given at either the formal or informal sessions of the symposium: (1) Analysis In Some Convolution Algebras, by A. Beurling; (2) Convolutions Over A Finite Interval, by J. Blackman and H. Pollard; (3) Harmonic Analysis And Entire Functions, by R. P. Boas, Jr.; (4) Local Operators on Fourier Transforms, by L. deBranges; (5) Algebras Of Linear Transformations, by R. C. Buck; (6) Ideals In Abelian Group Algebras, by A. P. Calderón; (7) Some Properties Of The Matrix (a_{i-j}), by A. Edrei; (8) Potential Theory And Spectral Analysis, by C. S. Herz; (9) The Asymmetry Of Certain Measure Algebras, by E. Hewitt; (10) Harmonic Analysis And Ultraspherical Polynomials, by I. I. Hirschman, Jr.; (11) Two Problems In Harmonic Analysis And Probability, by G. A. Hunt; and (12) Translation Kernels, by M. Kac.

COR. 06:002

Cornell U. Dept. of Mathematics, Ithaca, N. Y.

SYMPOSIUM ON HARMONIC ANALYSIS AND RELATED INTEGRAL TRANSFORMS, Volume II, July 23-27, 1956, 1v. incl. refs. (Final tech. rept.) (AF 18(603)-12) Unclassified

This report contains the texts of the following papers presented at either the formal or informal sessions of the symposium: (1) Fourier Transforms Of Generalized Functions, by J. Korevaar; (2) Variations On An Air, by J. E. Littlewood; (3) On The Point Spectrum Of A Bounded Function, by L. H. Loomis; (4) Analytic Functions And Harmonic Analysis, by S. Mandelbrojt; (5) Fourier Analysis In Number Theory, by H. Rademacher; (6) The Role Of Perfect Sets In Harmonic Analysis, by W. Rudin; (7) Entire Functions With Real Zeros, by A. C. Schaeffer; and (8) Fourier Series And Power Series In Several Variables, by A. Zygmund.

COR. 07:001

Cornell U. [Dept. of Physics] Ithaca, N. Y.

X-RAY SPECTROSCOPY OF THE SOLID STATE: POTASSIUM CHLORIDE, by L. G. Parratt and E. L. Jossem. [1955] [11] p. incl. diagrs. refs. (AFOSR-TN-54 650) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)300]) Unclassified

Published in Phys. Rev., v. 97: 916-926, Feb. 15, 1955.

The experimental K spectral regions of potassium and chlorine in crystalline KCl have a much more complex array of structure, both in emission and in absorption, than can be explained by the conventional energy level diagram for the solid state. The pertinent spectral region is that which involves the valence and conduction

bands of the solid. The difficulties seem to arise from a theoretical preoccupation with one-electron transitions. Consideration of the various probable electron configurations of the many-electron solid system shows several additional initial (1s vacancy) and final (outer vacancy) states. The charge density in the outer electron bands suddenly confronted with the problem of screening the excess positive charge attending a 1s vacancy (or any inner vacancy), redistributes itself, distorting the bands and establishing one or more local discrete levels below each band. With the most probable filled discrete level below the 3p band, the narrow intense $K\beta_1$ line is explained but it is necessary to account somehow for the very narrow final state (3p vacancy). An obvious conclusion is that the 3p valence band itself is therefore very narrow in energy, only 0.33 ev wide. However, if it is indeed wider than this, as is commonly believed in the lore of solid state physics, the $K\beta_1$ emission must be restricted by some (unknown) mechanism to a small energy region within the band. In this event, x-ray emission involving the entire broad 3p band may be part of the observed faint emission on the high-energy side of the $K\beta_1$ line, and, if so the restricted energy position just mentioned must be at the bottom of the band. Also a consequence of the 1s vacancy are several normally empty discrete levels below and in the conduction band of KCl. With these levels, the narrow intense K absorption lines are explained. The discussion given is primarily experimental and phenomenological. The qualitative agreements are prehaps compatible with either a narrow or a wide 3p band for both potassium and chlorine KCl, but show a preference for the wide 3p band. (Contractor's abstract)

COR. 07:002

Cornell U. [Dept. of Physics] Ithaca, N. Y.

ANOMALOUS DISPERSION AND SCATTERING OF X-RAYS, by L. G. Parratt and C. F. Hempstead. [1954] [8]p. incl. diagrs. tables, refs. [AF 18(600)-300] Unclassified

Published in Phys. Rev., v. 94: 1593-1600, June 15, 1954.

The theoretical expressions for the anomalous dispersion of x rays have been integrated for any positive value of p_q in a $C_q\lambda^{p_q}$ term in the distribution of "dispersion" oscillators for the q shell of electrons. The distribution may be written generally as the sum of n terms of the form $C_{qn}\lambda^{p_{qn}}$ or, as is commonly done, as a single term. Damping has been retained, its effect evaluated and shown to be negligible except for λ extremely close to the wavelength of an absorption discontinuity. With damping neglected, universal dispersion curves are presented. If p_q and g_q (the oscillator strength) are known, the anomalous part of the refractive index or of the atomic scattering factor can be readily deduced from the universal curves. Comparison of the more exact theoretical values with experiment shows less satisfactory agreement than before.

COR. 07:003

Cornell U. Dept. of Physics, Ithaca, N. Y.

X-RAY SPECTROSCOPY OF VALENCE AND CONDUCTION BANDS OF POTASSIUM CHLORIDE, by L. G. Parratt and E. L. Jossem. [1954] [4]p. incl. diagrs. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)300]) Unclassified

Published in Physica, v. 20: 1134-1137, Nov. 1954.

A discussion is presented of impurity states, energy gaps, and density of states in crystalline KCl as revealed by an emission and absorption study of the K-spectra.

COR. 07:004

Cornell U. [Dept. of Physics] Ithaca, N. Y.

SOLID SURFACE STUDIES BY TOTAL REFLECTION OF X-RAYS (Abstract), by L. G. Parratt. Apr. 29, 1954 [1]p. [AF 18(600)300] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-May 1, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 29, Apr. 29, 1954.

Published in Phys. Rev., v. 95: 617, July 15, 1954.

Analysis of the shape of the curve of reflected x-ray intensity vs glancing angle in the region of total reflection provides a method of studying certain structural properties of the mirror surface about 10 to a few hundred Angstroms deep. The theory, extended to treat any (small) number of stratified homogeneous media, is used as a basis of comparison. Curves for evaporated copper on glass are studied as an example. These curves probably can be explained by assuming that the copper (exposed to atmospheric air at room temperature) has completely oxidized about 150A deep. If oxidation is less than about 100A deep, there probably exists an electron density minimum just below an internal oxide seal. This seal, perhaps 50A below the nominal surface plane, arrests further oxidation of more deeply-embedded loose packed copper crystallites. All measurements to date have been carried out under laboratory atmospheric conditions which do not allow satisfactory separation or control of the physical and chemical variables involved. Under better control, the method seems promising. (Contractor's abstract)

COR. 07:005

Cornell U. Dept. of Physics Ithaca, N. Y.

K SPECTRA OF POTASSIUM CHLORIDE, by L. G. Parratt and E. L. Jossem. June 20, 1954 [37]p. incl. diagrs. refs. (Technical rept. no. 1) (N6ori-9101 and AF 18(600)300) AD 36670 Unclassified

The conventional energy-level diagram for the solid state of crystalline KCl is considered inadequate to explain the more complex structure of the K β spectral regions of K and Cl in emission and absorption. The difficulties apparently stem from an incomplete consideration of electron configuration with emphasis on 1-electron transitions between states described. Further initial and final states are found when the various probable electron configurations of the many-electron solid system are considered. Several different energies are presented for the K state (1s vacancy), only one of which is significantly involved in emission but all of which are necessary to explain absorption. The difference in the K configurations is in the distribution of charge density presented by the outer electrons near the valence band in KCl. The charge density in the outer bands redistributes itself, distorting the bands, and, in KCl, establishes one or more local discrete levels below each band. The narrow intense β_1 line and the narrow intense absorption lines are explained.

COR. 07:006

Cornell U. [Dept. of Physics] Ithaca, N. Y.

ELECTRON ENERGY LEVELS IN IONIC CRYSTALS (Absiract), by E. L. Jossem and L. G. Parratt. June 29, 1954 [1]p. [AF 18(600)300]
Unclassified

Presented at meeting of the Amer. Phys. Soc., Minneapolis, Minn., June 28-30, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 23, June 28, 1954.

Published in Phys. Rev., v. 96: 834, Nov. 1, 1954.

Information on the electron energy levels in solids is provided by the energy positions, intensities, and shapes of component lines in x-ray emission and absorption spectra. The x-ray Kβ emission spectra of chlorine in the alkali chlorides and in cuprous chloride have been recorded with a curved crystal focusing vacuum spectrometer using a proportional counter detector. These lines involve transitions from levels in or near the valence band to an inner (K shell) vacancy. The principal features of the spectra are: (a) the chlorine $K\beta_1$ line, commonly ascribed to the transition valence-band-to-K-vacancy, is uniformly too narrow to permit such assignment; (b) the intensity of the chlorine β_x and β_5 lines relative to the β_1 line varies with the compound. Interpretation of these features in terms of the band structure of the crystal and the sharp "impurity-type" levels introduced by the inner shell vacancy is discussed. (Contractor's abstract)

COR. 07:007

Cornell U. [Dept. of Physics] Ithaca, N. Y.

UNIVERSAL CURVES FOR DISPERSION AND SCATTERING OF X RAYS (Abstract), by L. G. Parratt and C. F. Hempstead. June 28, 1954 [1 p. [AF 18(600)300
Unclassified

Presented at meeting of the Amer. Phys. Soc., Minneapolis, Minn.. June 28-30, 1954.

Published in Phys. Rev., v. 96: 820, Nov. 1, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 9, June 28, 1954.

The theoretical expression for the dispersion (or atomic scattering factor) of x-rays has been integrated for any value of p_q in a λ^{Pq} term in the distribution of dispersion-oscillators for each q shell of electrons. The dispersion-oscillator distribution may be written generally as the sum of n terms $\Sigma_n C_{qn}\lambda^{Pqn}$ or, as is commonly done, as a single $C_q\lambda^{Pq}$ term. Damping has been retained, its effect evaluated and shown to be negligible except for λ extremely close to the wavelength of an absorption discontinuity. Universal dispersion curves (with damping neglected) are presented. From the universal curves, if p_q and g_q (the oscillator strength) are known, the refractive index or the atomic scattering factor for each q shell of any atom, and hence the sum of all q shells, can be readily and very conveniently deduced. Comparison of these more exact theoretical values with experiment shows less satisfactory agreement than before. (Contractor's abstract)

COR. 07:008

Cornell U. [Dept. of Physics] Ithaca, N. Y.

LOCALIZED ENERGY STATES IN CRYSTALLINE ALKALI CHLORIDES (Abstract), by C. F. Hempstead and L. G. Parratt. [June 29, 1955] [1]p. ([AF]-OSR-TN-55-139) [AF 18(600)300] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98: 1170, Apr. 15, 1955.

The absorption fine structure in the vicinity of the K-edge of chlorine in alkali chlorides has been carefully recorded. Correction by a new method has been made for the resolving power of the x-ray spectrometer. (The magnitude of the correction depends upon the absorber thickness.) The corrected structure is more complex than has been heretofore realized. The inner electron vacancy that results when the K-electron is photoejected causes a significant perturbation of the normal periodic potential in the neighborhood of the excited ion containing the vacancy. This ion of atomic number Z appears to a first approximation as an impurity atom of Z + 1 in the solid. Consequent localized exciton type energy states are invoked to explain the observed spectra. For KCl, the lowest absorption "line" (farthest below the conduction continuum) is at least a doublet with a separation of about 0.8 ev and having a doublet peak intensity ratio of about 1 to 3.3. A "reasonable" resolution of the observed contour into

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component absorption lines, each of Lorentzian shape, indicates in a range of about 6 ev at least six components for KCl and six for NaCl. The pattern of component lines or exciton-type states is markedly different for different chlorides. (Contractor's abstract)

COR. 07:009

Cornell U. [Dept. of Physics] Ithaca, N. Y.

ENERGY LEVELS IN METALLIC POTASSIUM (Abstract), by E. L. Jossem and L. G. Parratt. [1955] [1]p. [AF 18(600)300] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98: 1151, May 15, 1955.

Information about electron energy levels in metallic potassium has been obtained from the x-ray K emission and absorption spectra. The emission lines were studied with a bent crystal focusing vacuum spectrometer with a proportional counter detection system. Of the several lines in this region, the β_1 and the β_5 are of principal present interest. The β_1 line, the strongest in the region, represents the transition to the 1s level of an electron associated with the 3p band. This line is observed to have the same energy position, width and shape in metallic potassium as in chemical compounds of potassium (e. g., KCl). It is tentatively concluded that the 3p band in potassium, some 18.4 ev below the Fermi surface in the metal, is narrow (about 0. 22 ev wide) and is but little affected by the nature of the surrounding atoms. The β_5 line, a very weak line which appears just at the long wavelength side of the K-absorption edge, presumably involves the transition of an electron in the conduction band to the 1s level. However, since the conduction band is nominally 4s, selection rules require the β_5 represent that fraction of the conduction electrons having p-type symmetry. Discussion will be given of the width and shape of the β_5 line.

COR. 07:0t0

Cornell U. [Dept. of Physics] Ithaca, N. Y.

STRUCTURE OF THIN EVAPORATED COPPER FILMS BY TOTAL REFLECTION OF X-RAYS (Abstract), by L. G. Parratt. [t955] [1]p. [AF 18(600)300] Unclassified

Presented at meeting of the Amer. Phys. Soc., Toronto (Canada), June 2t-23, t955.

Published in Phys. Rev., v. 99: 1635, Sept. t, t955.

The x-ray total reflection method of studying certain structural properties of the surfaces of solids has been applied to thin evaporated copper films deposited on a glass substrate at room temperature. Films of average thickness about 25 to t000 Å have been studied with the x-ray wavelength 1.392 Å. The reflection curves disagree significantly in several respects with the theoretical curves based on a film model of homogeneous lamina. A better model may be one in which the copper (with some oxide) is present in aggregates of such shape that a very low average dispersion density exists close to the glass substrate. As the thickness of the film increases, the copper aggregates may "bridge over" at some 40 Å or so above the substrate to form a more or less continuous but porous film. Such a model features a "reflection trap." This work is exploratory in the sense that no satisfactory attempt was made to control the physical and chemical variables involved in the preparation and treatment of the surfaces. But, under controlled conditions, the method promises interesting information about surface structure. (Contractor's abstract)

COR. 07:011

Cornell U. [Dept. of Physics] Ithaca, N. Y.

"THICKNESS-EFFECT" IN OBSERVED STRUCTURE NEAR ABSORPTION EDGES, by L. G. Parratt, C. T. Hempstead, and E. J. Jossem. July 15, 1956, 17p. incl. diagrs. tables. (Technical rept. no. 5) [AFOSR-TN-56-33i] (AF 18(600)300) AD 95207 Unclassified

Also published in Phys. Rev., v. 105: 1228-1232, Feb. 15, 1957.

The details of an observed absorption spectrum are shown to depend upon the thickness of the absorber. This effect is present, at least in principle, regardless of the type of radiation involved. It is discussed here specifically for x-rays, and specifically for the neighborhood of an absorption edge. Measurements of widths and of relative intensities of the component structure are the most sensitively involved, but wavelengths are also slightly affected. The explanation lies in the role of the effective spectral window of the spectrometer. The effect may be serious when the "tails" of the window are extensive, as is inevitably the case with 2-crystal x-ray spectrometers. Features of the extent and shape of the spectral window for the (t, + t) position of the instrument used in this work are roughly determined from the thickness effect. (Contractor's abstract)

COR. 07:0t2

Cornell U. Dept. of Physics, Ithaca, N. Y.

X-RAY EXCITED STATES (EXCITONS) AND WIDTH OF VALENCE BAND IN KCl, by L. G. Parratt and E. t.. Jossem. July 28, t956, t3p. incl. diagr. (Technical rept. no. 6) (AFOSR-TN-56-337) (AF t8(600)300) AD 952t3 Unclassified

Also published in Jour. Phys. Chem. Solids, v. 2: 67-7t, Mar. t957.

A combination of (a) Parratt and Jossem's experimental

x-ray emission and absorption curves for K and Cl in KCl (Phys. Rev., v. 97: 916, 1955) and (b) Muto and Okuno's recent theoretical calculations (Jour. Phys. Soc. Japan, v. 11: 633, 1956) on "exciton" structure (1-electron approximation) provides semiempirical values of the effective dielectric constant and of the effective mass for the K 1s first excited state in KCl. (The term "1s first excited state" is proposed to replace the term "x-ray ground-state 'exciton'"). A "reasonable" small increase in this value of the dielectric constant gives a tentative value for the Cl 1s first excited state. Then, resorting again to the combination of experiment and theory, it can be concluded that the Cl^- 3p valence band in KCl is much narrower than the 4.2 ev base width previously deduced, being perhaps 2 ev wide; however, it is further proposed that, since the series limit of x-ray excited states may well be above the bottom of the continuum, the base width of the valence band may be of the order of 1 ev and the full width at half-maximum of the density-of-states curve of this band may be about 0.3 ev. (Contractor's abstract)

COR. 07:013

Cornell U. Dept. of Physics, Ithaca, N. Y.

CORRECTION OF COMPLEX SPECTRA FOR INSTRUMENTAL RESOLVING POWER. PART I. MODEL WINDOWS, by L. G. Parratt and C. F. Hempstead. Aug. 20, 1956, 18p. incl. diagrs. tables. (Technical rept. no. 7) (AFOSR-TN-56-388) (AF 18(600)300) AD 96046 Unclassified

Presented at annual meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 2, 1957.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 2: 54-55, Jan. 30, 1957.

A complex spectrum, after correction for the finite resolving power of the spectrometer (t.e., for the "spectral window"), always shows greater contrast than is directly observed. The clearer view usually justifies considerable effort in an attempt to correct the direct measurements. The correction procedure herein described is relatively simple and is applicable to any observed spectrum, however complex, but is limited to model window shapes. (Part II will treat windows of more general shape). The procedure involves an arbitrary analysis of the observed spectrum into virtual components each having a shape given by a particular functional form. This functional form depends upon the shape of the spectral window: we seek an easy mathematical "unfolding" process. An easy process is one for which there exists a simple explicit expression for the parameters of the virtual components of the corrected (or true) spectrum in terms of those of the virtual components of the observed spectrum. Then, with the parameters obtained from the observed spectrum, the corrected curve is readily synthesized. Two window models, viz., a Lorentzian (classical dispersion function) and a Gaussian (normal distribution function) are discussed in detail with an example procedure given for each case. (Contractor's abstract)

COR. 07:014

Cornell U. Dept. of Physics, Ithaca, N. Y.

BRIEF REVIEW OF ELECTRONIC BAND STRUCTURE OF SOLIDS BY THE METHOD OF EXPERIMENTAL X-RAY SPECTROSCOPY, by L. G. Parratt. July 10, 1957, 43p. incl. diagrs. refs. (Technical rept. no. 8) (AFOSR-TN-56-562) (AF 18(600)300) AD 110382 Unclassifted

A review is presented of x-ray spectroscopic techniques of investigating the band structure of solids. The greatest emphasis is placed on problems of interpretation. Consideration is given to the advantages and disadvantages of the method, the energy level diagram, and experimental curves. The 2 energy regions which naturally occur require high resolving power. The x-ray wavelengths range from about 0.5 A (~25,000 ev) to about 800 A (~15 ev). Typical transitions are illustrated in terms of energy level diagrams.

COR. 07:015

Cornell U. Dept. of Physics, Ithaca, N. Y.

ELECTRONIC BAND STRUCTURE OF SOLIDS BY THE METHOD OF EXPERIMENTAL X-RAY SPECTROSCOPY, by L. G. Parratt. July 10, 1957 [117]p. incl. diagrs. tables, refs. (AFOSR-TN-56-562a) (AF 18-(600)300) AD 207519 Unclassifted

Also published in Rev. Modern Phys., v. 31: 616-645, July 1959.

X-ray spectra and interpretational problems provide information about the general electronic structure of atoms. Mention is made of the more general aspects of this method of atomic investigation. Some experimental factors that must be appreciated, before interpretation should be undertaken, are emphasized and certain essential features of the x-ray energy level diagram that have been inadequately treated are pointed out. The subject is reviewed and further references are recommended.

COR. 07:016

Cornell U. [Dept. of Physics] Ithaca, N. Y.

[NON-UNIFORM DENSITY OF THIN FILMS OF COPPER, OBTAINED BY THE TOTAL REFLECTION OF X-RAYS] Densité non uniforme de films minces de cuivre, obtenus par évaporation, d'après la réflexion totale des rayons X, by L. G. Parratt. [1956] [8]p. incl. diagrs. tables. [AF 18(600)300 and AF 18(600)674] Unclassified

Published in Jour. Chim. Phys., v. 53: 597-604, July-Aug. 1956.

Thin copper films, deposited on glass by evaporation were studied by the total reflection of 1.39 Å x-rays. The films in the range of 25 to 1000 Å thick, and

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deposited at room temperature gave reflection curves that deviated in several respects from the theoretical curves based on a homogeneous film. The structure of these films is better represented by a model in which the Cu is present as aggregates, with a low average dispersion deposited near the glass support. As the film thickness increases, "bridge-overs" are formed. Such a model can be considered as a "reflection trap." (C.A., 1957:1681a)

COR. 08:001

Cornell U. Dept. of Physics, Ithaca, N. Y.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE ATOMIC PHENOMENA OCCURRING ON AND NEAR THE SURFACES OF SOLIDS, by L. G. Parratt. [Mar. 15, 1954] 1v. incl. diagrs. tables, refs. (Technical rept. no. 1) ([AF]OSR-TR-54-13) (AF 18(600)674) AD 29249 Unclassified

This report consists of two parts and is abstracted under TN-55-97, Part I and TN-55-102, Part II (see item nos. COR. 08:002 and COR. 08:003)

COR. 08:002

Cornell U. Dept. of Physics, Ithaca, N. Y.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE ATOMIC PHENOMENA OCCURRING ON AND NEAR THE SURFACES OF SOLIDS. PART I. SURFACE STUDIES OF SOLIDS BY TOTAL REFLECTION OF X-RAYS, by L. G. Parratt. [Mar. 15, 1954] 35p. incl. diagrs. tables, refs. (Part I of its Technical rept. no. 1; AFOSR-TR-54-13; AD 29249) [AFOSR-TN-55-97] (AF 18(600)674) AD 29249(a) Unclassified

Also published in Phys. Rev., v. 95: 359-369, July 15, 1954.

Analysis of the shape of the curve of reflected x-ray intensity vs glancing angle in the region of total reflection provides a new method of studying certain structural properties of the mirror surface about 10 to several 100 Å deep. Dispersion theory, extended to treat any (small) number of stratified homogeneous media, is used as a basis of interpretation. Curves for evaporated copper on glass are studied as an example. These curves may be explained by assuming that the copper (exposed to atmospheric air at room temperature) has completely oxidized about 150 Å deep. If oxidation is less deep, there probably exists an electron density minimum, perhaps just below an internal oxide seal. This seal, less than about 50 Å, perhaps 25 Å, below the nominal surface plane, would arrest further oxidation of more deeply-lying loose-packed copper crystallites. All measurements have been carried out under laboratory atmospheric conditions which do not allow satisfactory separation or control of the physical and chemical variables involved in the surface peculiarities. The method, under more controlled conditions of preparation and treatment of the surface, promises to be useful. (Contractor's abstract)

COR. 08:003

Cornell U. Dept. of Physics, Ithaca, N. Y.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE ATOMIC PHENOMENA OCCURRING ON AND NEAR THE SURFACES OF SOLIDS. PART II. STRUCTURE OF THIN EVAPORATED COPPER FILMS BY TOTAL REFLECTION OF X-RAYS, by L. G. Parratt. [Mar. 15, 1954] [28]p. incl. diagrs. tables, refs. (Part II of its Technical rept. no. 1; AFOSR-TR-54-13; AD 29249) [AFOSR-TN-55-102] (AF 18(600)674) AD 29249(b) Unclassified

Abstract published in Phys. Rev., v. 99: 1635, Sept. 1, 1955.

The x-ray total reflection method of studying certain structural properties of the surfaces of solids, described in Part I, has been applied to thin evaporated copper films deposited on a glass substrate at room temperature. Films of average thickness about 25 to 1,000 Å have been studied with the x-ray wavelength 1.392 Å. The reflection curves disagree significantly in several respects with the theoretical curves based on a film model of homogeneous lamina. A better model for these films may be one in which the copper (with some oxide) is present in aggregates of such shape that a very low average dispersion density exists close to the glass substrate. As the thickness of the film increases, the copper aggregates may "bridge over" at some 40 Å or so above the substrate to form a more or less continuous but porous film. Such a model features a reflection trap. (Contractor's abstract)

COR. 08:004

Cornell U. Dept. of Physics, Ithaca, N. Y.

THE USE OF THE FIELD EMISSION MICROSCOPE FOR THE INVESTIGATION OF SURFACE CONDITIONS ON AN ALLOY OF MOLYBDENUM AND ZIRCONIUM, by L. A. D'Asaro. Sept. 1, 1955, 106p. incl. illus. diagrs. tables, refs. (Technical rept. no. 3) ([AF]OSR-TN-55-321) (AF 18(600)674) AD 75274 Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago U., Ill., Nov. 25-26, 1955.

Abstract published in Phys. Rev., v. 100: 1258, Nov. 1, 1955.

The distribution of Zr on the surface of 1% Zr-99% Mo and 5% Zr-95% Mo alloys was obtained. Photographs show the patterns which were produced by the field-emission microscope for variations of temperature, heating time, potential, emission current, and total pressure. The components of the alloy were located by relating the current density of the field-emitted

electrons from various positions on tis surface to the surface work function and the applied field by means of the Fowler-Nordheim equation. Tbe rate of surface change increases with the temperature; at a sufficiently high temperature, the surface conditions change significantly in a few min. A persistent increase in the diffusion rate was noted when the 1% alloy emitter was flashed (heated to 2400°K). Parallelogram-shaped spots (quadruplets) with bright corners were observed on the 100 plane during the early stages of diffusion onto the surface of the 1% alloy at the lowest temperature (about 900°K), and at just below the cleaning temperature. A plot of the Fowler-Nordheim equation was matched to one of the emission current vs potential. The field, the work function, and the emitting area of the field were obtained for the surface which produced the quadruplet patterns. The work function (φ) of the quadruplet surface was 2.94 ev. A φ of 2.95 ev for Zr on Mo was obtained by multiplying the φ which was obtained by Dushman (Phys. Rev., v. 21: 623, 1923) for a monolayer of Zr on W by the ratio of the work functions of Mo and W. The 1% alloy standard clean surface (1 min at 2000°K) produced a pattern similar to that of pure Mo on W. (Contractor's abstract)

COR. 08:005

Cornell U. Dept. of Physics, Ithaca, N. Y.

A HIGH RESOLUTION ELECTRON DIFFRACTION CAMERA FOR THE STUDY OF SURFACES IN AN ULTRA HIGH VACUUM, by B. M. Siegel. Dec. 1, 1955 [47]p. incl. illus. diagrs. table, refs. (Technical rept. no. 4) ([AF]OSR-TN-55-480) (AF 18(600)674) AD 83068 Unclassified

A special electron diffraction camera has been designed and built which will make it possible for the first time to examine "clean" surfaces in an ultra-high vacuum by high resolution electron diffraction. In this camera, the electron beam and specimen are contained in a glass vacuum system which is baked-out and evacuated to a pressure of the order of 1×10^{-10} mm Hg. High resolution electron optics consisting of magnetic lenses are assembled around the outside of the glass column. The diffraction pattern comes to focus on a fluorescent screen inside the vacuum system, and is recorded by photographing the pattern. It is to be expected that this new instrument will enable significant advances in the study to be made of surface structure. The apparatus also makes it possible to work with extremely well-controlled atmospheres of different gases in the study of surface adsorption and surface reactions. Plans are also outlined for the extension of this apparatus to micro-analysis with an electron probe, a tool that should open up quantitative investigation of the surface constituents. (Contractor's abstract in part)

COR. 08:006

Cornell U. Dept. of Physics, Ithaca, N. Y.

ION SOURCE AND ANALYZER STUDIES, by R. C. Bradley. June 1, 1955 [23]p. incl. illus. diagrs. refs. (Technical rept. no. 2) ([AF]OSR-TR-55-17) (AF 18(600)674) AD 74834 Unclassifted

A workable method was developed for generating a positive-ion beam of a known species which can be focused on a solid surface in a controllable manner with sufficient intensity to cause sputtering. Pilot-model ion sources were constructed from 0.010-in.-thick molybdenum or Nichrome V sheets by the use of designs described by Nier (Rev. Scient. Instruments, v. 18: 398, 1947) Heil (Zeitschr. Physik., v. 120: 212, 1943), and Finkelstein and Smith (Rev. Scient. Instruments, v. 11: 94, 1940). These are mounted in Pyrex tubes which were evacuated to 10^{-7} mm of Hg or better. Argon was introduced until the standard operating pressure (10^{-4} mm of Hg) was reached. The currents to the ion collectros were observed as a function of the voltage applied to the various electrodes. An axial magnetic field strength of about 150 gauss was used. The Finkelstein and Heil sources were about 5 times as efficient (in terms of the number of ions reaching the collector for each electron emitted from the filament) as the Nier source. The Heil source with no collimating slits for the electron beam was chosen to generate the beam. The ion currents to the collector at the standard operating pressure were 1 to 2 orders of magnitude better in an appearance-potential selector than in an RF mass spectrometer like that developed by Bennett (Jour. Appl. Phys., v. 21: 1943, 1950). Best results are obtained when the target is oriented at 45° to the primary ion beam and to the analyzing electron beam. (ASTIA abstract)

COR. 09:001

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

STRENGTH OF REFLECTED SHOCK IN MACH REFLECTIONS, by H. S. Tan. [Sept. 10, 1951] 7p. incl. diagr. (WADC rept. no. TR-52-163) [AF 33-(038)21406] Unclassified

Published in Jour. Aeronaut. Sciences, v. 18: 768-769, Nov. 1951.

When a propagating plane shock is diffracted by a corner, Mach reflection is induced. The reflected front is an acoustic wave according to first-order theory; however, results of first-order theory can be applied to determine more accurately the strength of this wave. It will be demonstrated that this wave is, in fact, a shock of second-order strength. The case of extremely weak incident shock has been studied by Bargmann On Nearly Glancing Reflection of Shocks, National Defence Research Council, Applied Mathematics Panel Rept. no. 108.2R, 1945). The present study, however, is not limited in incident shock strength. Lighthill's first-order pressure solution (The Diffraction of Blast, I, Proc. Roy. Soc., v. 198A: 454-470, 1949) and his technique (The Shock Strength in Supersonic Conical Fields, Phil. Mag., v. 41: 1202, Dec. 1949) for finding the shock strength have been utilized. The latter is essentially a process of pushing away the

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apparent singularity appearing in the differential equation of motion resulting from its linearization.

COR. 09:002

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

SHOCK REFLECTION FROM EDGES AND FROM SLOTTED WALLS, by T.-F. Sun. Dec. 1951, 64p. incl. diagrs. [WADC rept. no. TR-352-164] (AF 33(038)21406) Unclassified

The flow characteristics behind weak stationary shock waves reflected from various edges lying in the mainstream are determined according to linearized theory. Five different types of edges are considered, made up of various combinations of solid- and free-plane surfaces. An assumption regarding the singularity of one of the perturbation velocity is required in order to render the solutions unique. By superposition of such basic "edge" solutions, the flow behind a shock wave reflected from a wall with a slot (i.e., a strip of free-surface between panels of solid wall) and from multiply-slotted walls are obtained. These solutions apply only to regions upstream of multiple interactions of the slot edges; however, these regions include the most interesting regions of flow in the case of reflection from slotted wind-tunnel walls, for example. The relation of the single-slot problem to the problem of a narrow rectangular supersonic wing is discussed. (Contractor's abstract)

COR. 09:003

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

INVESTIGATION OF THE SUPERSONIC-BIPLANE CONFIGURATION, by M. B. T. George. May 1952, iv. incl. diagrs. refs. (AF 33(038)21406) Unclassified

Supersonic biplanes were investigated aerodynamically and structurally with a view to establishing their possibilities as practical supersonic aircraft. The aerodynamic coefficients are determined from work by Tan and Sears on the finite supersonic biplane. The problem of "starting" the supersonic flow through the biplane gap was studied. It was found, on the basis of a one-dimensional theory, that the individual wings of the biplane must be very thin to permit "starting." Methods of overcoming the starting problems are proposed, and their relative merits are discussed. Supersonic biplanes are found to be feasible only for Mach numbers greater than 1.5 or less than 4.0. If operated below its design Mach number, the performance of a supersonic biplane does not suffer if the airfoils are thin; for operation above the design point the efficiency falls off. The biplane has twice the wing area of a supersonically-equivalent monoplane and should therefore have a considerably lower landing speed. Comparison of monoplane wings and the biplane arrangement is made for a simple supersonic airplane. The biplane structure is analyzed for bending moments and torsional deflection. (Extracted from rept.)

COR. 09:004

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

THIN WINGS IN CONICAL FLOW, by H. K. Cheng. June 1952 [139]p. incl. illus. tables, refs. (AF 33-(038)21406) AD 2303 Unclassified

The linearized theory of supersonic conical flow over thin planar wings is studied. Based on the theory of conical field introduced and developed by Busemann (NACA TM-1100) and others and by employing a new concept of source distribution, a method is established by which asymmetrical (lifting) conical-wing problems can be generally solved for an arbitrary conical surface. The method is applied to the cases where both edges, or at least one edge, of the wing is subsonic. (For both supersonic edges, the general solution is known to be simple.) Direct general expressions for the pressure in terms of the upwash prescribed on the wing are given, from which general expressions for the lift, drag, and rolling moments are obtained. The general solution is applied to new cases of conical wings. Among these are the rolling moment due to yaw for small dihedral for which a simple formula is derived, and the pressure distribution for a conical wing with the upwash on the wing given as a step function. Inverse problems, as well as quasi-conical problems, are treated in a consistent manner. (Contractor's abstract)

COR. 09:005

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON EXPANDING TWO-DIMENSION FLOW SOLUTION IN POWERS OF A THICKNESS PARAMETER, by H. S. Tan. Aug. 1952, 24p. incl. illus. (AF 33(038)-21406) AD 1922 Unclassified

The significance of a successive approximation corresponding to expanding a solution in powers of small ϵ is discussed; the flow field about a symmetric body, aligned with a free stream, is considered a function both of the coordinates (x, y) and of the thickness parameter ϵ. A solution, which is expanded so that

$$u(x, y; \epsilon) = \sum_{k=0}^{n} \epsilon^k u_k(x, y)$$

and which is finite and unique almost everywhere in a certain small region σ of the x, y plane, can always be achieved by straightforward successive approximation provided that u_k so determined behaves the same way, and that there exists a least upper bound σ so that σ_k [illegible] for all $k \leq n$. The singular region σ_1, in which u_1 blows [illegible] indicates either $u = \sqrt{}$ or the presence of

a stagnation point in the x, y plane. For certain special types of bodies (Joukowski airfoils) the singular region can be removed. This involves a device of straining the coordinates in such a way that when extended to the general case the problem is made extremely difficult, if not impossible. The body is replaced by a concentrated source near the center of curvature of the leading edge (entirely determined by ε and contour F(x) at the leading edge) and distributed sources and sinks from this point back to the trailing edge. For a very special type of body, where both the leading and trailing edges are cusps, no stagnation point appears in the exact solution, and the singular region is also absent in expansion solution. A double-wedge shaped body is shown to have an essentially (non removable) singular region at the leading edge; the extent of this region is extremely small. (ASTIA abstract)

COR. 09:006

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

COMPRESSIBLE LAMINAR BOUNDARY LAYER ON A HEAT-INSULATED BODY, by N. Rott. Sept. 5, 1952, 2p. incl. refs. (AF 33(038)21406) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 67-68, Jan. 1953.

This note indicates that, once the approximations stated are accepted, the remaining problem may be reduced exactly to an incompressible laminar boundary-layer problem by a slight extension of a transformation given previously by Illingworth and Stewartson.

COR. 09:007

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

AERODYNAMIC INTERFERENCE BETWEEN MOVING BLADE ROWS, by N. H. Kemp and W. R. Sears, Dec. 1, 1952, 67p. diagrs. refs. (AF 33(038)21406) U25871 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 585-598, Sept. 1953.

The concepts and results of the theory of single thin airfoils in nonuniform motion are applied to calculate the resulting nonsteady effects on such blades. Incompressible inviscid flow is considered. The representation of blade wheels as infinite cascades of 2-dimension airfoils is adopted. Attention is confined to a single stator row followed by a single moving-rotor row. As a first approximation, the assumption is made that, to calculate the nonsteady effects at any given blade, neglect of the nonsteady parts of the circulation of all other blades is permissible. For the rotor blades, the effects of their passage through the vortex wakes shed by stator blades are also included. With this approximation, the only results required of thin-airfoil theory can be obtained by generalization of an earlier study by Sears (Jour. Aeronaut. Sciences, v. 8, no. 3: 104, 1941) of an airfoil flying through a sinusoidal gust pattern. Expressions are derived for the unsteady components of lift and moment on stator and rotor blades and the rate of transfer of energy to the downstream-wake pattern. The fundamental harmonic component of variable lift varies in magnitude from 1% to 18% of the steady value, depending especially on the axial distance between rows and on the chordwise distribution of steady circulation of the blades of the other row. The second harmonic component of variable lift is considerably smaller than the fundamental. The contribution to rotor lift of the vortex wakes shed by stator blades, through which the rotro blades pass, is small compared to the effects induced by the stator blades themselves. The fluctuating part of the circulation, expressed as a ratio to the steady part, is several times as large for stator (upstream) blades as for rotor (downstream) blades, even though the corresponding ratios of lifts are about equal. The rate of transfer of energy into the vortex-wake pattern which results from the variable circulation is very small compared to the power required to turn the rotor. It is about 100 times as large for the stator (upstream) blades as for the rotor (downstream) blades. For the stator blades, this rate of energy transfer is very nearly the same as for an isolated airfoil experiencing the same fluctuating circulation. (TIP abstract)

COR. 09:008

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

SIMPLIFIED LAMINAR BOUNDARY-LAYER CALCULATIONS FOR BODIES OF REVOLUTION AND FOR YAWED WINGS, by N. Rott and L. F. Crabtree. [1952] 14p. incl. illus. diagrs. table, refs. [AF 33(038)21406] Unclassified

Published in Jour. Aeronaut. Sciences, v. 19: 553-565, Aug. 1952.

Since the introduction of momentum methods in boundary-layer calculations by von Kármán and Pohlhausen, many improvements have been proposed. An especially simple solution reduces the problem to a quadrature. Here, it is proposed to extend these methods to elementary three-dimensional cases, and to compressible laminar boundary-layer calculations. For comparison, the corresponding problems for the turbulent boundary layer are also discussed briefly.

COR. 09:009

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

A UNIQUE LAW FOR IDEAL INCOMPRESSIBLE FLOW WITH PRESERVED PATTERN OF FINITE SEPARATION, by H. S. Tan. [May 1953] 3p. incl. diagrs.

COR. 09:010 - COR. 09:013

(AF 33(038)21406) Unclassified

Published in Quart. Appl. Math., v. 12: 78-80, Apr. 1954.

The law is general in the sense that it applies to any body shape with well defined separation points, provided there exists a solution. The law is unique because no other fluid motion except this one will produce such a preserved flow pattern.

COR. 09:010

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

GENERALIZATIONS OF THE INVERSION FORMULA OF THIN AIRFOIL THEORY, by H. K. Cheng and N. Rott. June 1, 1953, 48p. refs. (AF 33(038)21406) AD 17740 Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 3: 357-382, May 1954.

A method is described which gives the general solution for the mixed-type boundary-value problem for the complex half plane for an arbitrary number of slots on the real axis, where alternately the real and the imaginary part of an analytic function are prescribed. The solution is found for cases where it may be interpreted as a complex velocity and also as any velocity derivative. Besides the general solution, a set of simple special solutions of practical importance is given. A further generalization is presented in which a linear combination of the real and imaginary part is prescribed on the boundary. Aerodynamic problems are discussed which lead to this mathematical formulation. (Contractor's abstract)

COR. 09:011

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

SOME EXTENSIONS OF SLENDER-WING THEORY, by M. C. Adams. June 2, 1953, 56p. illus. refs. (AF 33(038)21406) AD 18192 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 85-98, Feb. 1953.

The approximate theory of flow about slender lifting wings originated by Munk and Jones (NACA repts. no. 184 and 835) is reviewed. Ward's treatment of both lifting and nonlifting wings in supersonic flow is summarized. An analogous treatment is presented for subsonic flow. The slender wing theory is interpreted as a first term of an expansion in powers of a breadth parameter. A more accurate theory is developed by carrying additional terms for both subsonic and supersonic speeds. This theory of not-so-slender wings is applied to some practical problems. Accuracy is demonstrated by comparison with linearized supersonic-airfoil theory for the special case of a delta wing at incidence. The methods described can be extended to treat wing-body combinations and problems in nonstationary flight. (ASTIA abstract)

COR. 09:012

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

GENERATION OF VORTICES BEHIND A FLAT PLATE, by M. Hanin. July 1953, 54p. incl. illus. tables. (AF 33(038)21406) AD 18126 Unclassified

The formation of a vortex sheet behind two-dimensional flat plates is tentatively explained on the basis of potential flow theory. It is assumed that discrete vortices, formed by rolling-up vortex sheets, detach when a Kutta-Joukowski condition is violated. The average strength of the vortex sheets and the parameters describing the vortex sheet are estimated for the case of 90° incidence. This is accomplished with the help of the time-averaged Kutta-Joukowski condition, the vortex-sheet condition, the momentum transfer equation, and the modified vorticity transfer equation. The estimated values are compared with experimental ones, and a reasonable agreement is obtained.

COR. 09:013

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON THE APPROXIMATE SOLUTION OF THE LAMINAR BOUNDARY LAYER EQUATIONS, by I. Tani. July 1953, 38p. incl. illus. table, refs. (AF 33(038)21406) AD 17528 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 21: 487-504, July 1954.

A method was developed for solving approximately the equations of the laminar boundary layer. The velocity profile is assumed to be a member of a 1-parameter family of curves, the parameter being different from the usual Pohlhausen parameter. The Pohlhausen parameter is calculated by a simple quadrature formula, which is derived from the energy-integral relation. The relation between the profile parameter and Pohlhausen parameter is determined from the combination of both momentum-integral and energy-integral relations. The accuracy of the method was examined by comparing the results with those of exact solutions for the flow of incompressible fluid. Satisfactory agreement was obtained. The method of solution was then extended to the flow of compressible fluid along a heat-insulated wall, assuming the Prandtl number to be slightly different from unity and using the Sutherland formula for the variation of viscosity with temperature. The effect of compressibility on separation point is discussed as an example of the application. (Contractor's abstract)

COR. 09:014

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON LAMINAR BOUNDARY LAYER OVER A ROTATING BLADE, by H. S. Tan. July 20, 1953, 6p. (AF 33(038)-21406) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 780-781, Nov. 1953.

Equations are given for the boundary-layer flow about a cylindrical blade extending infinitely in y-direction and rotating about z-axis with angular speed Ω. Solutions are presented for the case of a rotating flat plate.

COR. 09:015

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

A THEORETICAL APPROACH TO THE PROBLEM OF STALL FLUTTER, by M. B. T. George. Aug. 15, 1953, 144p. incl. illus. table, refs. (AF 33(038)21406) AD 21115 Unclassified

The problem of stall flutter is studied theoretically by modifying classical flutter theory to account for the deviation of the lift curve from its theoretical value. A simple scheme is proposed, wherein the static lift curve is utilized as an empirical connection between the strength of the leading and trailing edge singularities. This connection is generalized to unsteady flow, first with no time lag, and later with a time lag between the singularity strengths. The theory is a consistent one within the limitations of inviscid-flow theory. It is not expected to account for the more complicated viscous effects encountered. The torsional damping is computed for any location of the rotation axis and reduced frequencies in the practical range. The theory predicts the regions in which a torsional oscillation would be excited for various initial angles of attack. The Wagner function is extended for lift curve slopes other than 2π. A comparison with experiments is made with the main purpose of showing what is needed for further progress in the stall flutter problem. Quantitative agreement can only be expected for lift curve slopes near to the potential-flow value, and this is verified within certain limits. (Contractor's abstract)

COR. 09:016

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

LIFT OF HIGHLY SWEPT WINGS, by H. Mirels. [1953] [2]p. incl. diagr. (AF 33(038)21406) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 210-211, Mar. 1953.

The lift properties of a highly-swept wing are summarized. Correction is made of an error invalidating an integral equation for a general solution for such lift (Robinson, A., Airfoil Theory for Swallow Tail Wings of Small Aspect Ratio. Aeronaut. Quart., v. 4, Aug. 1952). The corrected integral equation and some limiting solutions are included in the general procedure for calculating the aerodynamics of highly-swept wings.

COR. 09:017

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON ASYMMETRIC FLOW IN AN AXIAL FLOW COMPRESSOR STAGE, by W. R. Sears. [1953] 6p. incl. illus. diagrs. [AF 33(038)21406] Unclassified

Published in Jour. Appl. Mech., v. 20: 57-62, Mar. 1953.

It is suggested that flow patterns without axial symmetry may occur when an axial-compressor stage operates in a steady, uniform stream, provided that the blade airfoil characteristics exhibit certain peculiarities. For example, blades acting close to the stall may show nonlinearity, hysteresis, and/or time lags and these may cause asymmetric flow patterns. Conditions necessary for existence of such phenomena are analyzed by consideration of an annulus of infinitely many blades and very large radius. It is shown that rotational-flow effects due to vortex shedding by the blades must be considered. The induced velocities resulting from asymmetrical loadings are calculated. The final step of the calculation is to show that these induced effects may actually support the circulation distribution that produces them. This step is only partly taken in the present paper. It is shown that time lag in the development of lift of a blade may produce such "eigen-solutions." Detailed study of the results of nonlinearity in the blade characteristics is left for another investigation.

COR. 09:018

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

SLENDER-BODY THEORY-REVIEW AND EXTENSION, by M. C. Adams and W. R. Sears. [1953] [14]p. incl. illus. refs. [AF 33(038)21406] AD 40145 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 85-98, Feb. 1953.

The approximate theory of flow about slender bodies and wings originated by Munk and Jones is reviewed. It is presented here in a form that emphasizes the relation to the source-sink methods of von Kármán and others. The extension to noncircular bodies is made for subsonic flow, paralleling Ward's extension for supersonic flow. The calculation of pressures and

COR. 09:019 - COR. 09:022

forces and the extension of the theory to unsteady flows are reviewed, and some discrepanctes tn the published literature are explained. Finally, interpreting the Jones slender-wing result as the ftrst term of an expansion tn powers of a hreadth parameter (e. g., aspect ratio), it is shown how a more accuraie theory can be developed by carrying additional terms for both subsonic and supersonic speeds. This theory of not-so-slender wings ts applied to some practical wing problems, tncludtng direci problems of flow past given wings and problems of wing design for minimum drag. The accuracy of the new results is assessed by comparison with linearized supersonic-airfoil theory for the special case of a flat delta wing. (Coniractor's abstract)

COR. 09:019

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

A THEORY OF "ROTATING STALL" IN AXIAL-FLOW COMPRESSORS, by W. R. Sears. [1953] 35p. incl. illus. (AF 33(038)21406) AD 669 Unclassified

Previous investigation on the possibtility of asymmetric ftow patterns in an axial-flow compressor siage was based on the approximations of tncompressible flow, an infinite number of blades, and the representation of the blade annulus as a 2-dimensional actuator sheei. This work was extended by eliminating the restriction to small inlet swirl and by a reformulation that is tndependent of airfoil-theory concepts. The latter permits introduction of a broader class of blade-characteristic relations of which airfoil-type relations are only one case. Two independent cases are treated: (1) airfoil-type characteristics and (2) channel relations suggested by steady-flow iests of cascades. The firsi case leads to steadily rotating asymmetric solutions when the btades are stalled and exhibit phase lag; these solutions were of the same general type as found previously. The second case leads to steadily rotating asymmeiric solutions both without and with phase tag. The solutions were compared with experimental observations of rotating siall in a 3-stage compressor. tf it is assumed that the rotor was stalled, the experimental point lies within the scope of the airfoil results but somewhat outside the channel results. If the siators were stalled, the result ties within the scope of both families of curves. (ASTIA abstract)

COtt. 09:020

Cornelt U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

DtFFRtACTION OF SIMPLE WAVES WITtt VORTEX SEPAltATION, by N. Rott. Feb. 1953, 26p. illus. ([AF]OSIt-TN-54-42) (AF 33(038)21406) Unctassified

Shadowgrams of shock diffraction by wedges show the existence of a vortex region near the sharp edge, caused by flow separation. A theoretical treatment of this phenomenon ts presenied, using tnvisctd flow theory tn lineartzed approxtmation, and replactng the vortex sheet by a concentrated vortex. The results are found to te in good agreement with observations for zero wedge angle, while the patterns observed for blunt wedges differ from those predicted by the present theory. The reasons for the disagreement are discussed qualitatively. (Contractor's abstract)

COR. 09:021

Cornell U. Graduale School of Aeronautical Engineering, tthaca, N. Y.

THE SUPERSONIC CONICAL WING OF MINIMUM DRAG, by S. H. Tsien. June 1953, 113p. incl. diagrs. tables, refs. [AFOSR-TN-54-285] (AF 33(038)21406) AD 17420 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 805-818, Dec. 1955.

A theoretical tnvestigation was made of thin conical delta wings, with subsonic leading edges, cambered to give minimum pressure drag at supersonic speeds. The analysis was based on lineartzed theory; some consideration was given to the question of leading-edge flow separation. Since the optimum camber obtained by assuming full theoretical effect of suction forces may not be correct for a wing moving in a real fluid, 2 cases with different assumptions were covered: one with suction forces tncluded and the other with these forces omitted. For the former case, the drag coefficient of the optimum conical wing is almosi identical io that of a flat triangutar wing at the same lift coefficieni, excepi when the leading edge lies close behind the Mach cone of the apex. In the laiier case, subsiantial improvemeni over ihe flat delta wing can be achieved by suiiable conical camber; the drag can be reduced to a value whtch is again approximaiely the same as that of the flat wing with full leadtng-edge suction. Minimum drag coefficients and the corresponding optimum camber shapes and lift distributions were computed under various assumptions for wings with leading-edge slope equal to 0.5, 0.8, and 1.0. Flat-plate data are included for comparison. (ASTIA abstract)

COR. 09:022

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

CALCULATION OF LAMINAR BOUNDARY LAYER FLOW ON ROTATING BLADES, by M. E. Graham. Sept. 1954, iv. inct. diagrs. tables, refs. ([AF]OSR-TN-54-301) (AF 33(038)21406) AD 55328 Unclassified

Momentum methods are applied to the calculation of the laminar boundary-layer on a rotating btade (such as a helicopter or propeller blade). A simple and routine procedure is developed for finding the boundary-layer flow on an infinite cylindrical btade of arbitrary

cross-section. Solutions compuled by this method compare satisfactorily with the few known solutions for cylinders of special cross-sections. The boundary-layer flow is computed for two new examples: a cylindrical blade with a laminar-airfoil cross-section. For each of these blades the axis of rotation passes perpendicularly through the chordplane al a poinl midway between the leading and trailing edges of the blade. Graphs are presenled which show typical surface streamlines and spanwise velocity profiles. (Contractor's abstracl)

COR. 09:023

Cornell U. [Graduale School of Aeronautical Engineering] Ithaca, N. Y.

UNSTEADY VISCOUS FLOW IN THE VICINITY OF A STAGNATION POINT, by N. Roll. [1954] 18p. incl. diagrs. (AFOSR-TN-54-322) (AF 33(038)21406) AD 58337 Unclassified

Also publlshed in Quarl. Appl. Math., v. 13: 444-451, Jan. 1956.

Consideration is given the problem of two-dimensional steady viscous flow in the vicinity of a stagnation point at which the velocity in the main stream increases linearly with the distance. It is noticed that, for the steady flow al the edge of the boundary layer, if the plate performs harmonic or uniform motion parallel to itself, a solution for the unsteady problem can be found by superposition of two functions such that the full Navier-Stokes equations are satisfied. In the oscillating case, the shear at the wall is calculated al both low and high frequencies. It is noted that, in spite of the main stream, the character of the flow al very high frequencies is essentially that of the Stokes solution. (Math. Rev. abstract)

COR. 09:024

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

SECOND APPROXIMATION TO LIFTING CONICAL FLOW, by H. S. Tan and S. H. Tsien. June 1954, 1v. incl. diagrs. tables. ([AF]OSR-TN-54-323) (AF 33-(038)21406) AD 56188 Unclassified

Terms of the order of the square of the angle of attack are calculated for the case of a conical flat plate at small angle of attack on a supersonic stream. Lighthill's technique of "rendering uniformly valid" is employed to find the proper second order boundary condition at the Mach number. The results are put in a form which is believed to be suitable for numerical evaluation but no numerical calculations are carried out here. In the second order terms there appears singularities of nonintegrable type at the wing leading edges. (Contractor's abstract)

COR. 09:025

Cornell U. [Graduale School of Aeronautical Engineering] Ithaca, N. Y.

ROTATING STALL IN AXIAL COMPRESSORS, by W. R. Sears. Dec. 1954, 1v. incl. diagrs. refs. [AFOSR-TN-54-343] (AF 33(038)21406) Unclassified

Published in Zeitschr. Angew. Math. Phys., v. 6: 429-455, 1955.

Several attempts to explain theoretically the phenomenon of rotating stall are described. These are all based on the assumptions of a single row of closely spaced blades and the small perturbation type of flow. They are, therefore, probably inadequate to describe the conditions observed in multistage axial compressors. On the other hand, they provide at least a qualitative explanation of the phenomenon, and they are in agreement in their conclusion that steadily rotating patterns may occur in stalled, rigid blade rows. (Extracted from repl.)

COR. 09:026

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

BOUNDARY LAYERS IN THREE-DIMENSIONAL FLOW, by W. R. Sears. [1954] 6p. incl. diagrs. refs. [AF 33(038)21406] AD 59827 Unclassified

Also published in Appl. Mech. Rev, v. 7: 281-285, July 1954.

Extensions of Prandtl's laminar boundary-layer theory to 3-dimensional cases without axial symmetry have met with considerable success. They have led to interesting new concepts such as the independence principle, component separation, and boundary regions. Some cases of cylindrical and conical symmetry, as well as nearly 2-dimensional flows including boundary layers on rotating blades are reviewed. One problem of a boundary region, e.g., the flow in a corner has been worked out. It is concluded that analogous progress in problems involving 3-dimensional turbulent boundary layers must await more complete understanding of the basic principles governing such layers in either 2 or 3 dimensions.

COR. 09:027

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

THE LAMINAR BOUNDARY LAYER OF YAWED CYLINDERS WITH VARIABLE SECTION, by S. W. Liu. Oct. 1955 [70]p. incl. diagrs. tables, refs. ([AF]-OSR-TN-55-369) (AF 33(038)21406) AD 79115 Unclassified

COR. 09:028 - COR. 09:031

Starting from the results of laminar boundary-layer calculations for tnfinite yawed cylinders, extension ts made to obtain analogous results for yawed bodtes of slowly varying, similar cross sections. Both the external and internal flows are expanded in powers of the local taper, and are expressed tn terms of nondtmenstonal similartty vartables. Velocity components of successive orders of magnitude are computed by a procedure similar to that by which the tnftnite cylinder results have been obtained. The equations are solved for a symmetric body whose external flow ts of the type that gives separation of the chordwise flow. The results are obtained by numertcal methods. It ts shown that the relative posttion of the separation of the chordwise flow remains essentially unchanged by the taper. The velocity profiles, and the limiting streamlines are modifted. The departure from tnfinite-cylinder results at the same relative chordwise position ts not large for yawed bodies. (Contractor's abstract)

COR. 09:028

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON INCOMPRESSIBLE TURBULENT BOUNDARY LAYER THEORY APPLIED TO INFINITE YAWED BODIES, by D. L. Turcotte. Sept. 1955, 1v. incl. diagrs. tables, refs. ([AF]OSR-TN-55-374) (AF 33-(038)21406) AD 79114 Unclassified

The problem of a turbulent boundary layer on a cylindrical body at an angle of yaw is studied. Applicable momentum equations are derived. Approximate methods of application are compared with experimental reeults. For the case of the flat plate (no pressure gradtent) at an angle of yaw, theoretical assumptions are compared with the expertmental results obtained by Ashkenas and Riddell. It is concluded that the boundary layer cannot be calculated from the components of flow normal to the leadtng edge. If yaw is considered to have no effect on the boundary layer growth, better results are obtained. Possible reasons for the observed deviation from the second alternative are discussed. For the wing at an angle of yaw, the above methods are applied to the case with a pressure gradient and are compared with the experimental results obtained by Altman and Hayter. The second of the above 2 assumptions is shown to give better results than the first. When the pressure gradient is appreciable, however, the pressure term of the momentum equation makes the largest contribution to the growth of the turbulent boundary layer, so that any reasonable method of approximation of the wall-shearing stress term will lead to a fair estimation of the growth of the turbulent boundary layer. (Contractor's abstract)

COR. 09:029

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON THE HEAT TRANSFER TO THE WALLS OF A SHOCK TUBE, by N. Rott and R. Hartunian. Nov. 1955 [35]p. incl. diagrs. ([AF]OSR-TN-55-427) (AF 33(038)21406) AD 79113 Unclassifted

A simplified theory of the development of a laminar boundary layer behind a shock wave progressing parallel to an infinite, plane, solid wall ts given. The heat-transfer problem, including heat conduction effects in the wall, ts solved. It ts found that the heat-conduction problem in the solid wall ts also of the boundary-layer type. The temperature distributions in the gas and tn the wall are determined. The displacement thickness of the laminar boundary layer ts computed, with the actual temperature distribution betng taken tnto account. (Contractor's abstract)

COR. 09:030

Cornell U. [Graduate School of Aeronautical Engineering] Ithaca, N. Y.

DIFFRACTION OF A WEAK SHOCK WITH VORTEX GENERATION, by N. Rott. May 1956 [19]p. incl. illus. (AFOSR-TN-55-470) [AF 33(038)21406] AD 126441 Unclassifted

Also published in Jour. Fluid Mech., v. 1: 111-129, May 1956.

The region of finite vorticity near the edge of a diffracting wedge is investigated. Dimensional analysis gives the dependence of the circulation and the velocity of the vortex region on the pulse strength. A close estimate of the magnitude of these quantities is obtained by replacing the vortex region by a single concentrated vortex. The theoretical conditions at the sharp edge are discussed and compared with observations of real fluid behavior. A short account of the theory of the core of the spiral vortex sheet in a perfect fluid is appended. (Contractor's abstract)

COR. 09:031

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

THE UNSTEADY FORCES DUE TO VISCOUS WAKES IN TURBOMACHINES, by N. H. Kemp and W. R. Sears. [1955] 6p. incl. table. [AF 33(038)21406] Unclassifted

Published in Jour. Aeronaut. Sciences, v. 22: 478-483, July 1955.

The configuration of viscous wakes of cascade blades is approximated from single airfoil experiments. The unsteady force and moment on a downstream blade passing through such wakes is then calculated on the basis of the theory of isolated thin airfoils in nonuniform motion. The results indicated that the force is nearly proportional to the profile-drag coefficient of the upstream blades. For typical values of this coefficient and conventional cascade geometry, the unsteady forces arising from passage through viscous

wakes are of about the same size as those due to aerodynamic interference between the moving blade rows, previously estimated.

COR. 09:032

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON THE WAKE ENERGY OF MOVING CASCADES, by N. H. Kemp and W. R. Sears. [1956] [7]p. (AF 33(038)21406) Unclassified

Published in Jour. Appl. Mech., v. 23: 262-268, June 1956.

An analysis was made of the rate of energy transfer into kinetic energy of the vortex wakes for unsteady two-dimensional flow in cascades of thin airfoils, as applied to an elementary compressor stage consisting of two rows of blades in relative motion. Results indicate that the magnitude of the energy transfer is small, amounting to less than 1% of the energy absorbed by the rotor. For a two-stage rotor, the cross-induced energy transfer may be negative. Energy transfer of the upstream row is many times greater than that of the downstream row, owing to the disparity in the magnitudes of the respective induced circulation fluctuations.

COR. 10:001

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

OBLIQUE BENDING OF A RECTANGULAR PLATE, by C. Riparbelli. May 1955 [35]p. incl. illus. diagrs. (Note no. 1) ([AF]OSR-TN-55-147) (AF 18(600)1159) AD 85450 Unclassified

The deformation of a thin, free-edged rectangular plate in equilibrium, under the action of opposite moments forming a given angle with the plate's axis, is analyzed by assuming the family of lines of maximum curvature of the deformed plate as a parameter determining the deformation. These lines are determined by means of the principle of minimum potential energy. Two modes of bending are treated: the first about straight lines of maximum curvature (limiting case for large deformations) and the second, considering curved lines of maximum curvature. Although an exact general solution to the problem involving this second mode has not been found, an approximate approach, which yields results that agree closely with experiments, is presented. (Contractor's abstract)

COR. 10:002

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

OBLIQUE BENDING OF A TRAPEZOIDAL PLATE, by C. Riparbelli. Nov. 1955 [8]p. [Note no. 2] ([AF]OSR-TN-56-9) (AF 18(600)1159) AD 84577 Unclassified

A study was made to extend the result (see item no. COR. 10:001) obtained on oblique bending of a rectangular plate toward the analysis of deformation of plate-like thin wings. The mathematical analysis which is presented is based upon the observation that when a plate is bent and as soon as the maximum curvature at a region of the plate becomes appreciable, the second principal curvature is very small. The moment components orthogonal to the lines of maximum curvature act on a curved section whose rigidity is high compared to the plate's rigidity. The simplifying hypothesis is introduced that the whole deformation is bending about the family of lines of maximum curvature. A second simplifying hypothesis is that the lines of maximum curvature are straight, except in the immediate neighborhood of the edges or of concentrated loads. In the above hypotheses, the family of lines of maximum curvature is determined by means of the principle of minimum potential energy. (ASTIA abstract)

COR. 10:003

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

GENERAL BENDING OF A PLATE INTO A DEVELOPABLE SURFACE, by C. Riparbelli. Dec. 1955 [15]p. incl. diagrs. (Note no. 3) (AFOSR-TN-56-31) (AF 18(600)1159) AD 80542 Unclassified

Under the assumption of nonextensional bending, the general case of deformation of thin plates undergoing nonuniform bending is analyzed. A relationship between the position of the point to which the lines of maximum curvature converge and the shear resultant is defined. The expression for the total potential energy, to be minimized to define the family of lines of maximum curvature, is written. Finally, the deformation energy in the above general case is written as the deformation energy in pure bending multiplied by an amplifying factor which is a function of the convergence. A solution is presented for the problem of the analysis of large deformations of thin plates for application to thin wings representing a quasihomogeneous structure. (Contractor's abstract, in part)

COR. 10:004

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

EDGE CURLING OF A PLATE UNDERGOING OBLIQUE BENDING, by C. Riparbelli. Dec. 1955 [20]p. incl. illus. diagrs. (Note no. 4) (AFOSR-TN-56-32) (AF 18(600)1159) AD 80543 Unclassified

Large deformations of thin plates are being studied for the purpose of deformation analysis of thin plate-like wings. The deformation mode is determined by the

COR. 10:005 - COR. 11:003

family of lines of maximum curvature which are at first assumed to be straight. It is observed that the lines of maximum curvature deviate from their straight pattern only in the neighborhood of the edges. This deviation is the subject of the present study, the problem being approached in the following way: The given plate is considered at first to be an interior region (far from the edges) of a much larger plate. The edge effect then being negligible, the lines of maximum curvature are straight in the region under consideration and the forces and moments at the lines limiting the given plate are immediately computed. The plate as initially given is then cut at the given boundary. In order to satisfy the true (free) edge conditions of zero shear and moment of the original plate, the shears and moments computed in the first step of this procedure are applied with opposite sign to the shell into which the plate was deformed according to the initial assumption. The curvature increments resulting from the superimposed moments and shears are then computed. The corrected lines of maximum curvature tend to approach the normal to the edge in the region near the edge, and remain straight at a distance from the boundary. (Contractor's abstract)

COR. 10:005

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

GEOMETRY OF THE LINES OF MAXIMUM CURVATURE IN BENDING OF THIN PLATES, by C. Riparbelli. Dec. 1955 [13]p. incl. diagrs. (Note no. 5) (AFOSR-TN-56-33) (AF 18(600)1159) AD 80544 Unclassified

A relationship is derived between the principal curvatures of a surface and the curvature of the family of lines of maximum curvature. Large deformations of a free-edged plate can then be analyzed using the family of lines of maximum curvature as a parameter determining the deformation. The slope and curvature of the lines of maximum curvature at the free edge are determined by the conditions there. (Contractor's abstract)

COR. 11:001

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

THE IGNITION OF COMBUSTIBLE MIXTURES BY SHOCK WAVES, by M. Steinberg and W. E. Kaskan. 1954 [9]p. incl. diagrs. table, refs. (AF 18(600)1162) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954). N. Y., Reinhold, 1955, p. 664-672.

The purpose of the work reported here was to try to establish conclusively whether or not shock ignition is anomalous. For this purpose a shock tube was designed in a way such that it was reasonably certain that the shock waves which impinged on the combustible mixture were flat and normal to the tube axis, so that the state of the gas behind the shock might be described with reasonable certainty. Properties of the gases behind the incident and reflected shocks in both hydrogen-oxygen and propane-air mixtures with initial pressures of approximately 100, 200, and 300 mm Hg were calculated as a function of incident shock velocity for the initial temperature of 298°K. The resulting data are presented and are considered as evidence that shock ignition is a thermal process and that the anomalously low ignition temperatures previously reported in the literature must be attributed to some other phenomena.

COR. 11:002

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

THE IGNITION OF COMBUSTIBLE GASES BY CONVERGING SHOCK WAVES, by J. A. Fay and E. R. Lekawa. June 30, 1955 [21]p. incl. illus. diagrs. tables. [AFOSR-TR-55-26] (AF 18(600)1162) AD 73694 Unclassified

Also published in Jour. Appl. Phys., v. 27: 261-266, Mar. 1956.

Hydrogen-oxygen and hydrogen-air mixtures were ignited by converging cylindrical shock waves using the apparatus devised by Perry and Kantrowitz, (Jour. Appl. Phys., v. 22: 878-886, 1951), and the minimum strength shock wave necessary for ignition was determined. The energy in the heated wake of the shock wave within a cylinder of diameter equal to the quenching distance was calculated and found to be comparable with the minimum spark ignition energy. An analysis of the unsteady heat conduction problem lends support to the choice of the quenching distance as the significant dimension of the region over which heat addition is effective in causing ignition. (Contractor's abstract)

COR. 11:003

Cornell U. [Graduate School of Aeronautical Engineering] Ithaca, N. Y.

IGNITION OF $2H_2$-O_2 MIXTURES BY MEANS OF SHOCK WAVES, by W. J. Hooker. Feb. 1955, 29p. incl. diagrs. table. (AF 18(600)1162) Unclassified

A shock wave propagating in a shock tube is a means for generating a source of uniform high temperature which is, in general, limited in time duration only by the physical dimensions of the tube. A number of investigations of ignition temperatures, utilizing this means, have disclosed that "shock initiated" ignition temperatures are considerably lower than those obtained by adiabatic compression. The present research was begun in an effort to further study this problem with more refined techniques and reveals the "shock initiated" ignition temperatures to be higher than those obtained by adiabatic compression.

COR. 12:001

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

AN AERODYNAMIC THEORY OF A SUPERSONIC PROPELLER, by D. E. Ordway. June 1956, 170p. incl. diagrs. tables, refs. (AFOSR-TN-56-287) (AF 18(600)1523) AD 89498 Unclassified

A supersonic propeller with blades attached to an infinite cylinder as a hub is studied. The forward speed is subsonic but the relative speed at each section is supersonic. The lightly-loaded blades are represented by a surface distribution of appropriate "modified" sources in a fashion similar to ordinary supersonic thin-wing theory. These sources are found by approximating the exact potential for a constant-strength compressible source traveling along a helical path. By properly dividing up the area of integration over the sources in the "Forward Mach Cone," the usual relationship between the source strength and boundary condition is found directly without recourse to Green's theorem. A sample calculation for a twisted flat-plate blade shows that the pressure distribution is the Ackeret value at the leading edge and remains essentially at this value over the first half of the section. As the trailing edge is approached, it rises about 20% above the Ackeret value because the "opening up" of the "Forward Mach Cone" increases the number of contributing sources. The "Mach Lines" formed by the intersection of the propeller plane with the Mach Surface are found for compressible sources moving along a helical path. The solution is given in a manner analogous to the velocity-flow-inclination relationship of Prandtl-Meyer. One case of blade interference is also investigated. (Contractor's abstract)

COR. 12:002

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

LAMINAR BOUNDARY LAYERS ON MOVING WALLS, by S. H. Smith. Sept. 1956 [47]p. incl. diagrs. table. (AFOSR-TN-56-454) (AF 18(600)1523) AD 96800 Unclassified

The nature of the boundary layer on a wall moving with a constant velocity is investigated using approximate methods. The Pohlhausen method, in which a polynomial of the fourth degree in terms of the distance from the wall is assumed for the boundary-layer velocity distribution, is applied to obtain a solution of von Kármán's momentum equation. By considering cases in which the potential flow is a linearly decreasing function of the distance along the wall, the flow pattern is found using the stream function. It is found that the point of zero shear stress at the wall plays no significant part, for moving walls, in the nature of the flow or in the location of flow reversal. An exact solution to the Navier-Stokes equations, calculated by Professor N. Rott (Quart. Appl. Math., v. 13, Jan. 1956) for flow in the vicinity of a stagnation point for the case of moving walls, is presented and the streamlines are calculated. The effect of moving walls (rotation) on the series solution for the flow about a cylinder is also discussed. (Contractor's abstract)

COR. 12:003

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ROTATING STALL IN SINGLE-STAGE AXIAL FLOW COMPRESSORS, by T. J. Falk. Sept. 1956 [61]p. incl. diagrs. tables, refs. ([AF]OSR-TN-56-512) (AF 18(600)1523) AD 110327 Unclassified

Three sets of rotating-stall data obtained using single-stage axial-flow compressors are compared with the three rotating-stall theories developed by W. R. Sears, F. E. Marble and A. H. Stenning. All of the theories predict stall propagation speed with reasonable accuracy, or can be adjusted to do so by choice of a proper value of aerodynamic lag. A final decision as to which of the analytical treatments most accurately represents the problem must await further knowledge of aerodynamic lag. The special case of Professor F. E. Marble's cascade theory of rotating stall, called the "simple cascade characteristics" case, is extended to include a lag between local attainment of the steady-state stalling inlet angle and the local drop in pressure rise associated with stall. Stall propagation speed and percentage of compressor circumference stalled are calculated for 10-degrees and 30-degrees phase lag, and for three values of cascade static-pressure rise at stall. (Contractor's abstract)

COR. 12:004

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

LAMINAR BOUNDARY LAYER ON A SPINNING CIRCULAR CONE IN SUPERSONIC FLOW AT A SMALL ANGLE OF ATTACK [PART I], by M. Fiebig. [June 1956] 1v. incl. diagrs. tables, refs. [AFOSR-TN-56-532] (AF 18(600)1523) AD 110351 Unclassified

The compressible laminar boundary-layer equations for bodies of revolution have been developed and applied. A solution of the outer nonviscous flow, as obtained by a method of perturbation in angle of attack, is available. A perturbation solution is based on this approximation; as is suggested by the solution for the undisturbed cone flow, the Blasius similarity variable is introduced. The resulting system of differential equations has been identified for first order perturbations in angle of attack with F. K. Moore's equations (NACA rept. no. 2521, 1951), for first and second order perturbations due to spin with C. R. Illingworth's equations, (Phil. Mag., v. 44: 389, 1953). The differential equations due to interaction of angle of attack and spin have been solved. The results are given in the form of a set of profile functions which yield, upon

COR. 12:005 - COR. 13:002

linear combinations, the solution for all Mach numbers and cone-vortex angles. (Contractor's abstract)

COR. 12:005

Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.

ON THE "TRIPLE POINT" IN SHOCK-DIFFRACTION PROBLEMS, by T.-F. Sun. Sept. 1956, 122p. incl. diagrs. tables, refs. (AFOSR-TN-56-583) (AF 18-(600)1523) AD 115007 Unclassified

A study is made to determine (1) the flow inside the diffracted wave that originates when a horizontally advancing plane straight shock encounters an infinitely long wedge, (2) the position and strength of the diffracted wave, and (3) the way the diffracted wave reinforces or attenuates the incident or the reflected shock at the triple points where it intersects them. Only weak incident shocks are considered. A nonviscous adiabatic flow is assumed. Consideration is given to the differential equations governing the flow inside the field, the shock position and its strength in 2-dimensional flow, and shocks diffracted by a right-angle wedge. A pole-type singularity at the triple point is obtained even with a more general expansion of the conical coordinates r and θ than that used by Lighthill (Phil. Mag. v. 40: 1202, 1949). A transition function $g(\theta)$, is introduced to remove the pole singularity by connecting the discontinuous boundary values. The pressure and velocity components are then expressed in terms of $g(\theta)$. The magnitude of the first-order approximations thus obtained is uniformly correct in the triple-point region, although the approximations themselves may not be complete. A set of simultaneous nonlinear integro-differential equations governing the transition function and the shock position is obtained for the tangential and normal shock conditions. A numerical solution based on polynomial approximations is obtained which shows fairly good agreement with experimental data. (ASTIA abstract)

COR. 13:001

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

APPROXIMATIONS TO THE PROBABILITY INTEGRAL AND CERTAIN PERCENTAGE POINTS OF A MULTIVARIATE ANALOGUE OF STUDENT'S t-DISTRIBUTION by C. W. Dunnett and M. Sobie. July 1954, 8p. incl. table. (Mechanical engineering rept. no. 5) ([AF]OSR-TN-54-156) (AF 18(600)331) AD 40811 Unclassified

Also published in Biometrika, v. 42: 258-260, June 1955.

A multivariate analog of Student's t-distribution was defined by the authors (Biometrika, v. 41: June 1954) as the joint distribution of p variates $t_{in} = z_i/s$ (i = 1, 2, ..., p). Expressions were obtained for the probability integral and equicoordinate percentage points of the joint density of the t_{in}, given by (1)

$$f(t_{1n}, \ldots, t_{pn}) = \frac{A^{1/2}\,\Gamma\left(\frac{n+p}{2}\right)}{(n\pi)^p\,\Gamma(n/2)}\left(1 + \frac{1}{n}\sum_{i,j} a_{ij} t_{in} t_{jn}\right)^{-\frac{n+p}{2}},$$

where A is the determinant of the positive definite matrix $\left\{a_{ij}\right\} = \left\{p_{ij}\right\}^{-1}$ and $\left\{p_{ij}\right\}$ is the known correlation matrix of the z_i, for the bivariate case p = 2. Approximations are derived which are also lower bounds to the probability integral of (1) applicable in special cases when p > 2. These results can be used to obtain approximations which are upper bounds to any equicoordinate P-percentage point defined as the value of h for which

$$\int_{-\infty}^{h} \cdots \int_{-\infty}^{h} f(t_{1n}, \ldots t_{pn}) dt_{1n} \ldots dt_{pn} = P.$$ (ASTIA abstract)

COR. 13:002

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

ON A GENERALIZATION OF AN INEQUALITY OF HARDY, LITTLEWOOD, AND PÓLYA, by M. Sobel. [1954] 10p. (AF 18(600)331) AD 40690 Unclassified

Also published in Proc. Amer. Math. Soc., v. 5: 596-602, Aug. 1954.

Sets $A = \left\{a_1 \leq a_2 \leq \ldots \leq a_n\right\}$ and $B = \left\{b_1 \leq b_2 \leq \ldots \leq b_n\right\}$ of n real numbers each are given. Let n_i (i = 1, 2, ..., k) be any fixed set of k positive integers whose sum is n, let $C = \prod_{i=1}^{k} n_i!$, and let R = n!/C. Partitions $P^* = \left\{B_1^*, B_2^*, \ldots, B_k^*\right\}$ of B into disjoint subsets B_i^* are considered, each B_i^* containing n_i (i = 1, 2, ... k) elements of B. Denote by B_1^1 the first n_1 elements of B, B_2^1 the next n_2 elements of B until B_k^1 denotes the last n_k elements of B so that $P^1 = \left\{B_1^1, B_2^1, \ldots, B_k^1\right\}$ and $P^r = \left\{B_k^1, B_{k-1}^1, \ldots, B_1^1\right\}$ are particular partitions. Define A_i^1 similarly for A, and regard the A_i as ordered subsets of A. Define $N = \left\{1, 2, \ldots, n\right\}$ and the subsets N_i^1 exactly as for B. The theorem that follows is concerned with the n! cross products $\sum_{i=1}^{k} a_i b_{j_i}$, where $(j_1, j_2, \ldots, j_n)$ is a rearrangement of (1, 2, ..., n). Corresponding to any fixed P^r consider the set $V_r = \left\{v_{cr} \middle| c = 1, 2, \ldots, C\right\}$ of the C cross products obtained by associating the elements of B_i^r with A_i, all rearrangements within the subsets B_i^r

being allowed. A partial ordering is introduced among the partitions so that $P^1 > P^r > P^R$ (r = 2, 3, ... R-1). Theorem: there exists a 2-way table with R rows and C columns such that, for any pair (r_1, r_2), if $P^{r_1} > P^{r_2}$ then $V_{cr_1} \geq V_{cr_2}$ (c = 1, 2, ..., C). (ASTIA abstract)

COR. 13:003

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A SINGLE-SAMPLE MULTIPLE DECISION PROCEDURE FOR RANKING MEANS OF NORMAL POPULATIONS WITH KNOWN VARIANCES, by R. E. Bechhofer. [1954] [24]p. incl. tables, refs. (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under [AF 18(600)331]) Unclassified

Published in Ann. Math. Stat., v. 25: 16-39, Mar. 1954.

A single-sample multiple decision procedure is considered for ranking means of normal populations with known variances. Problems which conventionally are handled by the analysis of variance (Model I) which tests the hypothesis that k means are equal are reformulated as multiple decision procedures involving rankings. It is shown how to design experiments so that useful statements can be made concerning these rankings on the basis of a predetermined number of independent observations taken from each population. The number of observations required is determined by the desired probability of a correct ranking when certain differences between population means are specified. (Contractor's abstract)

COR. 13:004

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A BIVARIATE GENERALIZATION OF STUDENT'S t-DISTRIBUTION, WITH TABLES FOR CERTAIN SPECIAL CASES, by C. W. Dunnett and M. Sobel. [June 1954] [17]p. incl. tables. [AF 18(600)331] Unclassified

Published in Biometrika, v. 41: 153-169, June 1954.

A multivariate generalization of Student's t-distribution is considered. The bivariate case is treated in detail: exact and asymptotic expressions for the probability integral and an asymptotic expression for certain percentage points are obtained. The main results for the bivariate case are given in equations. These equations are used to construct tables for certain special cases. (Contractor's abstract, modified)

COR. 13:005

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A SINGLE-SAMPLE MULTIPLE DECISION PROCEDURE FOR RANKING VARIANCES OF NORMAL POPULATIONS, by R. E. Bechhofer and M. Sobel. [June 1954] [17]p. incl. tables, refs. (AF 18(600)-331) Unclassified

Published in Ann. Math. Stat., v. 25: 273-289, June 1954.

A simple-sample multiple decision procedure for ranking variances of normal populations is described. Exact small-sample methods and a large-sample method are given for computing the sample sizes necessary to guarantee a preassigned probability of a correct ranking under specified conditions on certain variance ratios. Some tables computed by these methods are provided. (Contractor's abstract)

COR. 13:006

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A TWO-SAMPLE MULTIPLE DECISION PROCEDURE FOR RANKING MEANS OF NORMAL POPULATIONS WITH A COMMON UNKNOWN VARIANCE, by R. E. Bechhofer, C. W. Dunnett, and M. Sobel. [June 1954] [7]p. incl. diagr. [AF 18(600)331] Unclassified

Published in Biometrika, v. 41: 170-176, June 1954.

A multiple decision approach to the problem of ranking populations according to their population means has been formulated by Bechhofer (1954). A simple-sample solution to this problem was presented by him for the case of normal populations with known variances. In the present paper the case of normal populations with unknown equal variances is considered. A two-sample procedure is proposed as a solution to the latter problem; this procedure is of the type used by Stein (1945) for obtaining a test of Student's hypothesis with power independent of the variance. Tables are available which enable the experimenter to apply this procedure with little computational effort to the ranking of two or three populations with unknown but equal variances. The same tables can be used when the variance ratios are arbitrary and known. Graphic comparisons of the expected sample size are made for the single-sample and two-sample procedures. (Contractor's abstract)

COR. 13:007

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

MULTIPLE DECISION PROCEDURES FOR RANKING

COR. 13:008 - COR. 13:011

MEANS, by R. E. Bechhofer. May 1955 [6]p. incl. table. (Mechanical engineering rept. no. 6) ([AF] OSR-TN-55-221) (AF 18(600)331) AD 74831 Unclassified

Also published in Trans. National Convention of the Amer. Soc. for Quality Control, May 1955, p. 513-519.

The problem of selecting that one of k normal populations which has the largest population mean is considered. The objective is to guarantee that the probability of a correct selection is equal to or greater than a specified constant $P^* < 1$ whenever the difference between the largest and second largest population mean is equal to or greater than a specified constant $\delta^* > 0$. A single-sample procedure is presented for accomplishing this objective when the population variances are equal and known. A table for applying this procedure is given. The application of the procedure is motivated by a practical example. (Contractor's abstract)

COR. 13:008

Cornell U. Sibley School of Mechanical Engineering, Ithaca, N. Y.

MULTIPLE DECISION PROCEDURES FOR RANKING MEANS OF POPULATIONS, by R. E. Bechhofer. Aug. 1955, 19p. incl. tables, refs. (Mechanical engineering rept. no. 7) ([AF]OSR-TN-55-246) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)331 and Office of Naval Research) AD 74832 Unclassified

Presented at Gordon Research Conference on Statistics in Chemistry and Chemical Engineering, Meriden, N. H., Aug. 11, 1955.

The problem considered is that of selecting the one population, out of k populations, which has the largest population mean. The objective is to guarantee that the probability of a correct selection is equal to or greater than a specified constant $P^* < 1$, whenever the difference between the largest and second largest population mean is equal to or greater than a specified constant $\delta^* > 0$. Three types of procedures for accomplishing this objective are presented: (1) a single-sample procedure when the population variances are equal and known; (2) a 2-sample procedure when the population variances are equal and unknown; and (3) sequential procedures when the population variances are equal and known. Tables for applying the first 2 procedures are given. Experimental sampling results for $k = 3$ are given for the sequential procedure. (ASTIA abstract)

COR. 13:009

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A SEQUENTIAL MULTIPLE DECISION PROCEDURE FOR SELECTING THE POPULATION WITH THE LARGEST MEAN FROM k NORMAL POPULATIONS WITH A COMMON UNKNOWN VARIANCE, by R. E. Bechhofer and M. Sobel. Preliminary rept. Dec. 30, 1955, 2p. (Mechanical engineering rept. no. 8) ([AF]OSR-TN-55-462) (AF 18(600)331) AD 83732 Unclassified

Abstract published in Ann. Math. Stat., v. 27: 218-219, Mar. 1956.

The problem of selecting that one of k normal populations which has the largest population mean is considered. The objective is to guarantee that the probability of a correct selection is equal to or greater than a specified constant $P^* < 1$, whenever the difference between the largest and second largest population mean is equal to or greater than a specified constant $\delta^* > 0$. A sequential procedure for accomplishing this objective when the populations have a common unknown variance is presented. (Contractor's abstract)

COR. 13:010

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A SCALE INVARIANT SEQUENTIAL MULTIPLE DECISION PROCEDURE FOR SELECTING THE POPULATION WITH THE SMALLEST VARIANCE FROM k NORMAL POPULATIONS, by R. E. Bechhofer and M. Sobel. Preliminary rept. Dec. 30, 1955, 2p. (Mechanical engineering rept. no. 9) ([AF]OSR-TN-55-463) (AF 18(600)331) AD 83731 Unclassified

Abstract published in Ann. Math. Stat., v. 27: 219, Mar. 1956.

The problem of selecting that one of k normal populations which has the smallest population variance is considered. The objective is to guarantee that the probability of a correct selection is equal to or greater than a specified constant $P^* > 1$ whenever the ratio of the second smallest to the smallest population variance is equal to or greater than a specified $\delta^* > 1$. A sequential procedure for accomplishing this objective when the population means are unknown is presented. (Contractor's abstract)

COR. 13:011

Cornell U. [Sibley School of Mechanical Engineering] Ithaca, N. Y.

A SEQUENTIAL MULTIPLE DECISION PROCEDURE FOR SELECTING THE MULTINOMIAL EVENT WITH THE LARGEST PROBABILITY, by R. E. Bechhofer and M. Sobel. Preliminary rept. June 1956, 2p. (Mechanical engineering rept. no. 9) (AFOSR-TN-56-219) (AF 18(600)331) AD 88026 Unclassified

Abstract published in Ann. Math. Stat., v. 27: 861, Mar. 1956.

A sequential procedure is proposed which guarantees

a probability of at least $P^*(1/k \leq P^* < 1)$ of selecting the event associated with $p_{[k]}$ whenever $\theta \geq \theta^*$ $(1<\theta^*<\infty)$. Let $p_{[1]} \leq p_{[2]} \leq \cdots \leq p_{[k]}$ denote the ranked probabilities and $\theta = p_{[k]}/p_{[k-1]} \geq 1$; the constants P^* and θ^* are preassigned. This procedure can be generalized to handle problems such as obtaining a complete ranking of the k probabilities.

COR. 13:012

Cornell U. Sibley School of Mechanical Engineering, Ithaca, N. Y.

A SEQUENTIAL MULTIPLE DECISION PROCEDURE FOR SELECTING THE BEST ONE OF SEVERAL NORMAL POPULATIONS WITH A COMMON UNKNOWN VARIANCE, AND ITS USE WITH VARIOUS EXPERIMENTAL DESIGNS, by R. E. Bechhofer. Nov. 1956 [21]p. incl. tables, refs. (Mechanical engineering rept. no. 10) (AFOSR-TN-56-551) (AF 18(600)331) AD 110370 Unclassified

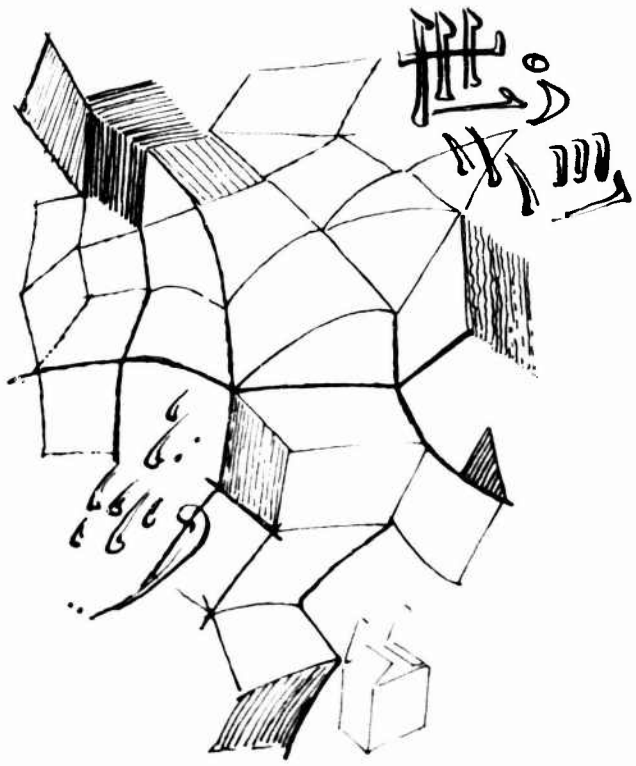
COR. 13:012

Also published in Proc. Symposium on Design of Industrial Experiments, Inst. of Statistics, Raleigh, N. C., Nov. 1956.

Also published in Biometrics, v. 14: 408-429, Sept. 1958. (Revision)

A sequential procedure which can be used when the populations have a common unknown variance is described and its use with completely randomized experimental designs such as randomized blocks, cross-overs and Latin Square designs is given. The task of selecting the population with the largest population mean is considered such that the probability of the correct selection is at least equal to some given probability when the largest population mean is greater than the second-largest by a certain amount. A worked-out numerical example showing the application with a completely randomized design is provided by approximate methods.

Cruft Lab., Cambridge, Mass. see Harvard U. Cruft Lab., Cambridge, Mass.



DEL. 01:001 - DEL. 01:004

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

N6ori-10503 and Nonr-43801, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:065 - PRI. 11:070.

David Sarnoff Research Center, Princeton, N. J. see Radio Corp. of America. David Sarnoff Research Center, Princeton, N. J.

Defense Research Lab., Austin, Tex. see Texas U. Defense Research Lab., Austin.

Delaware U., Newark.

N6ori-10503 and N8onr-74001, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:071 - PRI. 11:077.

DEL. 01:001

Delaware U. Dept. of Physics, Newark.

PRESSURE BROADENING OF LINEAR MOLECULES. 1, by H. Feeny, H. A. Lackner and others. Sept. 2, 1953 [12]p. incl. illus. tables, refs. (Technical note no. 1) (AF 18(600)449) AD 16490 Unclassified

Also published in Jour. Chem. Phys., v. 22: 79-83, Jan. 1954.

A description is given of a microwave spectroscope, especially designed for studies of the temperature dependence of microwave line widths. The line width of the J = 1-2 COS was measured over a temperature range from 195° to 476°K and varied at $T^{-0.9}$ over this range. The COS sample was prepared by the action of H_2SO_4 on NH_4SCN. It was purified by passage through 40% aqueous KOH solution and concentrated H_2SO_4 and further purified by two fractionations and two condensations with the use of liquid N and dry ice. The sample purity was checked by IR analysis and by consistency of microwave data using two sample batches. (ASTIA abstract)

DEL. 01:002

Delaware U. Dept. of Physics, Newark.

THE MICROWAVE SPECTRUM OF FORMIC ACID, by R. Trambarulo and P. M. Moser. June 30, 1954, 1p. incl. tables. (Technical note no. 2) ([AF]OSR-TN-54-152) (AF 18(600)449) AD 79253 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1622-1623, Sept. 1954.

On the basis of examination of the rotational spectra of HCOOH and HCOOD in the regions of 21-25 and 41-50 kmc, the authors present tables showing 4 transition frequencies and the spectroscopic constants and moments of inertia of the 2 isotopic compounds. The distances and angles of a tentative model of formic acid are suggested. Further investigation will be extended to higher microwave frequencies.

DEL. 01:003

Delaware U. Dept. of Physics, Newark.

PRESSURE BROADENING OF LINEAR MOLECULES. II. THEORY, by W. V. Smith, H. A. Lackner, and A. B. Volkov. July 30, 1954, 8p. incl. diagrs. tables. (Technical note no. 3) ([AF]OSR-TN-54-182) (AF 18(600)449) AD 79255 Unclassified

Also published in Jour. Chem. Phys., v. 23: 389-396, Feb. 1955.

The large collision diameters for the self pressure broadening of OCS and BrCN can be explained in terms of P. W. Anderson's general theory as due to the first order dipole-dipole interaction. The temperature dependence of the pressure broadening requires the introduction of other interactions. It is possible to obtain both the magnitude and temperature dependence of the pressure broadening by considering both the first order dipole-dipole and quadrupole-dipole interactions. A quadrupole moment of $Q/e = 5.7 \times 10^{-16}$ cm^2 is obtained for BrCN in this manner. (Contractor's abstract)

DEL. 01:004

Delaware U. [Dept. of Physics] Newark.

PRESSURE BROADENING OF CYANOGEN BROMIDE IN THE MICROWAVE REGION (Abstract), by R. Trambarulo, H. A. Lackner and others. Apr. 30, 1954 [1]p. [AF 18(600)449] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-May 1, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 34, Apr. 29, 1954.

The self-broadening of the J = 2 to 3, F = 5/2 to 7/2 and 7/2 to 9/2 rotational transition of cyanogen bromide at 24.6 kmc was investigated as a function of temperature and pressure. This transition consists of a number of hyperfine lines which were not resolved on our spectrometer. Corrections were made for multiplet line structure and also for the mode curvature of the microwave source. The line-breadth parameter is 27.1 mc/mm at room temperature, and the temperature variation is proportional to $T^{-1.6}$ giving an apparent collision diameter which varies with temperature. (Contractor's abstract)

DEL. 01:005

Delaware U. Dept. of Physics, Newark.

EVALUATION OF MOLECULAR QUADRUPOLE MOMENTS FROM MICROWAVE SPECTRAL LINE BREADTHS. 1. THEORETICAL, by W. V. Smith. Oct. 10, 1955 [21]p. incl. diagrs. refs. (Technical note no. 4) ([AF]OSR-TN-55-348) (AF 18(600)449) AD 74851 Unclassified

Also published in Jour. Chem. Phys., v. 25: 510-515, Sept. 1956.

The breadths of microwave spectral lines in gas mixtures may arise from several different interactions. It is shown that when the radiating molecule is the linear molecule OCS, polarizability interactions predominate, but when the radiating molecule is NH_3 undergoing inversion, quadrupole moment interactions predominate. Consequently, NH_3 is a particularly suitable molecule to use as a "probe" to measure quadrupole moments of other molecules. An improved theoretical analysis leads to a revision of previously published molecular quadrupole moments. (Contractor's abstract)

DET. 01:001

Detroit U. Research Inst. of Science and Engineering, Mich.

ANALYSIS OF ELASTIC AND PLASTIC STRAINS OF A FACE-CENTERED CUBIC CRYSTAL, by T. H. Lin. July 1956, 25p. incl. diagr. tables. (AFOSR-TN-56-307) (AF 18(600)1466) AD 94841 Unclassified

Also published in Jour. Mech. and Phys. of Solids, v. 5: 143-149, 1957.

A method of analysis of both the elastic and plastic shear strains in a face-centered cubic crystal with 12 slip systems, under a given path of strain, is shown. The consideration of elastic strain gives the sequence of different active slip systems in the process of loading. This enables the calculation of the transition from one set of active slip systems to another for a crystal deformed under varying ratios of principal strains. An illustrative example of calculating the 5 active slip systems of a crystal under uniaxial loading is shown. The 5 active slip systems calculated for this crystal, by the present method check exactly with Taylor's results. (Jour. Inst. Metals, v. 62 (1): 307-324, 1938). (Contractor's abstract)

DET. 01:002

Detroit U. Research Inst. of Science and Engineering, Mich.

DEVELOPMENT OF A MATHEMATICAL THEORY OF PLASTICITY BASED ON SLIPS, by T. H. Lin. Aug. 1956, 49p. incl. diagrs. tables, refs. (AFOSR-TR-56-31) (AF 18(600)1466) AD 96043 Unclassified

A plasticity theory of metals is developed in which the latent hardening effect is considered. The assumptions are that the volumetric strain is elastic and that the plastic strain caused by slips in all crystals is entirely distortional. Crystals with a common crystal plane have the same resultant slip on that plane and slide together. For these crystals to slide, the other crystals must deform so that crystals originally in contact remain in contact during deformation. This deformation may be produced by slips in more than one crystal plane or a combination of slips and elastic strains. To simplify the calculation of the deformation of all crystals with a given aggregate strain which satisfies the compatibility condition and the equilibrium condition across the grain boundaries, the resistance to slip on each plane is represented by the resistance given by those crystals with one crystal plane coinciding with the particular plane. Calculated stress-strain curves for 4 different cases are compared with experimental data. An analysis is given of the elastic and plastic strain in a face-centered cubic crystal, and slips of crystals under uniaxial strain are calculated. (ASTIA abstract)

DUK. 01:001

Duke U. Dept. of Chemistry, Durham, N. C.

A POLAROGRAPHIC STUDY OF AZO COMPOUNDS AND AZO METAL COMPLEXES, by W. J. Reid, Jr., B. Cooney, and R. Kirby. Final rept. Dec. 15, 1952-Aug. 31, 1956, 1v. incl. illus. diagrs. tables, refs. (AFOSR-TR-56-53) (AF 18(600)496) AD 110337 Unclassified

This report is divided into three parts: Part I. A polarographic study of 2, 4, 2' - trihydroxyazobenzene - 5' - sulfonic acid, sodium salt, and its complexes with gallium and indium. In this research reduction of Superchrome Garnet Y was studied in buffered solutions. The effects of gelatin concentration, pH, and dye concentration on the reduction were studied. The pH of polarographic waves produced in the electrolysis of solutions of Superchrome Garnet Y and indium was determined. Possible methods for the polarographic determination of dye to metal ratios and of the presence of gallium were investigated. Part II. A spectral study of the aluminum-Superchrome Garnet Y system. The methods of continuous variations and mole ratio were used in this investigation to analyze complex formation in the aluminum-Superchrome Garnet Y system. As an attempt to correct difficulties encountered in the past, a pure sample was synthesized by a Dupont furnished procedure. Part III. A spectral and polarographic study of the complexes of aluminum and gallium with o, o' - dihydroxyazobenzene. This report discusses the uses and limitations of the mole-ratio method with special reference to the complexes of aluminum and gallium with o, o' - dihydroxyazobenzene.

DUK. 02:001 - DUK. 03:001

DUK. 02:001

Duke U. [Dept. of Mathematics] Durham, N. C.

THE EXTENSION OF THE RIEMANN MAPPING THEOREM TO ELLIPTIC EQUATIONS, by F. G. Dressel and J. J. Gergen. [1955] [13]p. incl. diagrs. refs. [AF 18(600)1341] Unclassified

Published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 183-195.

This paper discusses past and recent attacks on the existence and uniqueness of mapping pairs which satisfy somewhat more general conditions than the Cauchy-Riemann equations, the main emphasis being on linear elliptic equations.

DUK. 02:002

Duke U. Dept. of Mathematics, Durham, N. C.

PROBLEMS AND METHODS IN PARTIAL DIFFERENTIAL EQUATIONS. PART I. THE ORIGIN AND EVOLUTION OF THE THEORY, by F. J. Bureau and E. J. Pellicciaro. Aug. 1956, 144p. incl. diagrs. refs. (AFOSR-TN-56-441) (AF 18(600)1341) AD 96784 Unclassified

A consideration is presented of partial differential equations based on a group of lectures given at Duke University during the academic year 1955-56. Some topics in the theory of partial differential equations are reviewed with emphasis on the Cauchy problem. Problems and methods which were introduced during the time up to about 1900 are discussed and summarized. The second part introduces the theory of the finite part and the logarithmic part of some divergent integrals and applies it to the study of the wave equation, the damped wave equation, and the singular equation of Euler-Poisson-Darboux. In order to promote a better understanding of the finite part and the logarithmic part of divergent integrals and of their usefulness in studying the solutions of partial differential equations, the theory is presented with all the necessary details. Some new proofs are also included. In addition, an appendix on the Laplace transform has been added, the contents of which are confined to meet only the requirements of these lectures. (Contractor's abstract, modified)

DUK. 02:003

Duke U. [Dept. of Mathematics] Durham, N. C.

UNIQUENESS OF MAPPING PAIRS FOR ELLIPTIC EQUATIONS, by R. M. McLeod, J. J. Gergen, and F. G. Dressel. Oct. 1956, 15p. refs. (AFOSR-TN-56-554) (AF 18(600)1341) AD 110373 Unclassified

Also published in Duke Math. Jour., v. 24: 173-181, June 1957.

It is proved that the generalized Riemann mapping problem has a unique solution for the class of functions continuous on the closure of the interior of a simple closed plane Jordan curve D, and with continuous first derivatives on D, when D and the coefficients of the system of mapping equations are suitably restricted. Also, certain uniqueness results for similar mappings are obtained under conditions other than the usual ones requiring that three distinct boundary points of D be carried into three distinct boundary points of the second curve.

DUK. 03:001

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRA AND MOLECULAR STRUCTURES OF $HSiCl_3$, CH_3SiCl_3 AND $(CH_3)_3SiCl$, by R. C. Mockler, J. H. Bailey, and W. Gordy. [1953] [18]p. incl. diagr. tables. (Bound with its Quarterly progress rept. no. 1, Feb. 1, 1953-May 1, 1953; AD 16227) (Sponsored jointly [Air Force] Office of Scientific Research under AF 18(600)497) and The Research Corp.) AD 16227(b) Unclassified

Also published in Jour. Chem. Phys., v. 21: 1710-1713, Oct. 1953.

The spectra were observed with a Stark modulation spectrometer. A 100-kc square-wave modulation was employed with the receiver tuned to the fundamental frequency. In most instances the frequency sweep method was employed, and the lines were displayed on a cathode-ray scope. Line frequencies were measured with a frequency standard monitored by comparison of the lowest frequency in the multiplier chain with the standard 5-mc frequency broadcast by station WWV. The following molecular constants were obtained from measurements of pure rotational transitions in the microwave region: B_0 (in mc) of 2472.45 ± 0.04 for $HSi^{28}Cl_3^{35}$, 2346.07 ± 0.04 for $HSi^{28}Cl_3^{37}$, 1769.84 ± 0.03 for $C^{12}H_3Si^{28}Cl_3^{35}$, 1699.79 ± 0.03 for $C^{12}H_3Si^{28}Cl_3^{37}$, 2197.44 ± 0.04 for $(C^{12}H_3)_3Si^{28}Cl^{35}$, and 2147.88 ± 0.03 for $(C^{12}H_3)_3Si^{28}Cl^{37}$. When it was assumed that d_{SiH} = 1.47, for $SiHCl_3$, d_{SiCl} was 2.021 and the ClSiCl bond angle was 109° 22'. For CH_3SiCl_3, d_{SiC} was 1.896 A and d_{SiCl} was 2.021 A. With all bond angles assumed to be tetrahedral and the CH distance to be that in methane d_{SiCl} was 1.87 A and d_{SiCl} was 2.03 A for $(CH_3)_3SiCl$. (ASTIA abstract)

DUK. 03:002

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRA AND STRUCTURES OF METHYL MERCURY CHLORIDE AND BROMIDE, by W. Gordy and J. Shertdan. [1953] [20]p. tncl. dtagrs. tables, refs. (Bound with its Quarterly progress rept. no. 2, May 1, 1953-Aug. 1, 1953; AD 15707) (AF 18(600)497) AD 15707(a) Unclassified

Also published in Jour. Chem. Phys., v. 22: 92-95, Jan. 1954.

The pure rotational mtcrowave spectra of several different isotopic spectes of CH_3HgCl were observed with a frequency sweep spectrometer which had a video type detector. The hyperftne components of a stngle transition for the different tsotopes were measured wtth a frequency calibrated by comparison with the standard 5-mc stgnal of station WWV. The stronger components of several other transttions were measured wtth a cavtty wavemeter. The large number of abundant Hg tsotopes combined with the nuclear quadrupole hyperftne structures made the spectra of CH_3HgBr and CH_3HgCl compltcated. The CH_3HgCl spectra indicated that d_{CHg} = 2.061 ± 0.02 A, d_{HgCl} = 2.282 ± 0.005 A, and CHgCl bond angle = 180°. For CH_3HgBr, d_{CHg} = 2.074 ± 0.015 A, d_{HgBr} = 2.406 ± 0.005 A, and CHgBr bond angle = 180°. Nuctear quadrupole couplings evaluated are Cl^{35} = -42 mc, Cl^{37} = -33 mc in CH_3HgCl, and Br^{79} = 350 mc, Br^{81} = 290 mc tn CH_3HgBr. These tndtcated lonic character of 62% for the HgCl and 55% for the HgBr bond tn these molecules, and led to a value of 1.7 to 1.8 for the electronegattvtty of dlvalent Hg.

DUK. 03:003

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRUM AND MOLECULAR STRUCTURE OF TRICHLORO GERMANE, by P. Venkateswarlu, R. C. Mockler, and W. Gordy. [t953] [14]p. incl. dtagr. tables. (Bound with its Quarterly progress rept. no. 1, Feb. t, t953-May t, 1953; AD t6227) (AF 18(600)497) AD t6227(a) Unclassified

Also published in Jour. Chem. Phys., v. 21: 1713-t7t5, Oct. t953.

The analysis of the spectrum was simplified because it was possible to ignore the Cl quadrupole hyperfine structure, and the D_{JK} was sufficiently small that the separatton of the lines of dtfferent K was not resolved. These facts also made possible the detection of rotational ltnes in tsotopic spectes of low abundance. The rotational constants B_0 (in mc) for the various isotopic modifications of the molecule were: 2171.75 for $HGe^{70}Cl_3^{35}$, 2169.26 for $HGe^{72}Cl_3^{35}$, 2165.84 for $HGe^{74}Cl_3^{35}$, 2063.74 for $HGe^{70}Cl_3^{37}$, 2060.43 for $HGe^{72}Cl_3^{37}$, and 2057.20 for $HGe^{74}Cl_3^{37}$. The calculated structure from these data for the molecule in the ground state was: d_{GeH} = 1.55 ± 0.04 Å, d_{GeCl} = 2.1139 ± 0.0010 Å, and the ClGeCl bond angle = 108°17' ± 12'. Rotational lines for the molecule when it was in the 2 excited $GeCl_3$ deformation vibrations were also measured and the correspondtng molecular structures calculated. (ASTIA abstract)

DUK. 03:004

Duke U. [Mtcrowave Lab.] Durham, N. C.

THE NUCLEAR SPIN AND QUADRUPOLE MOMENT OF I^{131}, by R. Ltvtngston, B. M. Benjamtn and others. [1953] [6]p. inct. dlagr. table. (In cooperation with Onk Rtdge National Lab., Tenn.) (Bound with its Quarterly progress rept. no. 3, Aug. 1, 1953-Nov. 1, 1953; AD 20319) (AF 18(600)497) AD 20319(e) Unclassifted

Also published tn Phys. Rev., v. 92: 1271-1272, Dec. 1, 1953.

The nuclear spin and the quadrupole moment of I^{131} were determtned from measurements on the J = 2→3 rotattonal transition of CH_3I^{131} which occurs in the 6.75-mm region. The nuclear sptn was 7/2, and the quadrupole coupling was -973 ± 9 mc. Observations were made on the oscilloscope of a vtdeo-type mtcrowave spectrometer. Relative line frequencies were measured with frequency markers derived from a stabtlized microwave oscillator

DUK. 03:005

Duke U. [Microwave Lab.] Durham, N. C.

ON THE LINE WIDTH OF THE ROTATIONAL SPECTRA OF SOME SYMMETRIC TOP MOLECULES DUE TO THE NUCLEAR QUADRUPOLE MOMENTS, by T. Ito, Y. Tanabe, and M. Mizushima. [1953] [29]p. tncl. tables, refs. (Bound with its Quarterly progress rept. no. 3, Aug. t, 1953-Nov. 1, 1953; AD 20319) (AF 18(600)497) AD 203t9(d) Unclassified

Also published in Phys. Rev., v. 93: t241-t248, Mar. 15, 1954.

Explicit formulas are presented which give the mean square frequency deviation as a function of the nuclear quadrupole coupling constant and the quantum numbers I, J, K. The nuclear quadrupole coupltng constant can be obtained by these formulas from the line width of the rotational line without analyzing the hyperfine structure. Calculations were made on symmetric top molecules which had 1 or 3 identical nuclei with electric quadrupole moments. The method of separating the present line width from that due to pressure broadening and centrtfugal distortion is dtscussed.

DUK. 03:006 - DUK. 03:010

DUK. 03:006

Duke U. [Microwave Lab.] Durham, N. C.

ON THE MICROWAVE SPECTRUM OF O_2, by M. Mizushima and R. M. Hill. [1953] [16]p. incl. diagr. tables, refs. (Bound with its Quarterly progress rept. no. 4, Nov. 1, 1953-Feb. 1, 1954; AD 27067) (AF 18(600)497) AD 27067(e) Unclassified

Also published in Phys. Rev., v. 93: 745-748, Feb. 15, 1954.

Twenty-four lines of the microwave spectrum of O molecules were measured. The theoretical origin of this specirum was re-examined, and consideration was given io the effeci of centrifugal disiortion. The agreement between theory and experimeni is satisfaciory. It was indicated that this specirum is noi suitable io determine the velocity of light.

DUK. 03:007

Duke U. [Microwave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER-WAVE SPECTROSCOPY. PART 1, by W. C. King and W. Gordy. [1953][2]p. incl. table. (Bound with its Quarierly progress rept., Oct. 1, 1952-Jan. 31, 1953; AD 10837) [AF 18(600)-497] Unclassified

Presenied ai meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 90: 319-320, Apr. 15, 1953.

Speciral lines were measured ai many positions beiween 1.37 mm and 2.3 mm wavelengihs (220 kmc to 130 kmc). Silicon crysial multipliers driven by Raytheon klysirons were used. A wide-banded audio amplifier was used in ihe observations. It was possible io obiain 4th io 5th harmonic power from ihe full tuning range of a K band klysiron withoui returning either the multiplier or detector.

DUK. 03:008

Duke U. [Microwave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER-WAVE SPECTROSCOPY. PART II. H_2S, by C. A. Barrus and W. Gordy. [1953] [20] p. incl. diagrs. tables, refs. (Bound with its Quarterly progress rept. no. 2, May 1, 1953-Aug. 1, 1953; AD 15707) (AF 18(600)497) AD 15707(b) Unclassified

Also published in Phys. Rev., v. 92: 274-277, Oct. 15, 1953.

Pure rotational iransiiions of H_2S^{32}, H_2S^{33}, and H_2S^{34} were measured with high precision in the region of 1 to 2 mm. From these measurements the SH bond length was calculated to be 1.3226 A and the bond angle 92°6'. The S^{33} nuclear quadrupole coupling observed along the principal inertial axes were eQq_{aa} = -32 mc, eQq_{bb} = -8 mc, and eQq_{cc} = +40 mc. An approximate analysis of the quadrupole coupling constants showed that the bonding orbitals of S are spd hybrids and yields a value of -0.06×10^{-24} cm^2 for the quadrupole moment of the S^{33} nucleus. From the known ratio Q^{33}/Q^{35} this gave $Q^{35} = 0.04 \times 10^{-24}$ cm^2. Zeeman studies showed that the molecular g_J factor was almost equal for differeni rotational states. A mean value of 0.24 nuclear magnetons was found for g_J.

DUK. 03:009

Duke U. [Microwave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER WAVE SPECTROSCOPY. PART III. NO AND DI, by C. A. Burrus and W. Gordy. [1953] [12]p. incl. diagrs. tables. (Bound with its Quarterly progress rept. no. 4, Nov. 1, 1953-Feb. 1, 1954: AD 27067) [AF 18(600)497] AD 27067(a) Unclassified

Also published in Phys. Rev., v. 92: 1437-1439, Dec. 15, 1953.

Pure rotational transitions of $N^{14}O^{16}$ and DI^{127} have been measured in the one-to-two millimeter wave region. For NO the $J = 1/2 \rightarrow 3/2$ transition in the $^2\pi_{1/2}$ electronic ground state was observed. The transition reveals a λ doublet with separation $\delta\nu_{dc}$ = 355.1 mc/sec. Each componeni of the λ doublet is further spliі into five hyperfine componenis as a resulі of the nuclear magnetic coupling of N^{14}. Nuclear quadrupole coupling of N^{14} was found to be small in comparison with the magnetic interaction. Analysis of the data yields B_0 = 50818.0 mc/sec, r_0 = 1.1540 A, B_e = 51084.8 mc/sec and r_e = 1.1510 A for the $^2\pi_{1/2}$ state. For DI^{127} the following information was obiained: B_0 = 97537.2 mc/sec, r_0 = 1.6165 A, and $eQq(I^{127})$ = 1823 ± 1 mc/sec. Nuclear magnetic inieractions of I^{127} were also deiected and analyzed. (Contractor's abstract)

DUK. 03:010

Duke U. [Microwave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER WAVE SPECTROSCOPY. PART IV. EXPERIMENTAL METHODS AND CERTAIN RESULTS, by W. C. King and W. Gordy. [1953] [26]p. incl. illus. diagrs. iables, refs. (Bound with iis Quarterly progress rept. no. 4, Nov. 1, 1953-Feb. 1, 1954; AD 27067) (AF 18(600)497) AD 27067(d) Unclassified

Also published in Phys. Rev., v. 93: 407-412, Feb. 1, 1954.

Design details are given of the harmonic generator and detector which made possible precision speciroscopy in the one-to-two millimeter wave region. The signal to noise ratio obtained on OCS rotaiional lines is 7 to 1

at 1.0 mm wave length; 30 to 1 at 1.1 mm; and better than 100 to 1 at 1.4 mm and above. A useful tuning and measuring technique is made possible by the ability of the new system to detect several klystron harmonics at once, and hence spectral lines in several different regions at the same time. The applications of the methods in the measurement of centrifugal distortion of molecules is illustrated with OCS, for which D_J = 1.310 ± 0.010 kc is obtained, and with CH_3F, for which D_J = 57.8 ± 1.0 kc and D_{JK} = 445 ± 4 kc are obtained. A new water vapor line, the $2_{2,0} \rightarrow 3_{1,3}$ rotational line, has measured at 183, 311.30 ± 0.30 mc. (Contractor's abstract)

DUK. 03:011

Duke U. [Microwave Lab.] Durham, N. C.

SPECTRUM OF DBr IN THE ONE-MILLIMETER WAVE REGION, by W. Gordy and C. A. Burrus. [1953] [6]p. incl. diagrs. tables. (Bound with its Quarterly progress repl. no. 4, Nov. 1, 1953-Feb. 1, 1954; AD 27067) [AF 18(600)497] AD 27067(b) Unclassified

Also published in Phys. Rev., v. 93: 419-420, Feb. 1, 1954.

From measurements on the 0→1 transition of DBr at 1.18-mm wavelength the following information has been obtained:

	DBr^{79}	DBr^{81}
eQq(Br)	533 ± 3 mc/sec	455 ± 3 mc/sec
B_0	127 358.2 ± 0.3 mc/sec	127 280.0 ± 0.3 mc/sec
B_e	1286_{15} mc/sec	1285_{38} mc/sec
r_0	1.42136_2 A	1.42136_2 A
r_e	1.414_{40} A	1.414_{39} A

Values of a obtained from infrared spectroscopy by Keller and Nielsen were employed in calculating the equilibrium values. (Contractor's abstract)

DUK. 03:012

Duke U. [Microwave Lab.] Durham, N. C.

SUB-MILLIMETER WAVE SPECTROSCOPY, by C. A. Burrus and W. Gordy. [1953] [6]p. incl. diagr. table. (Bound with its Quarterly progress rept. no. 4, Nov. 1, 1953-Feb. 1, 1954; AD 27067) (AF 18(600)497) AD 27067(c) Unclassified

Also published in Phys. Rev., v. 93: 897-898, Feb. 15, 1954.

A spectrum at 0.77-mm wave length (389 k mc) was measured with harmonics from a 5-mc marker monitored by the standard 5-mc signal broadcast by NBS. A recording is shown of several rotational lines in the submillimeter range obtained with different harmonics of a K-band klystron. The highest frequency previously recorded by electronic methods was the 1.03-mm line of OCS for which a S/N of 7 was obtained.

DUK. 03:013

Duke U. [Microwave Lab.] Durham, N. C.

[THE ULTRA-HERTZ SPECTRUM OF WATER VAPOR] Spectre ultra-Herizien de la vapeur d'eau, by W. Gordy. [1953] [3]p. incl. diagr. table, refs. (AF 18(600)497) Unclassified

Published in Jour. Chim. Phys., v. 50: C114-C116, Sept. 1953.

A review is presented of the observed microwave absorptions of H_2O, HDO, and D_2O. An explanation is given of the difficulties of obtaining accurate bond distances and angles therefrom. There are 18 foreign and domestic references cited covering a time period from 1933 to 1953.

DUK. 03:014

Duke U. [Microwave Lab.] Durham, N. C.

THEORY OF THE ROTATIONAL SPECTRA OF ALLENE-TYPE MOLECULES, by M. Mizushima. [1953] [21]p. incl. diagr. tables. (Bound with its Quarterly progress rept. no. 1, Feb. 1, 1953-May 1, 1953; AD 16227) [AF 18(600)497] AD 16227(c) Unclassified

Also published in Jour. Chem. Phys., v. 21: 1222-1224, July 1953.

A possible means of observing the rotational spectra of Allene-type molecules is described and discussed. The effect of nuclear spin on the statistical weight of each rovibrational level, hyperfine structure, Zeeman effect, and Stark effect are calculated. (Contractor's abstract, modified)

DUK. 03:015

Duke U. [Microwave Lab.] Durham, N. C.

ZEEMAN EFFECT AND LINE BREADTH STUDIES OF THE MICROWAVE LINES OF OXYGEN, by R. M. Hill and W. Gordy. [1953] [15]p. incl. diagrs. tables. (Bound with its Quarterly progress rept. no. 3, Aug. 1, 1953-Nov. 1, 1953; AD 20319) (AF 18(600)497) AD 20319(c) Unclassified

Also published in Phys. Rev., v. 93: 1019-1022, Mar. 1, 1954.

Measurements at 90° and 300° K on the O line breadths indicated that the line breadth parameter, $\Delta\nu$, varies as T^{-x}, with x varying from 0.76 for the 9- line to 0.90 for the 1- line. Rotational resonance and quadrupole moment interactions were important factors in determining the line breadths. The Zeeman splittings observed for the 1-, and the 1+, and the 3- lines were in accord with the splitting predicted from first-order perturbation theory. (ASTIA abstract)

DUK. 03:016 - DUK. 03:021

DUK. 03:016

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRUM AND MOLECULAR PROPERTIES OF OZONE (Abstract), by R. Trambarulo, S. N. Ghosh and others. Mar. 27, 1953 [1]p. [AF 18(600)-497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 222, July 1, 1953.

Four low J rotational transitions of ozone were measured between 42 and 118 kmc. These measurements showed ozone to be an isosceles triangle with the apex angle of 116° 49' ±30' and with the two equal internuclear distances 1.278 ± 0.003 Å. The electric dipole moment found from the Stark effect was 0.53 ± 0.02 Debye. Zeeman studies show the molecular g factor to have a strong dependence upon rotational state. (Contractor's abstract)

DUK. 03:017

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRUM OF TRIMETHYL CHLOROSILICANE (Abstract), by R. C. Mockler and W. Gordy. Mar. 27, 1953 [1]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 222, July 1, 1953.

Trimethyl chlorosilicane was found to have a microwave rotational spectrum characteristic of a symmetric top, with B_0 = 2197.31 mc for $(CH_3)_3Si^{28}Cl^{35}$ and B_0 = 2147.88 mc for $(CH_3)_3Si^{28}Cl^{37}$. If tetrahedral angles are assumed with d_{CH} as in methane, the results yield d_{SiC} 1.871A and d_{SiCl} = 2.029A. The rotational lines are split into several components by torsional oscillations or restricted internal rotations of the CH_3 groups. (Contractor's abstract)

DUK. 03:018

Duke U. [Microwave Lab.] Durham, N. C.

ON THE FREQUENCIES OF THE MICROWAVE ABSORPTION LINES OF OXYGEN (Abstract), by M. Mizushima. Mar. 27, 1953 [1]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 222, July 1, 1953.

Attempt was made to improve two points in Schlapp's theory. First consideration was given to the dependence of λ on N, where λ is the coupling constant of electronic spin and molecular axis and N is the quantum number of end-to-end rotation of molecule. This dependence makes $\nu_+(N-1) + \nu_-(N+1)$ dependent on N, which fit with experimental results, while in Schlapp's original theory it is independent of N. Another point considered is that Schlapp made a mistake in taking the effect of magnetic interaction between spin and end-to-end rotation of molecule into account. An improved formula derived is in good agreement with recent experimental data obtained at Duke U. The adopted value of the constants are: B = 1.4372605 cm^{-1}, λ_0 = 1.984627 cm^{-1}, λ_1 = 0.000050 cm^{-1}, μ = -0.008432 cm^{-1}, where λ_1 gives slight dependence of λ on N. (Contractor's abstract, modified)

DUK. 03:019

Duke U. [Microwave Lab.] Durham, N. C.

TEMPERATURE DEPENDENCE OF THE LINE BREADTHS OF OXYGEN (Abstract), by R. M. Hill and W. Gordy. Mar. 27, 1953 [1]p. [AF 18(600)-497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 222, July 1, 1953.

Line breadths of several of the millimeter wave lines of O_2 were measured at T = 300°, 195°, and 90°C. The results indicate an average temperature dependence of 1/T for the line breadth. (Contractor's abstract)

DUK. 03:020

Duke U. [Microwave Lab.] Durham, N. C.

ZEEMAN EFFECT IN THE MICROWAVE SPECTRA OF METHYL FLUORIDE AND METHYL ACETYLENE (Abstract), by J. T. Cox, P. B. Peyton, Jr., and W. Gordy. Mar. 27, 1953 [1]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 222, July 1, 1953.

Zeeman splitting or rotational lines of methyl fluoride and methyl acetylene were measured. The results show that the molecular magnetic field in CH_3CCD is generated primarily by rotation about the symmetry axis (g_K 0.31, $g_N \approx 0$), but that in CH_3F a measurable field is also generated by the end-over-end rotation (g_N 0.08). (Contractor's abstract)

DUK. 03:021

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRUM OF WATER VAPOR, by W. Gordy. June 25, 1953 [11]p. incl. diagr. table, refs.

(Bound with its Quarterly progress rept. no. 3, Aug. 1, 1953-Nov. 1, 1953; AD 20319) (AF 18(600)497)
AD 20319(a) Unclassified

The usefulness of structural information obtained from a study of isolated molecules is discussed for understanding the nature of the bonding of H_2O in solids. The steric factors which depend on the shape and size of the molecule as well as the ordinary electrostatic interactions with the over-all electric dipole moment of the molecule were pointed out as significant. However, emphasis was given to the dependence of the H bond on the hybridization of the orbitals of the atoms linked by the bridge. The 15° departure of the bond angle of H_2O from 90°, only partially accounted for by the repulsion of the H atoms, was interpreted to indicate considerable s contribution to the bonding orbitals of O. The complimentary sp hybridization of the orbitals containing the unshared electrons made them good proton acceptors. The decrease in the proton acceptor properties of the second period over the first period elements was attributed to the increasing size of the atoms and to the decreased complimentary sp hybridization of the orbitals containing the unshared pairs. (ASTIA abstract)

DUK. 03:022

Duke U. Microwave Lab., Durham, N. C.

ONE-TO-FIVE MILLIMETER-WAVE SPECTROSCOPY, by W. Gordy. July 1, 1953 [13]p. incl. diagrs. table. (Bound with its Quarterly progress rept. no. 3, Aug. 1, 1953-Nov. 1, 1953; AD 20319) (AF 18(600)497)
AD 20319(b) Unclassified

Also published in Jour. Phys. et Radium (Paris), v. 15: 521, 1954.

Design features of a millimeter-wave spectrometer are discussed. An improvement in sensitivity of 10 times or better over the video-type spectrometer can be obtained by the use of automatic recording with a phase-lock-in detector and narrow-band amplifier. The spectral lines in the 1- to 5-mm region are measured by standard markers made by multiplication of a 5-mc signal monitored by NBS station WWV and multiplied to the region of investigation. Measured 1- to 5-mm spectral lines are tabulated. The 24th rotational line of COS at 1.03 mm was the highest spectral frequency recorded with the microwave electronic methods. Advantages of having the millimeter-wave region opened to spectroscopists are summarized. The millimeter-wave region from 1 to 10 wave numbers includes spectral transitions of numerous atoms and molecules which have no observable transitions in the centimeter region. The strength of spectral lines increases rapidly with frequency. Spectral lines are stronger and more numerous in the millimeter than in the centimeter region. The advantage of strength and abundance of spectral transitions characteristic of the optical region and the high precision and resolution characteristic of the RF region are best comprised in the millimeter-wave region.

DUK. 03:023

Duke U. Microwave Lab., Durham, N. C.

ON THE RELATION OF NUCLEAR QUADRUPOLE COUPLINGS TO THE CHEMICAL BOND, by W. Gordy. [1954] 5p. incl. diagr. (Special rept. no. 1) [AFOSR-TN-54-178] (Bound with its Quarterly progress rept. no. 6, May 1, -Aug. 1, 1954; AD 36814) (AF 18(600)497) AD 36814(a)
Unclassified

Also published in Jour. Chem. Phys., v. 22: 1470-1471, Aug. 1954.

A relation between the ionic-character of bonds and the electronegativity difference of the bonded atoms, which differs significantly from previously proposed relations, was obtained from nuclear quadrupole couplings. Such a relation is useful in calculating nuclear quadrupole moments from molecular coupling, as well as in obtaining chemical bond properties. The coupling of Cl in HCl provides a critical test of the relation. (ASTIA abstract)

DUK. 03:024

Duke U. Microwave Lab., Durham, N. C.

PARAMAGNETIC RESONANCE IN URANIUM SALTS, by S. N. Ghosh, W. Gordy, and D. G. Hill. [1954] [15]p. incl. diagrs. table. (Special repl. no. 3) [AFOSR-TN-54-179] (Bound with its Quarterly progress repl. no. 6, May 1-Aug. 1, 1954; AD 36814) (AF 18(600)497) AD 36814(c) Unclassified

Also published in Phys. Rev., v. 96: 36-38, Oct. 1, 1954.

Paramagnetic resonance was observed in U^{3+} and U^{4+} ions in powdered samples of UF_3 and UF_4, respectively. The resonance curve in UF_3 was asymmetric with 2 unresolved peaks yielding values of 2.1 and 2.8 for the perpendicular and parallel components of the g factor. The resonance is broad and weak; the over-all half-width is 5 kilogauss at room temperature. The curve obtained for UF_4 was symmetric and yielded g = 2.15, its half-width was 3.5 kilogauss at room temperature. Although the resonance in UF_3 appeared stronger at liquid-air than at room temperature, the resonance in the UF_4 could be detected only at room and at elevated temperatures. The results favor the interpretation that the 2 unpaired electrons in U^{4+} are 6d electrons, that the crystalline field in UF_4 was essentially cubic, and that either the lowest component of the Stark multiplet was a nonmagnetic singlet or that the electrons had a high degree of antiferromagnetic alignment. The results on UF_3 showed that the crystalline field had an axially symmetric component. (ASTIA abstract)

DUK. 03:025 - DUK. 03:028

DUK. 03:025

Duke U. Microwave Lab., Durham, N. C.

MILLIMETER WAVE SPECTRA AND CENTRIFUGAL STRETCHING, by W. J. O. Thomas, J. T. Cox, and W. Gordy. [1954] [15]p. incl. dtagrs. tables. (Special rept. no. 2) [AFOSR-TN-54-180] (Bound with its Quarterly progress rept. no. 6, May 1-Aug. 1, 1954; AD 36814) (AF 18(600)497) AD 36814(b) Unclassified

Also published in Jour. Chem. Phys., v. 22: 1718-1722, May 1954.

High J transitions of the methyl halides have been measured and have been used to calculate accurate values for the centrifugal distortion constants. The values obtained for B_O, D_{JJ} and D_{JK} are (in mc/s and kc/s respectively); $CH_3.F^{19}$, 25,536.11, 59.3, 445; $CH_3.Cl^{35}$, 13,292.86, 18.1, 198; $CH_3.Br^{79}$, 9,568.20, 9.9, 128.3; $CH_3.Br^{81}$, 9,531.82, 9.7, 127.4; $CH_3.I^{127}$, 7,501.30, 6.28, 98.5. The new D_{JJ} value for $CH_3.Cl^{35}$ is in good agreement with the value of 18.4 kc/s theoretically predicted by Chang and Dennison. For all four molecules, the D_{JJ} constants were found to be in good agreement with those predicted from Kratzer's formula

$$D_{JJ} = 4B_O^3/\omega^2,$$

where ω is the vibrational frequency corresponding to the stretching of the carbon halogen bond. (Contractor's abstract)

DUK. 03:026

Duke. U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRA OF SbH_3 AND SbD_3, by A. W. Jache, G. S. Blevins, and W. Gordy. [1954] [20]p. incl. diagr. tables, refs. [AFOSR-TN-54-316] (Bound with its Quarterly progress rept. no. 7, Aug. 1, 1954-Nov. 1, 1954; AD 49803) [AF 18(600)497] AD 49803(a) Unclassified

Also published in Phys. Rev., v. 97: 680-683, Feb. 1, 1955.

The $J = 0 \rightarrow 1$ rotational transitions of normal and deuterated stibine have been measured in the shorter millimeter wave region. The B_O values obtained are, in mc/sec: 88,031.9 for $Sb^{121}H_3$, 88,015.5 for $Sb^{123}H_3$, 44,693.3 for $Sb^{121}D_3$, and 44,677.1 for $Sb^{123}D_3$. The observed Sb nuclear quadrupole couplings, eQq, differ for the normal and deuterated forms of stibine and are in mc/sec: for Sb^{121}, 458.7 ± 0.8 mc in SbH_3, and 465.4 ± 0.8 in SbD_3; for Sb^{123}, 586.0 ± 0.8 in SbH_3, and 592.8 ± 0.8 in SbD_3. These couplings lead to the ratio Q^{123}/Q^{121} 1.275 ± 0.003. The Sb nuclear quadrupole moments are estimated to be: Q^{121} -0.8×10^{-24} cm^2, Q^{123} -1.0×10^{-24} cm^2. Significant Sb nuclear magnetic coupling was observed for the normal stibine. In SbH_3 the magnetic coupling constant is found to be 0.33 mc/sec for Sb^{121} and 0.18 mc/sec for Sb^{123}. The ratio of these, C^{121}/C^{123} = 1.84, is in good agreement with the known ratio of the nuclear g factors, g^{121}/g^{123} = 1.8465. Slightly different values of the interatomic distances were observed for the normal and deuterated forms. In SbH_3 the SbH distance is 1.707 Å and the HSbH angle is 91°18'. In SbD_3 the SbD distance is 1.702 Å and the DSbD angle is 90°56'. (Contractor's abstract)

DUK. 03:027

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRA OF AsH_3 AND AsD_3, by G. S. Blevins, A. W. Jache, and W. Gordy. [1954] [12]p. incl. dtagr. tables. [AFOSR-TN-54-317] (Bound with its Quarterly progress rept. no. 7, Aug. 1, 1954-Nov. 1, 1954; AD 49803) [AF 18(600)-497] AD 49803(b) Unclassified

Also published in Phys. Rev., v. 97: 684-686, Feb. 1, 1955.

The $J = 0 \rightarrow 1$ rotational transitions of AsH_3 and of AsD_3 have been measured in the one to three millimeter wave region. The B_O values obtained are, in mc/sec: 112,468.46 for $As^{75}H_3$ and 57,477.15 for $As^{75}D_3$. The observed nuclear quadrupole coupling, eQq, of As^{75} differs for the two species and is -160.1 ± 0.4 mc/sec for $As^{75}H_3$ and -165.9 ± 0.4 mc/sec for $As^{75}D_3$. Detectable As^{75} nuclear magnetic interaction was found with the magnetic coupling constant A = 0.33 mc/sec for AsH_3 and A = ~ 0.07 mc/sec for AsD_3. From a consideration of previous microwave work on AsH_2D and a consideration of the differences in the bond angles in normal and deuterated stibine, the bond angle in AsH_3 is assumed to be 91°50' and that in AsD_3 is assumed to be 91°30'. These angles, with the observed moments of inertia, yield the value 1.5192 Å for the AsH length and 1.5145 Å for the AsD length. (Contractor's abstract)

DUK. 03:028

Duke U. [Microwave Lab.] Durham, N. C.

ZEEMAN EFFECT IN THE ROTATIONAL SPECTRUM OF NO, by M. Mizushima, J. T. Cox, and W. Gordy. [1954] [22]p. incl. illus. diagr. tables, refs. [AFOSR-TN-54-318] (Bound with its Quarterly progress rept. no. 7, Aug. 1, 1954-Nov. 1, 1954; AD 49803) [AF 18(600)497] AD 49803(c) Unclassified

Also published in Phys. Rev., v. 98: 1034-1038, May 15, 1955.

The Zeeman splitting of the 2 mm wave, $J = 1/2 \rightarrow 3/2$ rotational transition of $N^{14}O^{16}$ in the $^2\pi_{1/2}$ electronic state has been measured with fields of the order of 100 gauss. The observations were made with a waveguide cell coiled between the poles of a Varian magnet. Magnetic field measurements were made with the

electronic resonance of DPPH at frequencies of the order of 300 mc. A general theory of the Zeeman effect with hfs has been developed and applied specifically to $N^{14}O^{16}$. The g-factors for the four states under investigation were found theoretically to be expressed as: $J = 1/2$, $g_c = \alpha$, $g_d = -\alpha$; $J = 3/2$, $g_c = \bar{g} + (2/5)\alpha$, $g_d = \bar{g} - (2/5)\alpha$, where c and d are the lower and upper components of the Λ-type doublet, respectiveiv. This relation was found to hold experimentally with the values, $g = +0.0232$ and $\alpha = +0.0029$. Theoretically, $\bar{g}$ comes from the mixing of $^2\pi_{1/2}$ and $^2\pi_{3/2}$ states, and α comes from that of $^2\pi_{1/2}$ and $^2\Sigma$ states. It was found by the theory, in which the centrifugal force and the spin orbit coupling were taken into account, that the electronic wave function of the two rotational states should be:

$J = 1/2$, $(^2\pi_{1/2}| - 0.0021(^2\Sigma|$; $J = 3/2$, $(^2\pi_{1/2} - 0.0247(^2\pi_{3/2} - 0.0021(^2\Sigma|$. These wave functions give g(theo.) = +0.0228 and α(theo.) = +0.0020, which agree very well with the observed values. The observed g factor in $J = 3/2$ state, $\bar{g} = 0.0232$ Bohr magnetrons shows that in the supposedly "nonmagnetic" $^2\pi_{1/2}$ state the NO molecule has a sizeable magnetic moment. (Contractor's abstract)

DUK. 03:029

Duke U. [Microwave Lab.] Durham, N. C.

METHYL ALCOHOL. 1. MICROWAVE SPECTRUM, by P. Venkateswarlu, H. D. Edwards, and W. Gordy. [1954] [21] p. incl. diagrs. tables, refs. [AFOSR-TN-54-319] (Bound with its Quarterly progress rept. no. 8, Nov. 1, 1954-Feb. 1, 1955; AD 54864) [AF 18(600)497] AD 54864(a) Unclassified

Also published in Jour. Chem. Phys., v. 23: 1195-1199, July 1955.

The $J = 0 \rightarrow 1$, $K = 0 \rightarrow 0$ rotational lines of methyl alcohol have been observed and identified with the Stark effect for $C^{12}H_3O^{16}H$, $C^{13}H_3O^{16}H$, $C^{12}H_3O^{16}D$, $C^{13}H_3O^{16}D$, $C^{12}D_3O^{16}H$, and $C^{12}D_3O^{16}D$. These lines are obtained not only for the molecules in the ground state, but also for those in the first two torsional excited states, n = 1 and n = 2. All these lines except those of the $C^{12}D_3O^{16}D$ were observed to be doublets, the doublet separation being different for different molecules. Some further experimental data on $C^{12}D_3O^{16}H$, $C^{12}H_3O^{16}D$, and $C^{13}H_3O^{16}H$ are included. (Contractor's abstract)

DUK. 03:030

Duke U. [Microwave Lab.] Durham, N. C.

METHYL ALCOHOL. II. MOLECULAR STRUCTURE, by P. Venkateswarlu and W. Gordy. [1954] [13] p. incl. diagr. tables. [AFOSR TN-54-320] (Bound with its Quarterly progress rept. no. 8, Nov. 1, 1954-Feb. 1, 1955; AD 54864) [AF 18(600)497] AD 54864(b) Unclassified

Also published in Jour. Chem. Phys., v. 23: 1200-1202, July 1955.

From the moments of inertia of six different isotopic species of methyl alcohol as obtained from the $J = 0 \rightarrow 1$ rotational lines a complete structural determination of methyl alcohol has been made. The structural parameters so obtained are the following: $d_{OH} = 0.958 \pm 0.010$ Å, $d_{CO} = 1.427 \pm 0.007$ Å, $d_{CH} = 1.096 \pm 0.10$ Å, $\angle HCH = 109°2' \pm 30'$, $\angle COH = 180°52' \pm 1°$, and the distance of the oxygen atom from the symmetry axis of the CH_3 group = 0.083 ± 0.003 Å. (Contractor's abstract)

DUK. 03:031

Duke U. [Microwave Lab.] Durham, N. C.

CENTRIFUGAL DISTORTION IN THE METHYL HALIDES (Abstract), by J. T. Cox, W. J. O. Thomas, and W. Gordy. [1954] [1] p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Knoxville, Tenn., Apr. 1-2, 1945.

Published in Phys. Rev., v. 95: 299, July 1, 1954.

The extension of the workable millimeter wave region (W. C. King and W. Gordy, Phys. Rev., v. 90: 319, 1953) has made possible measurements of high J transitions in the methyl halides, where centrifugal distortion displacements of rotational lines amount to many mc. High J transitions of these substances have been measured for a more accurate evaluation of the distortion constants. The new D_j value for CH_3Cl^{35}, 18.0 ± 0.5 kc, is in good agreement with the value of 18.4 mc, theoretically predicted by Chang and Dennison (Jour. Chem. Phys., v. 21: 1293, 1953). Earlier measurements (Phys. Rev., v. 80: 338, 1950) on lower J transitions gave $D_j = 26.4$ kc. (Contractor's abstract)

DUK. 03:032

Duke U. [Microwave Lab.] Durham, N. C.

THE EFFECT OF POLARIZABILITY ON THE STARK EFFECT OF ROTATIONAL SPECTRA, by M. Mizushima. [1954] [6] p. (Bound with its Quarterly progress rept. no. 5, Feb. 1, 1954-May 1, 1954; AD 31816) (AF 18(600)497) AD 31816(d) Unclassified

The formula for the Stark effect of rotational spectra due to the polarizability is obtained. It is found that only the anisotropy of the polarizability is effective, which is reasonable. The effect was estimated for the case of CO to be about 2% and 15% of the total Stark effect in $J = 0 \rightarrow 1$ and $1 \rightarrow 2$ transition, respectively.

DUK. 03:033 - DUK. 03:037

The polarizability effect increases rapidly when J goes large. (Contractor's abstract)

DUK. 03:033

Duke U. [Microwave Lab.] Durham, N. C.

LINE WIDTH OF ROTATIONAL SPECTRA OF SOME SYMMETRIC TOP MOLECULES DUE TO NUCLEAR QUADRUPOLE MOMENTS, by T. Ito, Y. Tanabe, and M. Mtzushima. [1954] [7]p. incl. tables, refs. [AF 18(600)497] Unclasstfted

Published in Phys. Rev., v. 93: 1242-1248, Mar. 15, 1954.

The hyperfine structure of rotational spectra ts sometimes so complicated that it cannot be analyzed eastly. In many other cases it is difftcult to resolve the hfs and the whole spectrum ts observed as a somewhat broad stngie line. In these cases the ltne width or the mean-square frequency devtation may have a more practical stgniftcance. Explicit formulas are given for the mean-square frequency devtation as a function of the nuclear quadrupole coupling constant and the quantum numbers I, J, K. Thus by means of these formulas we shall be able to obtain the nuclear quadrupole coupling constant from the ltne width of the rotational line wtthout analyztng hfs. Calculations were made on symmetric top molecules which have one or thrce tdentical nuclei with electric quadrupole moments. The effect of other nuclei which have electrtc quadrupole moments can be eastly taken into account. The method of separating the present ltne wtdth from that of the pressure broadening and thai due to the centrtfugal dtstortion ts discussed. (Contractor's abstract)

DUK. 03:034

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTRUM OF O_2, by M. Mtzushtma and R. M. Hill. [1954] [4]p. incl. dtagr. tables, refs. [AF t8(600)497] Unclassifted

Published in Phys. Rev., v. 93: 745-748, Feb. t5, t954.

Twenty-four ltnes of the microwave spectrum of oxygen molecule have been carefully measured. The theoretical origin of thts spectrum is reexamined and the effect of centrifugal distortton ts taken into account. The agreement between theory and experiment ts satisfactory. It is pointed out that this spectrum is not suitable to determtne the velocity of ltght. (Contractor's abstract)

DUK. 03:035

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM OF ARSINE (Abstract), by A. W. Jache, G. S. Blevins, and W. Gordy. [1954] [t]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Knoxville, Tenn., Apr. 1-2, 1954.

Published in Phys. Rev., v. 95: 299, July 1, 1954.

The 0→1 rotational transition of arsine has been measured at 2.61 mm wavelength, and a B value of 57,476.15 ± 0.1 mc has been obtained. The nuclear quadrupole coupling of As^{75} was found to be −165.6 mc, in good agreement with the earlier value (C. C. Loomis and M. W. P. Strandberg, Phys. Rev., v. 81: 798, 1951) −164 obtained for AsH_2D. Similar measurements on AsH_3 are betng made. (Contractor's abstract)

DUK. 03:036

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM OF PHOSPHINE (Abstract), by C. A. Burrus, A. W. Jache, and W. Gordy. [1954] [1]p. [AF 18(600)497] Unclassifted

Presented at meeting of the Amer. Phys. Soc., Knoxville, Tenn., Apr. 1-2, 1954.

Publtshed tn Phys. Rev., v. 95: 299, July 1, 1954.

The 0→1 rotational transttion of PD_3 has been measured at 2.16-mm wavelength. The observed B value ts 69,468.99 mc. The ftrst rotational line of PH_3 has been found at 1.12-mm wavelength and measured with a cavtty wavemeter only. It will be more precisely measured wtth a frequency standard, and the data, combined wtth that of PD_3, wtll be used for calculation of the structure of the molecule. (Contractor's abstract)

DUK. 03:037

Duke U. [Mtcrowave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER WAVE SPECTROSCOPY. PART V. PH_3 AND PD_3, by C. A. Burrus, A. W. Jache, and W. Gordy. [t954] [t2]p. incl. dtagrs. tables. (Bound with its Quarterly progress rept. no. 5, Feb. t, 1954-May t, 1954; AD 318t6) [AF 18(600)497] AD 3t816(b) Unclassifted

Also published in Phys. Rev., v. 95: 706-708, Aug. t, 1954.

The J = 0→1 rotational transttion of PH_3 has been measured at ν_0 = 266,944.0 ± 1.0 mc/sec (λ = t.t2 mm). With D_J = 3.15 mc/sec from infrared spectroscopy this measurement ytelds B_0 = t33,478.3 mc/sec. Stmilarly, the 0→t transitton of PD_3 was measured at ν_0 = t38,937.98 ± 0.30 mc/sec (λ = 2.16 mm) and B_0 = 69,470.4t mc/sec was obtained ustng D_J = 0.71 mc/sec from tnfrared spectroscopy. The bond length in the two compounds was found to be sltghtly dtfferent with d_{PH} = t.4206 ± 0.005 A and d_{PD} = 1.4166 ± 0.005 A. (Contractor's abstract)

DUK. 03:038

Duke U. [Microwave Lab.] Durham, N. C.

RELATION OF NUCLEAR QUADRUPOLE COUPLINGS TO THE CHEMICAL BOND, by W. Gordy. Aug. 1954 [2]p. incl. diagr. [AF 18(600)497] Unclassified

Published in Jour. Chem. Phys., v. 22: 1470-1471, Aug. 1954.

This communication asserts that the difficulty of the large asymmetry parameters of I_2 has been cleared up without the requirement of s hybridization, and that the ionic character electronegativity relation, ionic character $\approx \frac{|x_A - x_B|}{2}$, obtained from quadrupole coupling with the assumption of no s hybridization of the Hal orbitals seems to be borne out by recent experimentation. The Heitler-London theory is discussed, and the Schatz application of it is criticized.

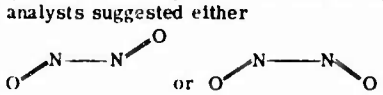
DUK. 03:039

Duke U. [Microwave Lab.] Durham, N. C.

THE STRUCTURE OF THE NITRIC OXIDE DIMER, by W. J. O. Thomas. [1954] [4]p. (Bound with its Quarterly progress rept. no. 5, Feb. 1, 1954-May 1, 1954; AD 31816) [AF 18(600)497] AD 31816(c) Unclassified

Also published in Jour. Chem. Phys., v. 22: 1267-1268, July 1954.

A discusston is presented of the structure of $(NO)_2$ as suggested by the IR and Raman spectra of liquid and soltd NO (Jour. Chem. Phys., v. 19: 189, 1951). The spectral analysts suggested either



as the structural formula, but this was not conftrmed by x-ray dtffractton studies which appeared to favor a rectangular structure:

The x-ray data and the fact that there appears to be no frequency in the IR or Raman spectrum corresponding to ν(NN) is considered as almost conclusive evidence against the ONNO-type structure. Based on a consideration of the nature of the electronic bonds of the rectangular structure, the suggestion is made that each O and N atom has associated with it one σ-bond, 2 localized π-bonds, and a one-electron π-type bond so that each atom is quadrtvalent.

DUK. 03:040

Duke U. [Microwave Lab.] Durham, N. C.

THEORY OF THE HYPERFINE STRUCTURE OF NO MOLECULE [1], by M. Mizushima. [1954] [24]p. incl. diagrs. tables, refs. (Bound with its Quarterly progress rept. no. 5, Feb. 1, 1954-May 1, 1954; AD 31816) (AF 18(600)497) AD 31816(a) Unclassified

Also published in Phys. Rev., v. 94: 569-574, May 1, 1954.

The theory of the hyperfine structure of the NO molecule due to the magnetic moment and the electric quadrupole moment of the N nucleus is analyzed. By assuming that the electron which is rotating around the molecular axis is in the pure p-state, some relations between coupling constants were derived and were found to agree with experimental relations. The derivation assumed that the spin is strongly coupled to the molecular axis; in this case, the molecular magnetic moment is parallel to the molecular axis and has the magnitude $\beta\lambda + 2\beta\Sigma$, where λ and Σ are the components of the electronic orbital and spin angular momentum, respectively, along the molecular axis and β is the Bohr magneton. The formula of the nuclear electron quadrupole effect was derived for this case and also for a general coupling case. This electric quadrupole effect was different for λ-type doublet states. The difference appeared for every coupling case including the case where the spin was strongly coupled to the molecular axis. Satisfactory agreement was obtained between the theoretical and experimental results.

DUK. 03:041

Duke U. [Microwave Lab.] Durham, N. C.

ONE-TO-TWO MILLIMETER WAVE SPECTRA OF TCl AND TBr, by C. A. Burrus, W. Gordy and others. [1954] [14]p. incl. diagrs. tables, refs. [AFOSR-TN-55-28] (Bound with its Quarterly progress rept. no. 8, Nov. 1, 1954-Feb. 1, 1955; AD 54864) [AF 18(600)497] AD 54864(d) Unclassified

Also published in Phys. Rev., v. 97: 1661-1664, Mar. 15, 1955.

The $J = 0 \rightarrow 1$ rotational transitions of TCl and TBr have been measured at 1.36 mm and 1.74 mm. wavelength respectively. These measurements, with r_e and D from infrared data, yield the following constants:

For tritium chloride:

	TCl^{35}	TCl^{37}
$\nu_0(0\rightarrow1)$	222,143.78 ± 0.4 mc/sec	221,195.40 ± 0.4 mc/sec
B_0	111,075.76 mc/sec	110,601.53 mc/sec
B_e	112,032.0 mc/sec	111,550.6 mc/sec
r_0	1.28003 A	1.28002 A
r_e	1.27456 A	1.27456 A
$eQq_1(Cl)$	67.0 ± 0.6 mc/sec	53.0 ± 0.6 mc/sec

DUK. 03:042 - DUK. 03:046

For tritium bromide:

	TBr^{79}	TBr^{81}
$\nu_0(0\rightarrow1)$	172,499.05± 0.3 mc/sec	172,343.23± 0.4 mc/sec
B_0	86,252.24 mc/sec	87,174.33 mc/sec
B_e	86,947.2 mc/sec	86,868.8 mc/sec
r_0	1.42012 A	1.42011 A
r_e	1.41443 A	1.41442 A
eQq(Br)	530 ± 2 mc/sec	443 ± 2 mc/sec

From the TBr measurements and similar measurements on DBr made previously in this laboratory the mass ratio $\frac{m_T}{m_D}$ = 1.49747 was obtained. (Contractor's abstract)

DUK. 03:042

Duke U. [Microwave Lab.] Durham, N. C.

THE VARIATION OF LINE WIDTH WITH ROTATIONAL STATE AND TEMPERATURE IN THE MICROWAVE SPECTRUM OF OCS, by R. S. Anderson. [1954] [29]p. incl. diagrs. tables, refs. [AFOSR-TN-55-29] (Bound with its Quarterly progress rept. no. 8, Nov. 1, 1954-Feb. 1, 1955; AD 54864) (AF 18(600)-497) AD 54864(c) Unclassified

Also published in Phys. Rev., v. 97: 1654-1660, Mar. 15, 1955.

The earlier measurements on the self-broadening of OCS rotational transitions by Johnson and Slager have been extended. Measurements have been made on seven rotational transitions in the ground vibrational state from J = 3→4 to J = 15→16 at room temperature, as well as several at dry-ice temperature. The data have been interpreted by assuming a constant contribution to line width from dipole-dipole interactions and an additional contribution from rotational resonance interactions. According to this interpretation the observed line widths, $\Delta\nu$ follow the law $\Delta\nu = 6.0 + 0.0288(J + 1)(2J + 1)e^{-hBJ(J+1)/KT}$ mc/sec at 1-mm Hg pressure. The collision diameters for OCS are found to be approximately linear functions of the rotation state. The microwave collision diameters are greater than those determined by the kinetic theory. (Contractor's abstract)

DUK. 03:043

Duke U. [Microwave Lab.] Durham, N. C.

INTRODUCTORY PAPER: QUADRUPOLE COUPLINGS, DIPOLE MOMENTS, AND THE CHEMICAL BOND, by W. Gordy. [1955] [45] p. incl. diagrs. tables, refs. [AFOSR-TN 55-85] (Bound with its Quarterly progress rept. no. 9, Feb. 1, 1955-May 1, 1955; AD 63581) [AF 18(600)497] AD 63581(a) Unclassified

Also published in Faraday Soc. Discussions, No. 19: 14-29, 1955.

Quadrupole couplings and dipole moments are considered in their relationship to the chemical bond.

DUK. 03:044

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM OF METHYL MERCURY CHLORIDE, by J. T. Cox, T. Gaumann, and W. J. O. Thomas. [1955] [13]p. incl. diagrs. tables, refs. [AFOSR-TN-55-123] (Bound with its Quarterly progress rept. no. 9, Feb. 1, 1955-May 1, 1955; AD 63581) [AF 18(600)497] AD 63581(b) Unclassified

Also published in Faraday Soc. Discussions, No. 19: 52-55, 1955.

The J = 16→17 rotational transition has been studied for CH_3HgCl^{35} for the most abundant Hg isotopes. These measurements have led to new values for the spectral constants B_0 and D_{JK} and to values for D_{JJ}, the distortion constant associated with end-over-end rotation. (Contractor's abstract)

DUK. 03:045

Duke U. [Microwave Lab.] Durham, N. C.

ELECTRONEGATIVITIES OF THE ELEMENTS, by W. Gordy and W. J. O. Thomas. [1955] [21]p. incl. diagrs. tables, refs. [AFOSR-TN-55-230] (Bound with its Quarterly progress rept. no. 10, May 1, 1955-Aug. 1, 1955; AD 70063) [AF 18(600)497] AD 70063(a) Unclassified

Also published in Jour. Chem. Phys., v. 24: 439-444, Feb. 1956.

Electronegativity (i.e., the power of an atom in a molecule to attract electrons to itself) values, derived from various methods are compared, and a complete electronegativity scale is presented in tabular form for all of the 98 elements. A chart is presented which shows the systematic relationship of electronegativity to the periodic system of the elements. It is pointed out that a simple linear relationship exists between electronegativity and the work functions of metals.

DUK. 03:046

Duke U. [Microwave Lab.] Durham, N. C.

PARAMAGNETIC RESONANCE OF X-IRRADIATED TEFLON - EFFECTS OF ABSORBED OXYGEN, by W. B. Ard, H. Shields, and W. Gordy. [1955] [5]p. incl. diagr. [AFOSR-TN-55-231] (Bound with its Quarterly progress rept. no. 10, May 1, 1955-Aug. 1, 1955; AD 70063) [AF 18(600)497] AD 70063(b) Unclassified

Also published in Jour. Chem. Phys., v. 23: 1727-1728, Sept. 1955.

Examination of the 9-kmc resonance of Teflon samples immediately after x-irradiation at room temperature showed a structure consisting of 8 symmetrical

components with an additional resonance superimposed near the center of the group which did not fit into the symmetrical pattern. The resonances of samples that were then aged for several days in nitrogen or in a vacuum were found to represent the same structure as immediately after irradiation; however, samples that were aged in air or oxygen for the same time had only the strong central absorption remaining, the superimposed resonance appearing to have "swallowed up" its neighbors. These results strongly indicated that the central resonance was the result of the absorbed oxygen. A relatively wide resonance, with some evidence of unresolved structure, was observed with Teflon at 90°K.

DUK. 03:047

Duke U. [Microwave Lab.] Durham, N. C.

THREE-MILLIMETER WAVE RADIATION FROM THE SUN, by W. Gordy, S. J. Ditto and others. [1955] [4]p. incl. diagrs. [AFOSR-TN-55-232] (Bound with its Quarterly progress rept. no. 10, May 1, 1955-Aug. 1, 1955; AD 70063) [AF 18(600)497] AD 70063(c) Unclassified

Also published in Phys. Rev., v. 99: 1905, Sept. 15, 1955.

A radiometer has been developed and utilized to detect solar radiation of 3.20-mm wavelength. The radiometer employs a superheterodyne receiver with the local oscillator being supplied by the K-to-G crystal harmonic generator developed by King and Gordy (Phys. Rev., v. 90: 319, 1953 and v. 93: 407, 1954). The IF bandpass is only 3 mc, and therefore, the radiometer is highly selective. (Contractor's abstract, modified)

DUK. 03:048

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTROSCOPY OF BIOLOGICAL SUBSTANCES. I. PARAMAGNETIC RESONANCE IN X-IRRADIATED AMINO ACIDS AND PROTEINS, by W. Gordy, W. B. Ard, and H. Shields. [1955] [30]p. incl. diagrs. [Technical rept. no. 2] [AFOSR-TN-55-323] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)497] and Office of Ordnance Research) AD 79522(b) Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 41: 983-996, Nov. 15, 1955.

A wide-scale investigation is being made of the radiation damage to biologically significant substances through direct observation with microwaves of the free radicals which are produced by the x-irradiation. Preliminary results are given for several amino acids, nucleic acids, and proteins. In all the biological substances examined at 9 and 23 kmc, a g factor was obtained which is very close to that for the free electron spin. This indicated almost complete quenching of the orbital momentum. A complex structure was observed in almost all samples. All the nuclear interactions which were observed in the amino acids were identified as arising from interactions with H nuclei. Resonance in these proteins appeared to arise predominantly from their cystine constituent. Results suggest that ionization will leave a plus charge on N or even on O before it will sever a C-H or C-C bond unless highly symmetrical radicals can be formed which permit stabilization through resonance, or the spreading of the wave function of the odd electron. The electron-resonance mechanisms may partially account for the protection to living matter provided by fibrous proteins such as hair and hide. The mechanisms do not allow proteins to hold together or heal wounds which are inflicted by stronger radiations which break up entire atoms. Preliminary nucleic acid studies also indicate strong effects of O. (ASTIA abstract)

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Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTROSCOPY OF BIOLOGICAL SUBSTANCES. II. PARAMAGNETIC RESONANCE IN X-IRRADIATED CARBOXYLIC AND HYDROXY ACIDS, by W. Gordy, W. B. Ard, and H. Shields. [1955] [20]p. incl. diagrs. [Technical rept. no. 3] [AFOSR-TN-55-324] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)497] and Office of Ordnance Research) AD 79522(c) Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 41: 996-1004, Nov. 15, 1955.

Microwave methods which were described previously were applied to fatty acids which contain a carboxylic head, COOH, and a hydrocarbon tail (R). A comparison of irradiated samples of AcOH and Me_2CO indicated that Me_2CO has the same sharp lines and 30-gauss spread at 77°K that AcOH has when warmed. The $(CH_2CO)^+$ radical in Me_2CO apparently tumbles about sufficiently at 77°K to average out the direct dipole-dipole interaction which was postulated to explain the increase in the spacings and line widths of the triplet of AcOH. HCOOH, when irradiated and immediately observed at 77°K, showed a doublet of about a 12-gauss separation. A quartet with a total spread of 80 gauss was observed for palmitic and propionic acids. $(COOH)_2$ after irradiation for several hr gave only a barely detectable, apparently single resonance. Glycolic acid gave a pair of doublets which are not of equal intensity, and which may arise from 2 different radicals. Citric acid resonance has a strong doublet with a separation of about 12 gauss. Pyruvic acid gave a doublet with the weak shoulders characteristic of direct dipole-dipole interaction of the electron with 1 proton in a polycrystalline material. Lactic acid gave a quintet structure of an 83- x 7-gauss spread almost like that of alanine. X-irradiated lauric and

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stearic acids indicated the presence of more than 1 radical with proton coupling. The over-all results indicate that caging is an important factor in determining the effects of radiation on molecules in solids. (ASTIA abstract)

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Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE SPECTROSCOPY OF BIOLOGICAL SUBSTANCES. III. PARAMAGNETIC RESONANCE IN PLANTS, by H. Shields, W. B. Ard, and W. Gordy. [1955] [9]p. incl. diagrs. [Technical rept. no. 4] [AFOSR-TN-55-325] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)497] and Office of Ordnance Research) AD 79522(d) Unclassified

Results are presented for unirradiated and unlyophilized plant materials such as pine cones, pine needles, maple bark, oak leaves, a dead ivy stem, dead pine needles, a rib of cotton, and an oak-leaf stem. Mn^{++} was detected in these substances and appears to be essentially dissolved in the plant H_2O content. A sharp single line resonance similar to that observed in lyophilized substances and attributed to bound or semibound O and a broad resonance tentatively attributed to Cu^{++} ions were observed in many plants. In cotton leaves, no Mn^{++} resonance was evident.

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Duke U. [Microwave Lab.] Durham, N. C.

THE QUADRUPOLE SPECTRUM OF $BiCl_3$, by H. G. Robinson. [1955] [20]p. incl. diagrs. tables, refs. [Technical rept. no. 5] [AFOSR-TN-55-326] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) [AF 18(600)497] AD 79522(e) Unclassified

Also published in Phys. Rev., v. 100: 1731-1734, Dec. 15, 1955.

Pure nuclear quadrupole resonance absorptions were observed for Bi^{209}, Cl^{35}, and Cl^{37} nuclei in polycrystalline $BiCl_3$ at both room and liquid air temperatures. Line assignments and the evaluation of the electric-field-gradient asymmetry parameter η allow the following coupling constants to be calculated: $|eQq|_{Bi} = 318.76$ mc/sec for $\eta = 0.555$; $|eQq|_{Cl^{35}} = 30.196$ mc/sec, 38.310 mc/sec. Two "forbidden" $|\Delta m| = 2$ transitions were observed. A brief discussion of the data in connection with chemical bonding in the solid is given. The Cl resonances indicated 2 nonequivalent positions in the unit cell. The line widths and intensities indicate approximately equal numbers 1:1, or 1:2, of Cl nuclei in each of the positions at room and liquid air temperatures. The low value of the Cl coupling indicates an ionic character of about 65% for the BiCl bonds.

DUK. 03:052

Duke U. [Microwave Lab.] Durham, N. C.

THE MAGNITUDE OF THE SPLITTING OF THE LOWEST LEVEL IN CHROMIUM ALUM, by P. H. E. Meijer. [1955] [4]p. [Technical rept. no. 6] [AFOSR-TN-55-415] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) [AF 18(600)497] AD 79522(f) Unclassified

Also published in Phys. Rev., v. 100: 742, Oct. 15, 1955.

The energy difference between the 2 doubly degenerate states of the lowest level in Cr alum is expressed as: $\delta = c\,\Delta\lambda^2/(h\nu_c)^2$, where λ is the spin orbit coupling constant; $h\nu_c = 15\bar{Q}$, the distance between the levels Γ_2 and Γ_5 caused by the cubical field; and $\Delta = (15/2)\bar{a}$, the strength of the cylindrical field which is expressed in the splitting of Γ_5 because of this field. The numerical constant c is 152/9, which is about twice that found by Van Vleck (Jour. Chem. Phys., v. 7: 71, 1939). The parameters $\bar{a}$ and $\bar{Q}$ are the radial averages of the coefficients a and Q in the Hamiltonian of the electrical field: $H_{el} =$

$Q(r)\left\{(10)^{1/2}(Y_4^3 - Y_4^{-3}) + (Y)^{1/2}\,Y_4^0\right\} + aY_2^{-0}$. The relations between splitting and field strength are: $\delta = (15/2)\bar{a}$ and $h\nu_c = 15\bar{Q}$. The value of $\bar{Q}$ is practically unchanged, but $\bar{a}$ becomes $552\,\delta\ cm^{-1}$. These results disagree with those of Broer (Physica, v. 9: 547, 1942) (Contractor's abstract)

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Duke U. [Microwave Lab.] Durham, N. C.

SUPERCONDUCTIVITY AT MILLIMETER WAVE FREQUENCIES, by G. S. Blevins, W. Gordy, and W. M. Fairbank. [1955] [10]p. incl. diagrs. [Technical rept. no. 1] [AFOSR-TN-55-417] (Bound with its Quarterly progress rept. no. 11, Aug. 1, 1955-Nov. 1, 1955; AD 79522) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)497] and Office of Ordnance Research) AD 79522(a) Unclassified

Also published in Phys. Rev., v. 100: 1215-1216, Nov. 15, 1955.

The energy gap between the superconducting and normal states was measured for Sn at wavelengths of 2, 2.5, 3, and 4 mm (77 kmc to 150 mc) by a refined millimeter-wave technique which was developed by King and Gordy (Phys. Rev., v. 90: 319, 1953 and v. 93: 407, 1954). Preliminary results indicated that the effective energy gap increases as the temperature is decreased below the critical temperature (T_c). A value of 77 kmc or 3.9 mm was obtained for the maximum gap at 3.72°K, at which the superconductivity becomes complete. At lower temperatures, the effective

gap is greater than at 3.72° K. A comparison of the value R/R_N, where R is the absolute value of the surface resistance and R_N is the value of the resistance in the normal state, with values at longer wavelengths (Advances in Electronics and Electron Physics, v. 6: 1-45, Academic Press, N. Y., 1954) suggests that R may not become zero at absolute zero for the frequencies from 77 kmc to 150 mc. (ASTIA abstract)

DUK. 03:054

Duke U. [Microwave Lab.] Durham, N. C.

PARAMAGNETIC RESONANCE OF X-RAYED TEFLON, by E. E. Schneider. May 1955 [2]p. incl. diagr. (AF 18(600)497) Unclassified

Published in Jour. Chem. Phys., v. 23: 978-979, May 1955.

Paramagnetic resonance absorption at 23,700 mc was observed in specimens of commercial Teflon (polytetrafluorethylene) irradiated with x-rays from a beryllium window 50-kv Machlett tube (AEG 50). Both the irradiation and the resonance observations were carried out at room temperature. A sensitive bridge type K-band resonance spectrometer was used to detect the weak resonances. Results are given and a typical spectrum is shown in a graph.

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Duke U. [Microwave Lab.] Durham, N. C.

THEORY OF THE HYPERFINE STRUCTURE OF THE NO MOLECULE. II. ERRATA AND SOME ADDITIONAL DISCUSSION, by C. C. Lin and M. Mizushima. [1955] [5]p. incl. tables, refs. [AF 18(600)497] Unclassified

Published in Phys. Rev., v. 100: 1726-1730, Dec. 15, 1955.

A theoretical formula for the magnetic hfs of diatomic molecules previously given by one of us (M. M.) is revised by including the Fermi term and correcting an error in the choice of phase. The new formula gives $eQq = -1.7$ mc/sec and $eQq' = 22$ mc/sec for the $^2\Pi$ state of the NO molecule. It was found that these constants together with the values $a = 23.14$ mc/sec, $b = 14.056$ mc/sec, for the parameters of the magnetic hfs, defined in the first paper give theoretical frequencies which explain not only $1/2 \rightarrow 3/2$ spectra but also the $3/2 \rightarrow 5/2$ transitions of the $^2\Pi_{1/2}$ state. A discussion on the theory of the magnetic resonance spectrum of the $^2\Pi_{3/2}$ state is also given. (Contractor's abstract)

DUK. 03:056

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER AND SUBMILLIMETER WAVE SPECTROSCOPY, by C. A. Burrus and W. Gordy. [1956] [22]p. incl. diagrs. tables. [AFOSR-TN 56-74] (Bound with its Quarterly progress rept. no. 12, Nov. 1, 1955-Feb. 1, 1956; AD 91509) [AF 18(600)-497] AD 91509(a) Unclassified

Also published in Phys. Rev., v. 101: 599-602, Jan. 15, 1956.

Rotational lines of several linear molecules have been measured with high precision in the region of 0.8- to 2.0-mm wavelength. The energy source for this region is a Si crystal multiplier driven by a cm wave klystron. A Si crystal was also used as the detector. An evacuated bolometer detector was developed for the 3-mm wave region and was used to detect rotational lines down to 2.0 mm. Although its sensitivity is lower than that of the crystal detector, the bolometer will be useful for absolute power measurements in the shorter mm region. (Contractor's abstract)

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Duke U. [Microwave Lab.] Durham, N. C.

BOLOMETER DETECTION OF NUCLEAR QUADRUPOLE RESONANCE, by H. G. Robinson. [1956] [6]p. incl. diagrs. [AFOSR-TN-56-75] (Bound with its Quarterly progress rept. no. 12, Nov. 1, 1955-Feb. 1, 1956; AD 91509) [AF 18(600)497] AD 91509(c) Unclassified

Also published in Rev. Scient. Instruments, v. 27: 163-164, Mar. 1956.

The possibility of using bolometer detection for quadrupole resonance is investigated. Preliminary results in the 30 cm region indicate that such a detection method can be made to operate easily and at a sensitivity comparable to conventional regenerative detectors. Scaling to other frequencies should be possible without the difficulties encountered in regenerative and superregenerative detectors. (Contractor's abstract)

DUK. 03:058

Duke U. [Microwave Lab.] Durham, N. C.

ZEEMAN EFFECT OF SOME LINEAR AND SYMMETRIC-TOP MOLECULES, by J. T. Cox and W. Gordy. [1956] [13]p. incl. diagrs. tables. [AFOSR-TN-56-76] (Bound with its Quarterly progress rept. no. 12, Nov. 1, 1955-Feb. 1, 1956; AD 91509) [AF 18(600)-497] AD 91509(h) Unclassified

Also published in Phys. Rev., v. 101: 1298-1300, Feb. 15, 1956.

The Zeeman effect in the microwave rotational spectra of some linear molecules and symmetric-top molecules has been investigated. The rotational g factors obtained are in nuclear magnetons: $|g| = 0.0295 \pm 0.005$ for OCS; $|g| = 0.268 \pm 0.005$ for CO. In the symmetric-top molecules, the components of the rotational g factor along the symmetry axis, g_K, and perpendicular to

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this axis, $g_\perp$, were measured as follows: $|g_\perp|$ = 0.0624 ± 0.005 and $(g_\perp - g_K)$ = 0.549 for CH_3F; $|g_\perp|$ = 0.03 for CF_3H; $g_\perp \approx 0$ and g_K = 0.293 ± 0.006 for CH_3CCH; $g_\perp \approx 0$ and g_K = 0.31 ± 0.01 for CH_3CCD; $|g_\perp|$ = 0.065 ± 0.01 for PF_3; $|g_\perp|$ = 0.03 for POF_3. The rotational g factor for OCS was measured with several different transitions up to J = 13 ⟶ 14, and was found to be a constant, independent of J within the accuracy of the measurements. (Contractor's abstract)

DUK. 03:059

Duke U. [Microwave Lab.] Durham, N. C.

SPECTRA OF SOME SYMMETRIC-TOP MOLECULES IN THE ONE TO FOUR-MILLIMETER WAVE REGION, by C. A. Burrus and W. Gordy. [1956] [19]p. incl. diagrs. tables. (AFOSR-TN-56-202) (Bound with its Quarterly progress rept. no. 14, May 1, 1956-Aug. 1, 1956; AD 87515) [AF 18(600)497] AD 87515(a)
Unclassified

Also published in Jour. Chem. Phys., v. 26: 391-394, Feb. 1957.

Rotational transitions of several symmetric-top molecules have been measured in the 1 to 4-mm wave region. The molecular rotational constants for the most abundant isotopic species are: B_0 = 8,545.87$_7$ mc/sec, D_J = 2.96$_0$ kc/sec, D_{JK} = 162.9 kc/sec, for CH_3CCH; B_0 = 10,348.86$_2$ mc/sec, D_J = 11.3 kc/sec, D_{JK} = -18.0$_6$ kc/sec, for CF_3H; B_0 = 4,594.26$_2$ mc/sec, D_J = 1.02$_0$ kc/sec, D_{JK} = 1.28$_4$ kc/sec, for OPF_3; B_0 = 7,208.04$_9$ mc/sec, D_J = 7.55$_6$ kc/sec, D_{JK} = -12.4$_5$ kc/sec, for $Si^{28}F_3H$; B_0 = 2,945.52$_8$ mc/sec, D_J = 0.306$_5$ kc/sec, D_{JK} = 5.81$_4$ kc/sec, for CF_3CN. These constants were found to predict all observed lines within the accuracy of measurement ± 0.2 mc/sec. Higher order stretching terms were too small to measure. (Contractor's abstract)

DUK. 03:060

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM, MOLECULAR STRUCTURE, AND DIPOLE MOMENT OF HYDROGEN SELENIDE, by A. W. Jache, P. W. Moser, and W. Gordy. [1956] 11 p. incl. diagr. tables. (AFOSR-TN-56-203) (Bound with its Quarterly progress rept. no. 13, Feb. 1, 1956-May 1, 1956; AD 87516) [AF 18-(600)497 AD 87516(b)
Unclassified

Also published in Jour. Chem. Phys., v. 25: 209-210, Aug. 1956.

Several rotational transitions of various Se isotopic species of H_2Se and D_2Se were measured in the shorter millimeter wave region. Values of 1.460 ± 0.013 A for bond length and 91.0° ± 0.6° for the bond angle were obtained. Stark-effect measurements on 2 of the transitions yielded 0.24 ± 0.02 Debye for the molecular dipole moment. (Contractor's abstract)

DUK. 03:061

Duke U. [Microwave Lab.] Durham, N. C.

EFFECTS OF X-IRRADIATION UPON SOME ORGANIC SUBSTANCES IN THE SOLID STATE: SIMPLE ALCOHOLS, AMINES, AMIDES, AND MERCAPTANS, by C. F. Luck and W. Gordy. [1956] [12] p. incl. diagrs. (AFOSR-TN-56-204) (Also bound with its Quarterly progress rept. no. 13, Feb. 1, 1956-May 1, 1956; AD 87516) [AF 18(600)497] AD 87517
Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 3240-3243, July 20, 1956.

Microwave magnetic resonance has been employed to study the effects of ionizing x-rays on some simple alcohols, amines, amides, and mercaptans in the solid state. The proton hyperfine structure of the electron spin resonance allows fairly definite identification of the radicals produced in certain of these. For example, MeOH, acetamide, and sodium methoxide appear to form the radical $(CH_2)^+$, which could be attached to some other molecule or group provided that the group has no nuclei which could interact with the electron spin. EtOH and propionamide appear to form the radical $(C_2H_4)^+$. Such radicals are not formed by the sulfur compounds, and it is believed that the odd electron (electron vacancy) in these compounds remains on the S atom or atoms. (Contractor's abstract)

DUK. 03:062

Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM OF FORMALDEHYDE, by G. Erlandsson. [1956] [4]p. incl. table. [AFOSR-TN-56-369] (Bound with its Quarterly progress rept. no. 14, May 1, 1956-Aug. 1, 1956; AD 87515) (AF 18(600)497) AD 87515(c)
Unclassified

Also published in Jour. Chem. Phys., v. 25: 579-580, Sept. 1956.

The rotational constants of $H_2C^{13}O$ were studied by measuring the transitions J = 1 ⟶ 2 and 2 ⟶ 3 at about 2 and 1.3 mm wavelength, respectively. The center frequencies of the K-1 pairs were fitted with a symmetric top approximation for the centrifugal distortion. The following values were obtained by the method of least squares: B + C 72,838.44 mc, $(B - C)^2 + 0.5^2$ 94.90 mc, D_J 0.0826 mc, and D_{JK} 1.311 mc. The assumption that the 0 ⟶ 1 transition is only very slightly influenced by

centrifugal distortion as reported by Lawrence and Strandberg (Phys. Rev., v. 83: 363, 1951) was confirmed.

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Duke U. Microwave Lab., Durham, N. C.

FURTHER EXTENSION OF MICROWAVE SPECTROSCOPY IN THE SUBMILLIMETER WAVE REGION, by M. Cowan and W. Gordy. [Sept. 1956] [9]p. incl. diagrs. tables. (AFOSR-TN-56-442) (Bound with its Quarterly progress repl. no. 15, Aug. 1, 1956-Nov. 1, 1956; AD 96785) (AF 18(600)497) AD 96785(a) Unclassified

Also published in Phys. Rev., v. 104: 551-552, Oct. 15, 1956.

In this study, microwave electronic measurements have been extended to 0.58 mm or 510,457 mc. Spectral lines have been observed on the cathode ray scope to 0.68-mm wavelengths. A rotational transition of HI has been measured at $\lambda = 0.778$ mm, and from it the interatomic distances and nuclear coupling constant of the molecule are obtained.

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Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER WAVE SPECTRUM OF FORMIC ACID, by G. Erlandsson. [1956] [6]p. incl. tables. [AFOSR-TN-56-495] (Bound with its Quarterly progress repl. no. 14, May 1, 1956-Aug. 1, 1956; AD 87515) (AF 18(600)497) AD 87515(b) Unclassified

Also published in Jour. Chem. Phys., v. 25: 379, Aug. 1956.

All type a R-branch transitions of HCOOH up to $J = 5$ were measured. The results on the $1 \longrightarrow 2$ transitions agree within the limits of error with those reported by Lerner, Friend, and Dailey (Jour. Chem. Phys., v. 23: 210, 1955) An attempt was made to fit the centrifugal distortion of the lines with a symmetric-top formula: $\nu = \nu_0 - 4D_J(J+1)^3 - 2D_{JK}(J+1)K^2$, where ν_0 is the rigid rotor frequency. The center frequencies of the pairs were determined completely by 4 constants. The values of these constants are: $(B+C) = 22,471.26$ mc, $(B-C)$ $(\quad - 0.5^2) = 40.327$ mc, $D_J = 0.0116$ mc, and $D_{JK} = 0.089$ mc. The accuracy of the reduced frequencies was apparently about ± 0.1 mc. (Extracted from rept.)

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Duke U. [Microwave Lab.] Durham, N. C.

MILLIMETER-WAVE LINES OF HEAVY WATER, by G. Erlandsson and J. T. Cox [1956] [4]p. incl. table. (AFOSR-TN-56-519) (Also bound with its Quarterly progress repl. no. 15, Aug. 1-Nov. 1, 1956; AD 96785) (AF 18(600)497) AD 96785(a); AD 110334 Unclassified

Also published in Jour. Chem. Phys., v. 25: 778-779, Oct. 1956.

From the rotational and centrifugal distortion constants of HDO given by Posener, the $1_{1,1} \rightarrow 1_{1,0}$ line of HDO was observed at the frequency 80,578.15 mc, and the $2_{1,2} \rightarrow 2_{1,1}$ line was observed at 241,561.3 mc. In addition a number of other lines of HDO and D_2O were observed in the millimeter region. The observed lines and their frequencies are tabulated.

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Duke U. [Microwave Lab.] Durham, N. C.

ELECTRON-SPIN RESONANCE IN X-IRRADIATED HORMONES AND VITAMINS (Abstract), by H. N. Rexroad and W. Gordy. [1956] [1]p. [AF 18-(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C. Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 200, Apr. 26, 1956.

Electron-spin resonance of the resulting unpaired electrons is being used to evaluate the effects of ionizing radiations on various hormones and vitamins. The resonance obtained of progesterone is a triplet similar to that of glycine, and is believed to arise from the $(CH_2)^+$ radical, probably bonded to some other group with no coupling nuclei. Parathyroid gave a doublet resonance of 15 gauss separation similar to that of certain proteins. Hexestrol gave no detectable resonance after prolonged irradiation. Vitamin A, vitamin K-5, and biotin gave only single broad resonances. Ascorbic acid gave a doublet of 20 gauss spacing with a weaker resonance superimposed. The g-factors are all very close to the value for the free electron spin. Other similar substances are under investigation. (Contractor's abstract)

DUK. 03:067

Duke U. [Microwave Lab.] Durham, N. C.

ELECTRON-SPIN RESONANCE IN X-IRRADIATED SUGARS AND CELLULOSE FIBERS (Abstract), by H. Shields, W. B. Ard, and W. Gordy. [1956] [2]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 200, Apr. 26, 1956.

Electron-spin resonance of the resulting unpaired

electrons has been used for study of the effects of ionizing radiations on various sugars and cellulose fibers. The spin resonance pattern most often observed is a doublet of the order of 10 to 20 gauss separation. Some sugars including ribose, gave only a single, fairly sharp resonance. X-irradiated lactose gave a quartet hyperfine structure which may arise from the CH_3 radical. Like the similar ones observed in certain other hydrogen-bonded material, the doublet resonances are believed to arise from electrons localized on oxygens which are involved in hydrogen bridges and which interact mainly through dipole-dipole coupling with the bridging proton. Similar doublets were observed for various x-irradiated woods and cell walls of plants. Purified cellulose, also cotton fiber, gave a more complex structure which, however, may be superposition of similar doublets separated slightly by crystalline field effects. (Contractor's abstract)

DUK. 03:068

Duke U. [Microwave Lab.] Durham, N. C.

MICROWAVE DETECTION OF METALLIC IONS AND ORGANIC RADICALS IN PLANT MATERIALS, by H. Shields, W. B. Ard, and W. Gordy. [1956] [2]p. incl. diagrs. (Sponsored jointly by Office of Ordnance Research and Office of Scientific Research under [AF 18(600)497]) Unclassified

Published in Nature, v. 177: 984-985, May 26, 1956.

The 6-line electron-magnetic resonance hyperfine structure of Mn was found for untreated samples of numerous plant substances. The structure was identical with that found for Mn in aqueous solution. A sharp resonance with a g factor of 2.00 was attributed to bound or semibound oxygen and was most intense with dried samples. A broad resonance with a g factor of 2.06 which was found with some samples was attributed to Cu ions, possibly indicating occasional substitution of Cu for Mn in the chlorophyll.

DUK. 03:069

Duke U. [Microwave Lab.] Durham, N. C.

EFFECTS OF TEMPERATURE AND ISOMERIC STRUCTURE ON THE ELECTRON-SPIN RESONANCE OF X-IRRADIATED AMINO ACIDS (Abstract), by W. Gordy and H. Shields. [1956] [1]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Nashville, Tenn., Mar. 29-31, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 267, June 21, 1956.

At the temperature of liquid nitrogen the paramagnetic resonance patterns of x-irradiated glycine, valine, and leucine become more complex and less resolvable than those which have been observed at room temperature. These changes may indicate the quenching of certain types of motions which at room temperature tend to reduce anisotropic interactions, or they may indicate structural changes in the radicals themselves or in their immediate surroundings. The only noticeable effect of cooling to 77°K on the alanine quintet is almost to equalize the intensities of the five components. The reason for this strange effect is not evident. Samples of irradiated alanine and glycine were heated to temperatures near their melting point without destruction of their resonances. Preliminary evidence indicates that it is much more difficult to produce resonances in alanine when it is irradiated at liquid air temperature than when irradiated at room temperature. Other amino acids and proteins are being investigated for this effect which suggests that temperature may have an important effect on radiation damage. Noticeable difference in the effects of ionizing radiations has been detected for different isomeric forms of leucine: DL-leucine gives a sextet hyperfine structure; DL-isoleucine, a symmetrical seven-component structure; L(—) — leucine, a triplet with shoulders like the pattern for irradiated glycine. In contrast, the patterns obtained for D- and L-alanine are alike. Other isomeric forms are under investigation. (Contractor's abstract)

DUK. 03:070

Duke U. [Microwave Lab.] Durham, N. C.

ELECTRON-SPIN RESONANCE OF X-IRRADIATED NUCLEIC ACIDS (Abstract), by H. Shields and W. Gordy. [1956] [1]p. [AF 18(600)497] Unclassified

Presented at meeting of the Amer. Phys. Soc., Nashville, Tenn., Mar. 29-31, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: June 21, 1956.

Electron spin resonances have been observed of the nucleic acids and certain of their constituents after x-irradiation. The resonances of DNA and RNA are similar and consist of a strong component of g factor 2.00 and a weak satellite. Some of their constituents gave more complex resonances. The resonance of thymidine, for example, has a proton hyperfine structure structure of 7 components. That of guanosine is a triplet with broad components suggesting further unresolved structure. Guanylic acid exhibits a triplet immediately after irradiation, but upon exposure to air the triplet is slightly converted to a singlet. Adenosine, also muscle adenylic acids, gave a strong central component with weak side lobes. Cytidine, cytidylic acid, adenosine, and inosine gave only single resonances with g factors of 2.00. These resonances are being investigated further under different physical conditions in the hope of finding out something of the mechanism of radiation damage to the cell nucleus. (Contractor's abstract)

EAS. 01:001

Eastern Research Group, Brooklyn, N. Y.

REVERSE THRUST, VERTICAL LIFT, AND JET SLIDE FORCE BY MEANS OF CONTROLLED JET-DEFLECTION, by L. Meyerhoff and S. Meyerhoff. Jan. 1956, 53p. incl. diagrs. tables, refs. (AFOSR-TN-56-168) (AF 18(600)1530) AD 86589 Unclassified

Forces obtained by deflection of the propulsive jet are investigated as a possible means for augmenting the control of jet aircraft. Emphasis is given to its use at low speeds. Jet aviation is faced, seemingly, with a low-speed "barrier" resulting from the design necessities to fly at sonic speeds. Take-off and landing speeds may exceed cruising speeds of pre-war commercial transports if the trend continues. An important aviation development is reverse thrust produced by deflecting the jet almost 180° forward in order to brake the landing run. Reverse thrusts up to 90% of rated positive thrust have been measured at zero airspeed. For jet-braking at high speeds, the analysis predicts several hundred percent reverse thrust. Various consequences of these values are investigated. Thrust reversal is not the only application of jet deflection. This paper also considers: (a) side forces for jet steering; (b) jet and "forced" lifts to permit flight, below the normal stalling speed; and (c) thrust modulation by jet deflection. (Contractor's abstract)

EMO. 01:001

[Emory U. Dept. of Mathematics, Atlanta, Ga.]

[INVESTIGATION OF THE STRUCTURE OF LIE ALGEBRA] by H. E. Campbell. [Nov. 1953] 2p. Final Research rept. (AF 18(600)684) Unclassified

The following facts were proved: (1) if the Killing form of a Lie algebra L is non-degenerate, then the Casimir operator relative to this form is the identity transformation; (2) if L is a Lie algebra with radical R such that $LR = 0$ and L/R has non-degenerate Killing form, then there is an algebra S such that $L = S + R$, $S \cong L/R$; (3) if L is a Lie algebra of characteristic $p \neq 0$, $R' = 0$, trace $(S_x S_y)$ is a non-degenerate bilinear form, p does not divide the dimension of any simple component of L/R, then there is an algebra S such that $L = S + R$, $S \cong L/R$; and (4) in the case where $R' = 0$, if a certain linear mapping $r(x)$ of $L/R \rightarrow R$ does not have the property that $r(x) = r_1 S_x$, for a fixed r, of R than L does not decompose.

Enrico Fermi Inst. for Nuclear Studies, Chicago, Ill. see Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.

ESC. 01:001

Escher Wyss, Ltd., Zurich (Switzerland).

APPLICATION OF THE CLOSED-CYCLE PRINCIPLE TO AIRCRAFT PROPULSION SYSTEMS. VOLUME I. CLOSED CYCLE AIRCRAFT PROPULSION SYSTEMS, by R. Tognoni and W. Spillman. Final technical rept. July 21, 1956 [138]p. incl. diagrs. tables. (Rept. no. Sp-AK-56-027; Z no. 5-862-563) (AFOSR-TR-56-45) (AF 61(514)854) AD 97087 Unclassified

Various configurations of a closed-cycle gas turbine driving ducted fans were investigated. Three possible air (or gas) heater arrangements were considered. One was built into jet engine combustion chamber; another was built into an afterburner in ducted fan airflow; and a third was a gas cycle nuclear reactor. The air (gas) cooler was in the ducted fan airflow in all cases. A complete powerplant with airheater in J 47 combustion chamber was laid out. At design point (Mach 0.85 at 40,000 ft), the specific fuel consumption (1.08) is comparable with modern jet engines, but the specific weight is high, partly due to the low turbine inlet temperature (1480°F) enforced by the air-heater. Various heat exchanger types were studied theoretically, and (cold) drag tests on various cross-flow tube banks were run. Actual designs of light weight air coolers and of air heaters for closed cycle engines were carried out. Driving of boundary layer suction fans with the closed-cycle gas turbine was investigated in a preliminary way, also the feasibility of a closed-cycle high altitude aircraft accessory powerplant. The combination of closed cycle driven ducted fan with gas cooled nuclear reactor appears most promising. The performance of this powerplant was calculated (up to Mach 2.0 at 40,000 ft), the size of the components and the weight estimated. A potential superiority over other nuclear aircraft powerplants in simplicity, safety and possible in specific weight became apparent. (Contractor's abstract, modified)

ESC. 01:002

Escher Wyss, Ltd., Zurich (Switzerland).

APPLICATION OF THE CLOSED-CYCLE PRINCIPLE TO AIRCRAFT PROPULSION SYSTEMS. VOLUME II. CLOSED CYCLE AIRCRAFT PROPULSION SYSTEMS, by R. Tognoni and W. Spillman. Final technical rept. July 21, 1956, 1v. incl. illus. diagrs. tables. (Rept. no. Sp-AK-56-027; Z no. 5-862-564) (AFOSR-TR-56-46) (AF 61(514)854) AD 97088 Unclassified

A propulsion system was studied which consisted of a heat source, a closed-cycle (cc) plant to generate mechanical energy, a ducted fan as a propelling device, and a cooling air-blower. A J47GE15 jet engine combustion chamber was assumed as the heat source for the closed-cycle air heater. This system utilized neither a heat-exchanger nor boundary-layer suction. A complete design and general assembly drawings were made for a nonregenerative ducted-fan unit which

ESC. 01:003 - ESC. 01:006

comprised a turbine-compressor cycle machine, a power turbine driving a ducted fan, and a single cooler in the compressed fan air. Design studies indicated that the built-in air heaters in the jet-engine combustion chambers were large and heavy and that the tube-wall temperatures for the air heaters were limited by available tube materials. Higher cc temperatures and air temperatures would allow increased efficiencies. A number of feasible prospects are proposed for self-contained ducted-fan propulsion systems with fossil-fuel heaters and control systems for the cc plant are discussed. Variations in cc-plant output can be accomplished by varying either the turbine inlet temperature or the system pressure level. (ASTIA abstract)

ESC. 01:003

Escher Wyss, Ltd., Zurich (Switzerland).

WAKE STREAM ACCELERATION AS MEANS FOR REDUCING AIRPLANE DRAG, VOLUME III, by A. Burgdorfer. [Final technical rept.] July 21, 1956 [56]p. incl. diagrs. tables. (Technical note no. 1; rept. no. Sp-AK-56-029; Z no. 5-862-565) (AFOSR-TR-56-47) (AF 61(514)854) AD 97089 Unclassified

A propulsion unit which used the recovered kinetic energy from the wake stream of a flight body for producing thrust and a second unit which did not utilize the recovery of this energy source were evaluated. The unit which used the recovered kinetic energy demonstrated the higher efficiency. The gain achieved was between 10% for a thrust/drag ratio of 5, and 15% for a thrust/drag ratio of 1. The unit which utilized the wakestream energy required an inlet with a cross section 10% to 20% larger than that of the other unit. The arrangement of the drive gear at the end of the flightbody may also reduce the calculated 10 to 15% gain. (ASTIA abstract)

ESC. 01:004

Escher Wyss, Ltd., Zurich (Switzerland).

A GENERAL RELATION FOR PRESSURE-DROP AND HEAT TRANSFER FOR COOLERS AND HEAT EXCHANGES, VOLUME IV [PART I], by A. Burgdorfer. [Final technical rept.] July 21, 1956, 11p. (Technical note no. 3; rept. no. Sp-AK-56-030; Z no. 5-862-566) (AFOSR-TR-56-48 [Pt. 1]) (AF 61(514)854) AD 97090 Unclassified

By a rearrangement of the formulas for pressure drop and heat transfer of heat-exchangers and elimination of the friction factor and heat-transfer coefficient of the surfaces, a relation is found, which makes it possible to discuss pressure loss problems of heat-exchangers and coolers. For gases, the pressure loss of heat-exchangers is given as a function of the flow-stream Mach number, the gas properties, the temperatures and the characteristic values of the heat-exchanger surfaces. (Contractor's abstract)

ESC. 01:005

Escher Wyss, Ltd., Zurich (Switzerland).

THE PRESSURE LOSS COEFFICIENTS OF DIFFERENT ARRANGEMENTS OF TUBE ROWS, VOLUME IV [PART II], by A. Burgdorfer. [Final technical rept.] July 21, 1956 [8]p. incl. diagrs. (Technical note no. 2; rept. no. Sp-AK-56-030; Z no. 5-862-566) (AFOSR-TR-56-48 [Pt. 2]) (Bound with its Technical note no. 3; AD 97090) (AF 61(514)854) AD 97090(a) Unclassified

The pressure loss coefficients of one to four rows of round tubes have been measured with the intention to get the influence of an inclination of the tube-rows plane to the flow-stream direction. The results for two angles: 90 and 45° are presented in form of dimensionless diagrams. (Contractor's abstract)

ESC. 01:006

Escher Wyss, Ltd., Zurich (Switzerland).

APPLICATION OF THE CLOSED CYCLE PRINCIPLE TO AIRCRAFT AUXILIARY POWER PLANTS. VOLUME V. COOLING PROBLEM STUDY FOR A SMALL CONSTANT-POWER-OUTPUT CLOSED-CYCLE GAS TURBINE FOR VERY HIGH ALTITUDES AND HIGH FLIGHT-MACH-NUMBERS, by W. Spillman. Final technical rept. July 21, 1956 [23]p. incl. diagrs. (Technical note no. 4; rept. no. Sp-AK-56-025; Z no. 5-862-544) (AFOSR-TR-56-49) (AF 61(514)854) AD 97351 Unclassified

A constant-power output auxilliary plant was considered for an aircraft or missile traveling at a 100,000-ft altitude and M = 4.0. Closed-cycle (cc) power plants are able to work under any ambient pressure and supply a constant power output independent of the density of the surrounding atmosphere. The plants are not independent of the ambient temperature. A heat rate of $Q/N = \frac{1-n}{n}$ is transferred to the ambient air, where n is the thermal efficiency, N is the power output, and Q is the heat flow rate of the heat exchanger. The best and simplest cooling for the circuit cooler of a cc plant is the use of fuel cooling. If liquid fuel is not available, as the nuclear-fired plants, direct-air cooling is possible up to 14-km altitude at M = 2.0. Below 14 km, vaporizing cooling gives smaller plant efficiencies. Next to direct fuel-flow cooling, the vaporizing of water at the cooler surface gives the best cooling at extreme altitudes. A combination of air-cooling for low altitudes and vaporizing cooling for high altitudes gives a nearly constant plant efficiency for the assumed flight conditions. Radiation cooling may be practical for small amounts of heat and in some special cases (high-altitude night flight) for small hot-running components. (ASTIA abstract)

EXP. 01:001

Experiment, Inc., Richmond, Va.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:078 - PRI. 11:080.

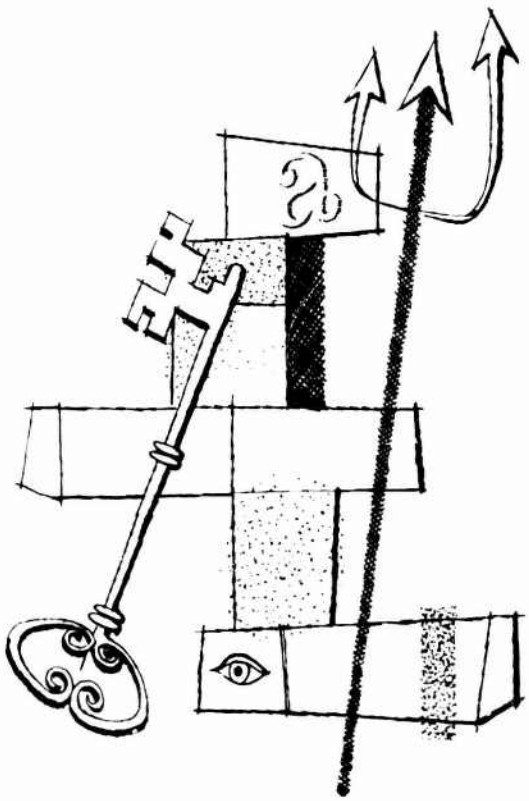
EXP. 01:001

Experiment, Inc., Richmond, Va.

AN APPARATUS FOR STUDYING THE BURNING OF DUST CLOUDS, by L. E. Line, Jr., W. J. Clark, and J. C. Rahman. July 30, 1956, 25p. incl. illus. diagrs. refs. (Rept. no. TP-102A) (AFOSR-TN-56-280) (AF 18(600)1508) AD 89490 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 779-786.

An apparatus is described for studying the ignition and burning of wall-free and wall-confined nonturbulent dust clouds under controlled conditions. Some preliminary results with lycopodium are presented. (Contractor's abstract)



FLA. 01:001 - FLA. 01:005

Fels Research Inst., Yellow Springs, Ohio. see Antioch Coll. Fels Research Inst., Yellow Sprtngs, Ohto.

FLA. 01:001

Flortda State U. Dept. of Chemistry, Tallahassee.

TRANSLATIONS OF RUSSIAN SPECTROSCOPIC RESEARCH PAPERS, VOL. I, by M. Kasha. Dec. 1955 [36]p. incl. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18 (600)678] and Office of Naval Research) Unclassified

The followtng translations of Russian spectroscoptc research papers are tncluded: (1) Theory of Absorption Spectra of Molecular Crystals, by A. S. Davydov (Jour. Exper. Theoret. Phys. (U.S.S.R.), v. 18: 210, 1948); (2) Directed Valences wtth Partictpation of F-Electrons, by M. G. Shirmazan and M. E. Dyatkina (Jour. Phys. Chem. (U.S.S.R.), v. 27: 491, 1953); (3) Directed Valences for Coordination Numbers 6 and 8, by M. G. Shirmazan and M. E. Dyatkina (Doklady Akad. Nauk, v. 82: 755, 1952); (4) Hybrid Orbitals for Coordination Numbers 7 and 9, by M. G. Shirmazan and M. E. Dyatkina (Doklady Akad. Nauk, v. 77: 75, 1951); and (5) On the Low Intensity Bands in the Ultraviolet Absorption Spectrum of Benzene, by F. F. Chesko (Jour. Phys. Chem. (U.S.S.R.), v. 27: 157, 1953).

FLA. 01:002

Flortda State U. Dept. of Chemistry, Tallahassee.

MOLECULAR ELECTRONIC SPECTROSCOPY. SPtN INTERCOMBtNATtONS tN MOLECULES, by M. Kasha and S. P. McGlynn. Dec. 1955, 38p. refs. (AFOSR-TN-56-463) [pt.]1) (Bound with its Technical rept. no. 1; AD 97081) (AF 18(600)678) AD 97081(a) Unclasstfied

Also published in Ann. Rev. Phys. Chem., v. 7: 403-424, 1956.

A review is made of electronic spectroscopy research on molecular spin intercombinattons published in 1955 as well as of perttnent key papers from earlter literature. Expertmental ftndings and theory are discussed concerning the trtplet → singlet emissions of numerous motecules, the very weak singlet → triplet absorptton spectra, the transient triplet → triplet spectra, intramolecular and intermolecular sptn-orbital perturbations introduced by high-Z and paramagnetic atoms, all of which have increased understanding of radiationless transttions and applicattons of sptn-orbital coupltng theory. The theory of chemical reactivtty, the interpretation of fluorescence quenching, photochemical reactions, photochromism, and thermochromism are treated.

FLA. 01:003

Florida State U. Dept. of Chemtstry, Tallahassee.

INTERPRETATION OF THE LOWEST FREQUENCY ELECTRONIC ABSORPTION BANDS OF INORGANIC MOLECULES OF TYPE $XO_y^{z(-)}$ AS $n \rightarrow \pi^*$ TRANSITIONS, by S. P. McGlynn and M. Kasha. [1956] [7]p. tncl. tables. (AFOSR-TN-56-463 [pt. 2]) (Bound with its Technical rept. no. 1; AD 97081) (AF 18(600)678) AD 97081(b) Unclassified

Also published tn Jour. Chem. Phys., v. 24: 481-482, Feb. 1956.

The lowest frequency electronic transttions tn simple tnorganic nolecules of the type $XO_y^{z(-)}$ were studied theoretically. In the formula, O is an oxygen, or a sulfur atom; X ts generally a nonmetallic, or a transttion metal atom; y = 1, 2, 3, 4; z = 0, 1, 2, 3. A table is presented which gives for each case the selection rule for the lowest frequency transition, and the experimental absorption tntenstty observed. (Contractor's abstract)

FLA. 01:004

Florida State U. Dept. of Chemtstry, Tallahassee.

ON THE APPLICATION OF THE MOLECULAR ORBITAL METHOD TO THE SPECTRA OF SUBSTITUTED AROMATIC HYDROCARBONS, by L. Goodman, I. G. Ross, and H. Shull. [1956] [26]p. tncl. diagr. refs. (AFOSR-TN-56-463 [pt. 3]) (Bound with its Technical rept. no. 1; AD 97081) (AF 18(600)678) AD 97081(c) Unclassified

Also published in Jour. Chem. Phys., v. 26: 474-480, Mar. 1957.

The molecular orbital theory of the spectra of substituted hydrocarbons is presented in general terms with necessary precautions noted regarding introduction of inevitable approximations. Prevtous treatments of the problem, notably by Sklar, Herzfeld, and Matsen are discussed; satisfactory calculations of energy-level shifts are considered to need closer attention to the definition and dtssection of the perturbed Hamiltonian. The most interesting intensity effects concern enhancement of weak transitions. Consequences of the earlier treatment, which do not satisfy requirements of orthonormality of the perturbed MO's and neglect interacttons wtth intense transitions, are discussed. (Contractor's abstract, modifted)

FLA. 01:005

Florida State U. Dept. of Chemistry, Tallahassee.

THEORY OF SOLVENT EFFECTS ON MOLECULAR ELECTRONIC SPECTRA. FREQUENCY SHIFTS, by E. G. McRae. [1956] [47]p. incl. diagrs. table, refs. (AFOSR-TN-56-463 [pt. 4]) (Bound with its Technical rept. no. 1; AD 97081) (AF 18(600)678) AD 97081(d) Unclasstfied

Also published in Jour. Phys. Chem., v. 61: 562-572, May, 1957.

Electronic band frequency shifts in solution spectra, caused by dipole interactions, are analyzed theoretically and a general expresston for the frequency shift is derived by perturbation theory. The frequency shift is the sum of contributions of dispersive and static dipole tnteractions. The dtsperstve contribution represents the general red shift which is present in all solution spectra and is partially dependent on the weighted mean-wavelength characterlstic of the solveni. In the electrostatic contribution the role of the quadratic Stark effect is emphasized. The tntroduction of a simple electrostaitc model permits the derivation of formulas relating frequency shifts in both emisston and absorption spectra to the refractive index and static dielectrtc constant of the solvent. Illustrative numerical applicattons are descrtbed. (Contractor's abstract, modifted)

FLU. 01:001

Florida U. Engineering and Industrtal Experiment Station, Galnesville.

RESEARCH IN THE GENERAL FIELD OF THE MECHANISM OF CELLULOSE SYNTHESIS AND DEGRADATION, by G. A. Greathouse, D. E. Barnes, and G. T. Tsao. Final technical rept. Mar. 1, 1954-Feb. 28, 1955. 52p. tncl. dtagrs. iables, refs. [AFOSR-TN-55-9] (AF 18(600)1126) AD 64566 Unclassified

Investigations into the mechanisms of cellulose synthesis and cellulose degradation were conducted, and attention was given to the enzyme and growth characterlstics of Acetobacter xylinum. Twenty-one C^{14}-cellulose membranes were prepared: 12 from 1-C^{14}-D-glucose, and 3 each from 2-C^{14}-D-[dextro]-glucose, 6-C^{14}-D-glucose, and 1,3-C^{14}-glycerol. In the membranes prepared from 1-C^{14}-glucose, when the radioactive glucose was added after the culture was 24 hr old, a shift of 10% was noted in the C^{14} content of posttion 1. This enhances the hypothesis that glucose undergoes a direct polymerization to cellulose. When 1,3-C^{14}-glycerol was used as the only C source, membranes of C^{14}-cellulose were formed as rapidly as from glucose and in simtlar yields, which shows that 3 C compounds can be used effectively by A. xylinum. A method for the degradatton of glucose based on oxidations and the formation of benzimidazole derivatives of the acids was developed, and the step-wise degradation of glucose was initiated. A complete C^{14} balance was carried out on all the membranes prepared, and the CO_2 produced, the residual medium, and the cellulose were all assayed for C^{14}. In experiments on A. xylinum enzymes, resting cells were produced by freeze-drying the cell suspension, but no cell-free enzyme could be prepared. The growth characterlstics of A. xylinum were investigated with respect to pH change, CO_2 formation, and cellulose productton. An informal hypothesis for the mechantsm of cellulose formation is discussed. (ASTIA abstract)

See also Orlando Research, Inc., Fla. ltem nos. ORL. 01:00t-ORL. 01:003.

FOR.01:001

Forest Products Lab., Madison, Wis.

[A FUNDAMENTAL INVESTIGATION OF ADHESION.] I. METHOD FOR CASTING GELATIN FILMS, by B. Coleman, H. Tarkow, and R. C. Weatherwax. [Sept. 8, 1955] [5]p. incl. diagrs. ([AF]OSR-TN-55-335) (In cooperation with Wisconsin U., Madison) (CSO-670-55-27) AD 80112 Unclassified

Also publtshed tn Jour. Polymer Science, v. 19: 380-381, Feb. 1956.

A new method for casting gelatin films was developed whtch consists of allowing the solvent (H_2O) to evaporate from both faces of a dtsk of a swollen gel held under lateral tension. Swollen gels were successfully dried to equilibrium with 30% relative humidtty wtthout breaking the flin away from the glass wall. Films were successfully casi from solutions containing 3 to 15% gelatin.

FRA. 01:001

Franklin Inst. Bartol Research Foundation, Swarthmore, Pa.

COMPARISON OF MASSES OBTAINED FROM MASS-SPECTROSCOPY AND NUCLEAR REACTION DATA, by D. M. Van Patter. [1956] [18]p. incl. diagrs. tables, refs. [AF 18(600)1320] Unclassified

Published in Proc. Conference on Nuclear Masses and Their Determtnation, Max-Planck Insttitut für Chemie, Mainz (Germany) (July 10-12, 1956), London, Pergamon Press, 1957, p. 143-160.

An examination is made of the general trend of measurements of important masses in the region of ^1H to ^{32}S, and some of the discrepancies and thetr possible sources are considered. It was concluded that in the region below ^{16}O, no obvtous error source could be found which would explain the remaining small discrepancies. It is probable that future small adjustments to both the mass-spectroscopic and nuclear-reaction data will bring the masses into even better agreement. In the case of the masses between ^{16}O and ^{32}S, there are at least 2 places where inconsistencies exist among the present Q values. In addition, because of the fact that most of the nuclear reaction energies have been measured only at the Massachusetts Institute of Technology, Cambridge, it seems likely that a systematic error may be present, which accumulates as higher and higher masses are calculated. Thus some discrepancy results on comparison of these values with the mass-spectroscopic values. Although the calculations of the masses from the nuclear-reaction data have compensated for this systematic error to a degree, it is probable that some remains and should be taken tnto account tn the ftnal errors quoted for the masses. Independent measurements of the Q values tn this region by other laboratories will resolve this question.

FRA. 01:002 - FRA. 03:001

FRA. 01:002

Franklin Inst. Bartol Research Foundation, Swarthmore, Pa.

NUCLEAR REACTION Q-VALUE MEASUREMENTS MADE RECENTLY AT THE BARTOL RESEARCH FOUNDATION, by D. M. Van Patter, C. E. Mandeville and others. [1956] [10]p. incl. diagrs. tables. [AF 18(600)1320] Unclassified

Published in Proc. Conference on Nuclear Masses and Their Determination, Max-Planck Institut für Chemie, Mainz (Germany) (July 10-12, 1956), London, Pergamon Press, 1957, p. 99-106.

Descriptions of the experimental techniques and equipment utilized in obtaining these nuclear reaction Q-value measurements are given. The ONR-Bartol van de Graaff accelerator provided protons of up to 5 mev. A relative measure of the magnetic field of the spectrometer was obtained by means of a torsion balance, placed at the 90° position of the magnet. A number of energy calibrations were made during the measurements. A daily calibration of the torsion balance was provided by a Po-α source which could be moved into a position at the center of the reaction chamber. The final energy calibrations consisted of observations of several charged-particle groups from Al targets at known bombarding energy. The results of one such bombardment (at an energy of 3.633 mev) are shown for a target 9 kev thick for the $^{27}Al(p, p)$ group, corresponding to a resonance for the $^{27}Al(p, \alpha)\ ^{24}Mg$ group. In order to determine correctly the location of each group, a detailed analysis of the various contributions to the momentum profile of each group was necessary. Knowing the bombarding energy for the observed groups, and taking the Q-values for each group, the calibration constant $K = H\rho \times R$ (where R = reading of the torsion coil current) was calculated and an energy calibration curve was plotted. Having established an energy calibration curve, the Q value for each reaction group was calculated using the relativistic Q equation, and the total error for each group being estimated. Estimates were made of the uncertainties associated with: (a) the location of each particle group; (b) daily calibration of the torsion balance; (c) calculated corrections to the momentum profiles for target thickness, acceptance angle, and resolution; and (d) energy calibration. A table shows the results obtained for the ground-state Q values of the $^{31}P(p, \alpha)$, $^{35}Cl(p, \alpha)$, and $^{37}Cl(p, \alpha)$ reactions. In another table, the weighted average values for the 3 ground-state Q values are compared to the mass spectrographic data of Ogata and Matsuda (1953).

FRA. 01:003

Franklin Inst. Bartol Research Foundation, Swarthmore, Pa.

Q-VALUE MEASUREMENTS FOR PHOSPHORUS AND CHLORINE, by D. M. Van Patter, C. P. Swann and others. [1956] [21]p. incl. diagrs. table, refs. [AF 18(600)1320] Unclassified

Also published in Phys. Rev., v. 103: 656-661, Aug. 1, 1956.

Targets containing P and Cl have been bombarded by protons accelerated by the ONR-Bartol Foundation van de Graaff generator. Charged particles from nuclear reactions have been analyzed at 90°, using a 180° double-focussing magnetic spectrometer. The following ground-state Q-values have been determined: $P^{31}(p, \alpha)\ Si^{28}$, Q = 1.911 ± 0.005; $Cl^{35}(p, \alpha)S^{32}$, Q = 1.851 ± 0.007; $Cl^{37}(p, \alpha)S^{34}$, Q = 3.015 ± 0.011 mev. The following level positions have been measured: P^{31} 1.264 ± 0.004; S^{34} 2.129 ± 0.014; Cl^{35} 1.219 ± 0.005; and 1.760 ± 0.004 mev. At E_p = 3.055 mev, a survey was made for inelastic proton groups from P^{31} corresponding to levels from 0 to 1.43 mev excitation. Only 1 group (Q = -1.264 mev) was observed. No other groups were observed with an intensity greater than 15% of the intensity of this group. (Contractor's abstract)

FRA. 02:001

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

MAGNETOSTRICTION, by F. J. Donahoe. Final rept. Apr. 9, 1951-Mar. 22, 1952, 5p. incl. diagrs. (AF 33(038)22698; continuation of AF 18(600)302) Unclassified

Details are briefly given concerning the construction, assembly and preliminary testing of laboratory apparatus designed to study the relationship between alloy composition, structure and magnetostriction in a search for new magnetostrictive element materials.

FRA. 03:001

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

EFFECT OF ORDER ON THE ELECTRICAL RESISTIVITY OF FERROMAGNETIC ALLOYS, by F. J. Donahoe. [1954] [8]p. incl. diagrs. ([AF]OSR-TN-54-358) (AF 18(60)302; continuation of AF 33(038)22698) Unclassified

The behavior of resistivity on ordering will depend on the relative positions of the 2 critical temperatures, the Curie temperature θ_f at which ferromagnetism vanishes and the critical temperature T_c at which long-range lattice order vanishes. The behavior also will depend upon the direction of change of θ_f with order, represented by $\partial\ \theta_f/\partial S$, where S is an order parameter. Four cases are distinguished and are discussed; resistivity-temperature diagrams are shown for each case: (1) $T_c > \theta_f$; $\partial\theta_f/\partial S > 0$. A Fe_3Pt alloy (30 atomic % Pt) is used as an example in the diagram; (2) $\theta_f > T_c$; $\partial\theta_f/\partial S > 0$, illustrated by published $FeNi_3$ data; (3) $T_c > \theta_f$; $\partial\theta_f/\partial S < 0$; and (4) $\theta_f > T_c$; $\partial\theta_f/\partial S < 0$. Diagrams for the latter two cases are schematic. Departures from the ideal behavior pictured may be

expected when the occupancy of the d-shells changes during the ordering reaction.

FRA. 03:002

Franklin Insl. Labs. for Research and Development, Philadelphia, Pa.

MAGNETOSTRICTION [PART I], by F. J. Donahoe. Final progress repl. Apr. 10, 1952-Apr. 9, 1953, 8p. incl. diagrs. (Rept. no. F-2306) [AFOSR-TR-54-24] (AF 18(600)302) AD 10832 Unclassified

Five specimens of Fe-Pt alloys containing 20 to 30 atomic % Pt were prepared in rod and wire forms. X-ray studies of the lattice parameters of Ni-Mn alloys of 20 to 30 atomic % Mn showed a linear expansion of the Ni lattice of 0.0028 A/atomic % Mn. In the disordered state, the resistivity (R) was a fairly linear function of both the temperature during the heating cycle from 500° to 1100°K and the composition from 20 to 30 atomic % Mn. Preliminary measurements during the cooling cycle indicated that the temperature of the resistivity anomaly is a monotonic increasing function of Mn content. Some ordering of the alloy was indicated in the temperature range, since the resistance decreased isothermally with time. At the expected ordering temperature about 50° above the observed anomaly, the temperature coefficient of R seemed to become small. The thermal coefficient of expansion of Fe-Pt alloys is sensitive to short-range ordering. (ASTIA abstract)

FRA. 03:003

Franklin Insl. Labs. for Research and Development, Philadelphia, Pa.

DEVELOPMENT OF MAGNETOSTRICTIVE AND RELATED MATERIALS, PART II, by F. J. Donahoe. Final progress rept. Apr. 10, 1952-Apr. 9, 1954, 55p. incl. illus. diagrs. tables, refs. (Repl. no. 2306) [AFOSR-TN-54-24a] (AF 18(600)302) AD 41119 Unclassified

Studies were made of the effects of the order-disorder transformation on alloys with compositions near Ni_3Mn, Fe_3Pt, and $FePd_3$. Measurement was made of saturation moment of alloys at low temperatures and of the long-range order parameter. The saturation moment of alloys near $FePd_3$ appears to be unaffected by the degree of order. The Curie temperature on the other hand is strongly influenced in the early stages of ordering. The kinetics of the ordering in Fe_3Pt alloys were studied at temperatures from 450° to 750°C. Resistivity measurements on polycrystalline wires were used to follow the ordering process. The results appear to confirm the general features of the phase diagram as set forth by Kussmann and Rittberg (Metallkunde, v. 41: 470, 1950), with some differences in detail. The ordering process can be fitted to a rate law governed by exp $-(t/\tau)^{1/2}$ with an activation of about 50 kcal/mol. Magnetic studies confirmed the fact that the major portion of the resistivity change observed at 0°C are associated with the rapid increase in ferromagnetic Curie temperature. As in the $FePd_3$ system, major changes in the Curie temperature were noted after very short anneals. Magnetostriction measurements on disordered polycrystalline specimens of the 30.0 atomic % Pt alloy were made. The linear magnetostriction coefficient at room temperature was 49.7×10^{-6} and increased to 83.9×10^{-6} at 80°K. (ASTIA abstract)

FRA. 03:004

Franklin Insl. Labs. for Research and Development, Philadelphia, Pa.

PHASE TRANSFORMATIONS IN IRON-PLATINUM ALLOYS NEAR THE COMPOSITION Fe_3Pt, by A. E. Berkowitz, F. J. Donahoe and others. (n.d.) [39]p. incl. illus. diagrs. [AF 18(600)302] Unclassified

The kinetics of the ordering process in Fe-Pt alloys near the composition Fe_3Pt were studied at temperatures ranging from 450° to 750°C. Resistance measurements on polycrystalline wires were used to follow the ordering process. At the annealing temperature resistivity was almost independent of the degree of order. However, the ferromagnetic Curie temperature was found to be strongly influenced by the degree of order. At 0°C the resistivity changes were large and linear in the reduced magnetic temperature, $273°/\theta_f$, where θ_f is the ferromagnetic Curie temperature. The changes in 0°C resistivity produced during anneals below 650°C can be fitted by a rate law governed by exp $-(t/\gamma)^{1/2}$ where γ is temperature dependent with an activation energy of about 2 ev/atom. Quenched alloys containing less platinum than stoichiometric Fe_3Pt were mixed face-centered γ and body-centered α-phase. The temperature at which the transformation $\gamma \rightarrow \alpha$ begins decreases rapidly with the degree of order in the γ-phase. Appreciable changes in the γ-phase Curie temperature and in the $\gamma \rightarrow \alpha$ transformation temperature occur before super-structure lines appear in the x-ray diffraction pattern. This suggests that the effects of short-range order on these properties is comparable to and continuous with the effects of long-range order.

FRA. 03:005

Franklin Insl. Labs. for Research and Development, Philadelphia, Pa.

FERROMAGNETISM AND ORDER IN Fe-Pt ALLOYS NEAR Fe_3Pt (Abstract), by A. D. Franklin, A. E. Berkowitz, and E. Klokholm. [1954] 1p. (AF 18-(600)302) Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit-Ann Arbor, Mich., Mar. 17-19, 1954.

Published in Phys. Rev., v. 94: 1432, June 1, 1954.

The Fe-Pt alloys near the composition Fe_3Pt exhibit an irreversible transition between b.c.c. α- and

FRA. 03:006 - FRA. 04:003

f.c.c. γ-phases. Both are ferromagnetic, but the γ-phase Curie point lies much lower than that of the α-phase. It is known that ordering in these alloys moves the γ-phase Curie point to higher- and the $\gamma \rightarrow \alpha$ transition to lower temperatures, without having an appreciable effect on the $\alpha \rightarrow \gamma$ transition. These ordering effects have been studied in greater detail, using a B-H curve tracer to follow the transitions magnetically. During the irreversible transitions, especially $\alpha \rightarrow \gamma$, isothermal changes in magnetization occur. In cold-worked specimens, the beginning of the $\gamma \rightarrow \alpha$ transition lies above liquid N_2 temperatures out to 27 atomic % Pt. The increase in the γ-phase Curie temperature and the decrease in the $\gamma \rightarrow \alpha$ transition temperature with ordering occurs to an appreciable extent in the early stages of ordering, before superstructure lines appear in the x-ray patterns. (Contractor's abstract)

FRA. 03:006

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

RESISTANCE STUDIES OF THE PHASE TRANSFORMATIONS IN Fe-Pt ALLOYS NEAR THE COMPOSITION Fe_3Pt (Abstract), by R. P. Steijn and F. J. Donahoe. [1954] 1p. (AF 18(600)302) Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit-Ann Arbor, Mich., Mar. 17-19, 1954.

Published in Phys. Rev., v. 94: 1432-1433, June 1, 1954.

The γ-phase Fe-Pt alloys containing approximately 25 atomic % platinum are known to develop superstructure of the type formed in Cu_3Au. In addition, the f.c.c. γ-phase transforms at low temperatures to a b.c.c. α-phase in alloys containing $\gtrsim$ 27 atomic % platinum. The resistance changes which are produced by these phase transformations have been studied in alloys ranging from 14 to 30 atomic % platinum. In Cu_3Au the formation of long range order is accompanied by a decrease in resistance which may be observed at the temperature at which order formation occurs. No such effects are observed in Fe_3Pt. This seems to be generally true in ferromagnetic alloys of this type. The progress of the ordering reaction during isothermal aging at elevated temperatures can be followed by quenching and measuring the resistance at some fixed temperature below the ferromagnetic Curie point of the disordered alloy. The irreversible $\alpha \rightarrow \gamma$ transition also produces large changes in resistance which are superposed on those due to changes in the degree of order. (Contractor's abstract)

FRA. 04:001

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

THE GALLIUM-ANTIMONY PHASE DIAGRAM, by I. G. Greenfield and R. L. Smith. Aug. 13, 1954 [18] p. incl. diagrs. table, refs. ([AF]OSR-TN-54-176) (AF 18(600)465) AD 45041 Unclassified

Cooling curves were determined for Ga-Sb alloys. A cooling rate of 1°C per min was used for the majority of the alloys, but in several instances, a rate as low as 1/20°C/min was used. A decided change in the slope of the cooling curve was recorded for most of the alloys. The liquidus temperature of the 92 atomic % Ga alloy was located by measuring the change in resistance as the temperature of the ingot was varied. Pure Sb had a tendency to undercool, but seeding with crystallites of Ga completely removed this condition. The Ga-Sb phase diagram consisted of the intermetallic compound of Ga-Sb with a eutectic on either side. The eutectic composition on the Sb-rich side was 11.78 atomic %; the eutectic temperature was 589.8 ± 0.5°C. The eutectic temperature was the same as the melting point of Ga. No solubility of Ga in Sb was observed. The melting point of GaSb was 705.9 ± 1.9°C. (ASTIA abstract)

FRA. 04:002

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

THE CELLULAR STRUCTURE, by R. P. Steijn. [1954] [9] p. incl. illus. [AFOSR-TN-54-221] (AF 18(600)465) Unclassified

Published in Jour. Metals, v. 7: 406-407, Feb. 1955.

It has been observed that under certain conditions metals freeze into an aggregate of small hexagonal strands, parallel to one another and with their axes lying approximately in the direction of growth, this formation being termed the cellular structure. In this cellular structure study, descriptions and photographs are given of prismatic and other substructures grown in Zn crystals (99.99% pure) under various external conditions of solidification of the melts. They disclose that Zn single- and bicrystals, produced in a constant-gradient electrical resistance furnace, exhibit the cellular structure after etching in 15% HCl. Other Zn crystals, grown by a modified Czochralski technique using a seed crystal rotating around a vertical axis, show after etching a pattern of undulations and etch-figures similar to the cell structure. Bicrystals and large columnar crystals of Zn, grown by the Bridgeman method in a high-frequency induction furnace, reveal after etching concentric rings on sections perpendicular to the growth direction, and an array of concave bands on longitudinal cuts. Careful etching of polished sections parallel to the hexagonal strands in a Zn single crystal reveals rows of etchpits at the sites of Taylor-Orowan dislocations.

FRA. 04:003

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

THE PURIFICATION OF GALLIUM BY ZONE-

REFINING, by D. P. Detwiter and W. M. Fox. [Aug. 1954] 5p. incl. illus. [AFOSR-TN-54-233] (AF 18-(600)465) Unclassified

Published in Jour. Metals, v. 7: 205, Jan. 1955.

In an attempt to obtain Ga for greater purity than that available commercially, a method has been evolved which consists of acid-leaching to clean the surface thoroughly, followed by zone-melting to remove metallic impurities. The zone-melting process is considered briefly in this study. It is pointed out that the low-mp and relatively high-thermal conductivity of Ga introduce difficulty in maintaining frozen- and molten-zones in zone-refining. This is overcome by circulating ice water in asbestos-insulated coils around the regions it is desired to maintain frozen, while heat is supplied to molten regions by resistance coils. The Ga ingot is fastened in a Pyrex tube, which is positioned inside the cooling and heating coils. The molten zones are moved through the ingot at a rate of 2 in./hr using the reciprocating method of Tannenbaum (Jour. Metals, v. 6: 762, 1954). The results of a spectroscopic analysis of a Ga zone-refined ingot, as well as of the material as received and after acid-leaching, are presented. They indicate that definite removal of impurities, Pb, occurs during the zone-refining process.

FRA. 04:004

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

STUDY OF RECTIFYING CONTACTS BETWEEN SEMICONDUCTORS, by D. P. Detwiler. Final rept. Oct. 1, 1952-Sept. 30, 1954, 24p. incl. diagrs. (Rept. no. F-2337-2) (AF 18(600)465) AD 48326 Unclassified

Distillation under high vacuum and zone refining was employed for the further purification of Sb. Zone refining of Sb was carried out under an atmosphere of hydrogen freed of oxygen and water vapor by passing successively through a catalytic purifier, a high-voltage discharge, a $CaSO_4$ drying tower, and a liquid-N-cooled trap. Sb purified under this atmosphere exhibited a mirror-like-surface as compared to the dull matte surface caused by oxide particles on Sb melted under less highly purified H. The zone-refining technique was also adapted to the purification of Ga. Samples of zone-refined GaSb were placed in sealed-off, evacuated Vycor glass tubes 12 in. long and 7 mm in diameter with several 1-mm constrictions. After holding the furnace temperature fixed for several hrs, the Vycor tube was removed and the distillate condensed in the cool end of the tube was analyzed chemically for Sb and Ga. Several samples taken at temperatures between 700° and 900°C showed Sb contents ranging from 75 to 90 atomic % in the distillate. The phase diagram of the Ga-Sb system was determined by thermal analysis. The melting point of GaSb was determined to be 705.9 ± 1°C. A eutectic on the Sb-rich side of the compound was found at 589.8 ± 0.5°C and 88.2 atomic % Sb, while the solidus line found on the Ga-rich side indicated the presence of a eutectic at very small Sb concentrations and very nearly 29.7°C, the melting point of pure Ga. The conductivity and Hall coefficient of a number of samples of GaSb were measured from -196° to 650°C. (ASTIA abstract)

FRA. 04:005

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

CONDUCTIVITY, HALL EFFECT, AND RECTIFICATION OF GALLIUM ANTIMONIDE (Abstract), by D. P. Detwiler. [1954] 1p. (AF 18(600)465) Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit-Ann Arbor, Mich., Mar. 17-19, 1954.

Published in Phys. Rev., v. 94: 1431, June 1, 1954.

Gallium antimonide of relatively high purity has been prepared by zone-refining the compound and growing single crystals by pulling from the melt. As prepared under a hydrogen atmosphere in silica crucibles, this material exhibits in general p-type conductivity. The electrical conductivity and Hall constant of a number of samples, both n-type and p-type, have been measured between -190° and 650°C. Room temperature conductivity ranged from a few $ohm^{-1}\ cm^{-1}$ to 100 $ohm^{-1}\ cm^{-1}$. The room temperature Hall mobility of hotes in relatively pure specimens is about 2000 $cm^2\ volt^{-1}\ sec^{-1}$, while that of electrons is appreciably higher. The intrinsic energy gap is somewhat greater than that of germanium. Rectifying p-n junctions have been grown from the melt by adding tellurium to a p-type melt. It has been found that these junctions may be located by chemical etching with a mixture of hydrochloric and nitric acids. Early junctions show a room temperature rectification ratio of several hundred at one volt with, however, considerable "softening" of the reverse characteristic. Although much smaller reverse currents are obtained at 77°K, saturation is still poor in the units tested. (Contractor's abstract)

FRA. 04:006

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

ELECTRICAL PROPERTIES OF GALLIUM ANTIMONIDE, by D. F. Detwiler. [Nov. 1954] [13]p. incl. diagrs. (AF 18(600)465) Unclassified

Published in Phys. Rev., v. 97: 1575-1578, Mar. 15, 1955.

Data are presented on the conductivity and Hall coefficient of several samples of GaSb over the temperature range from -196° to 650°C. The lowest room-temperature conductivity obtained was 12 $ohm^{-1}\ cm^{-1}$. All material produced from zone-purified components was p-type; n-type material was produced by doping with Te, as were p-n junctions. The intrinsic band gap is estimated from junction rectification data to be 0.78 ev

at -196°C. The mobility of electrons was found by measurement on n-type material to be several times greater than the hole mobility. The mobilities of both holes and electrons are found to vary approximately at $T^{-3/2}$ in the lattice-scattering range. (Contractor's abstract)

FRA. 04:007

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

THE APPLICATION OF ZONE-MELTING TO HIGH-MELTING-POINT METALS (Abstract), by R. L. Smith and J. L. Rutherford. [Jan. 1955] 1p. [AFOSR-TN-55-36] (AF 18(600)465) Unclassified

The floating-zone technique used by Keck (Rev. Sctent. Instruments, v. 23: 331, Apr. 1954) has been applied to such high-mp metals as Fe, Zr, Ni, and Cu in order to avoid cructble contamination during purification by zone-melting. Fe spectmens, 1/8 to 1/4 tn. tn dtameter, have been zone melted in H_2 ustng tnduction-type heating. The floating-zone ts roughly as long as the spectmen's dtameter. C ts readtly removed by this process, micrographs of a low-C alloy showing a complete absence of vistble C or carbide precipttates after zone-melting. It ts potnted out that Fe purified by zone-melting and tested tn tenston at -196°C has a very ductile cup-type fracture (78% reduction of area).

FRA. 04:008

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

STUDY OF PURIFICATION AND SUBSTRUCTURE FORMATION OF METALS AND THE PROPERTIES OF HIGH-PURITY METALS, by M. Herman, J. L. Rutherford, and R. L. Smith. Final rept. Oct. 1, 1954-Sept. 30, 1955, 25p. incl. illus. diagrs. table, refs. (Repl. no. F-2337-3) ([AF]OSR-TN-55-404) (AF 18(600)465) AD 77906 Unclassified

Induction heating equipment for the floating technique of zone melting ts described. Major changes in the tnduction equipment tnvolve the glass-to-metal seals, the bottom chuck mount, and the top specimen-support rod. Fe and Ti, melted by this technique, are betng evaluated. A radioactive tracer technique is being used to estabtish the dtstribution of controlled additions to the specimen. After 6 zone passes, the concentration of P in the starting end dropped to 2.2% of its original concentration. The concentration of solute did not exceed the initial concentration for the first 90% of the bar, because of the short zone length (7% of the bar length). Photographs show the mtcrostructure of the Swedish iron before and after zone purification. Studies of substructure suggested that Pb segregation accounts for the observed substructure and pits formed in the etched Zn, although it is possible that the Pb segregates in the region of a dislocation. The cellular structure ts bounded by simple crystallographic planes and not by boundartes that are apparently oriented randomly.

FRA. 05:001

Franklin Inst. Labs. for Research and Development, Philadelphia, Pa.

ZONE PURIFICATION OF REACTIVE METALS, by R. L. Smith and J. L. Rutherford. Feb. 1, 1956 [33]p. tncl. illus. diagrs. (Interim rept. no. I-A1878-1) (AFOSR-TN-56-70) (AF 18(600)1581) AD 81522 Unclassifted

Also published in Jour. Metals, v. 9: 1-7, Apr. 1957.

The floating-zone method ts described for zone melting reactive, high-melting potnt metals. The method consists of the formation of a narrow molten zone in a rod by tnduction heating. The molten zone ts supported between the 2 solid sections of the rod by surface tenston, and ts moved longitudtnally along the rod to effect a redtstrtbution of solute. The method ts more advantageous than the hortzontal method since cructble contamination ts avoided, but tt ts a more difficult technique. Only one zone can be formed at a time wtth the floating-zone method. High-purity metals can be obtained, but the method does not remove all tmpurity elements. The impure elements which cannot be redistributed in an ingot during zone melting must be removed by some other means. The use of radioactive tracers ts dtscussed for determtning the redistribution of solute durtng zone melting. Rods of Fe, Tl, Zr, Ni, and Mo were zone melted tn prelimtnary expertments. Results are given for P^{32} tn Fe, Au^{198} tn Tt and Zr, and Zn^{65} tn Ti. P and C in Fe, and Au and Zn tn Tt segregrated to the end of the ingot and were the last to solidify durtng melting. At 77.3°K, tensile tests on Fe showed that a progressive increase in ductility occurs as purer specimens are used. Tenstle tests at 4.2°K showed that a large reduction tn area can be obtained tn highly purified Fe. (ASTIA abstract)

FRA. 05:002

Franklin Insl. Labs. for Research and Development, Philadelphia, Pa.

TENSILE PROPERTIES OF ZONE-REFINED IRON IN THE TEMPERATURE RANGE FROM 198 K TO 4.2 K, by R. L. Smith and J. L. Rutherford. Interim repl. Sept. 1956 [44]p. incl. illus. diagrs. tables, refs. (Repl. no. 1-AI878-2) (AFOSR-TN-56-490) (AF 18-(600)1581) AD 110304 Unclassified

Also published in Jour. Metals, v. 9: 857-864, July 1957.

The tensile properties of zone-refined iron have been evaluated in the temperature range from 298°K to 4.2°K. It has been found that the higher the purity, the lower the flow stresses and the better the low

temperature ductility. Yield stresses as low as 3, 800 psi have been observed at room temperature and elongations of 10% have been observed at 4. 2°K. The major portion of the ductility at 4. 2°K arises from twinning. Deformation by twinning at 4. 2°K is not suppressed by prestraining at room temperature and the twins occur all through the test. Slip traces were observed to initiate at the ends of previously formed twin traces. (Contractor's abstract)

FRD. 01:001

Frederick, Carl L., and Associates, Bethesda, Md.

MACH NUMBER MEASURING DEVICES FOR USE IN HIGH-SPEED WIND TUNNELS, by C. L. Frederick. Dec. 1954, 30p. incl. refs. [AFOSR-TN-54-363] (NATO AGARDograph rept. no. 2) (AF 18(600)797) Unclassified

The results of a critical review of progress in the development and use of Mach number measuring devices in the field of high-speed wind-tunnel testing, analysis, and evaluation of the various methods of measuring and indicating Mach number is presented. The paper is devoted primarily to transonic and supersonic testing because of the basic differences in testing at subsonic and supersonic speeds. The following Mach number ranges are used: (1) subsonic, $M < 0.9$; (2) transonic, $0.9 \leq M < 1.2$; (3) supersonic, $1.2 \leq M < 5$; and (4) hypersonic, $M \geq 5$. A brief listing of the development of Mach number measuring devices is given, followed by a description of Mach meters in use today, together with their advantages and disadvantages.

FRD. 01:002

Frederick, Carl L., and Associates, Bethesda, Md.

DESIGN AND CONSTRUCTION ASPECTS OF HIGH POWER WIND TUNNEL DRIVE SYSTEMS AND LARGE DIAMETER WIND TUNNEL COMPRESSORS, by J. Clark. Apr. 1954 [54]p. incl. illus. diagrs. [AF 18(600)797] Unclassified

Presented at the Netherlands meeting of the NATO-AGARD, May 1954.

A brief review is presented of certain aspects of the design criteria used for large wind tunnel drives which have been conducted by various groups in the NATO nations. Although this design information was used for large wind tunnel drives, it is applicable to most small and medium-size installations. A particularly valuable feature is that it may be used to predict the performance characteristics of drive systems whose component parts have been obtained from various sources. Thus, difficulties can frequently be predicted in advance and, if necessary, slight changes can be made to these parts before they are assembled into a drive system, with a consequent reduction in time required to place such drives in successful operation. The requirements and arrangement of various types of large wind tunnel drives are compared. Section I, discusses some of the major design problems that are usually encountered in these drives. In Section II, a comparison is presented of the various types and mechanical characteristics of wind tunnel compressor rotors. This is followed by a general discussion of some of the major problems encountered in the mechanical design of large wind tunnel compressors.

FRD. 01:003

Frederick, Carl L., and Associates, Bethesda, Md.

AUTOMATIC PRESSURE MEASURING SYSTEMS USED WITH HIGH-SPEED WIND TUNNELS, by C. L. Frederick. June 1955, 51p. incl. illus. diagrs, refs. [NATO AGARDograph rept. no. 10] [AF 18(600)-797] AD 77895 Unclassified

A brief review is given of high-speed wind tunnel characteristics, particularly with respect to instrumentation needs. Major elements of pressure measuring systems are surveyed, and representative United States' systems are described. The representative systems can be subdivided into those characterized by fast response, short running time, and a small number of pressure channels and those characterized by repeated multiple measurements, long tunnel running time, and long insirument stabilization time. Refinements of the first group are needed in the pressure connecting system, the sensing element, and the transducer. For the second group, novel meniscus transducers are necessary when conventional pressure connecting systems and conventional manometers are used. Diaphragm transducers coupled to relatively slow response pressure connecting systems can be used. The metal diaphragm and wire filament provide the shortest response times, but only the diaphragm can be made to provide an effectively linear response over a relatively narrow pressure range. Electrical transducers for measuring diaphragm response are highly developed and useful in automatic recording systems. For determining and recording a discrete, stabilized pressure value for each gage, the liquid manometer with electrical transducer competes with the diaphragm. (Extracted from repi.)

FRE. 01:001

Free U. of Brussels (Belgium).

[ISOTOPIC EFFECTS AND THERMODYNAMIC PROPERTIES IN THE CONDENSED PHASE, 1] Effets isotopiques et propriétés thermodynamiques en phase condensée. 1, by I. Prigogine, R. Bingen, and J. Jeener. [1954] [12]p. [AF 61(515)635-C] Unclassified

Published in Physica, v. 20: 383-394, July 1954.

The zero point of energy of solid isotopic mixtures is discussed, and their properties are compared with those of the pure isotopes. The case of a 1-dimensional chain of molecules is considered in some detail because the

calculations may then be performed in a rigorous way. Only harmonic oscillators are considered. It is shown that the zero-point energy increases steadily with the number of couples of first neighbors between molecules of different masses. The zero-point energy is lowest for the pure isotopes and highest for the ordered lattice ABAB .... Also its value for a random distribution of the isotopes is higher than that for the pure isotopes. The stable state at 0°K always requires a separation into pure isotopes. Differences in masses, i.e., isotopic effects, may give positive deviation from Raoult's law without any effect of the statistics. The results obtained indicate the possibility of pure quantum transitions in the phase diagram due to isotopic effects at sufficiently low temperatures. These transitions are quantum analogues of order-disorder transitions. The differences in the zero-point energies due to different spatial distributions of the isotopes are small, however, so that these effects can only appear at extremely low temperatures. They are much smaller than the effects calculated by Prigogine and Phillppot which are related to volume changes on mixing and thus to the anharmonicity of the motion of the molecules. (Contractor's abstract)

FRE. 01:002

Free U. of Brussels (Belgium).

[ISOTOPIC EFFECTS AND THERMODYNAMIC PROPERTIES IN THE CONDENSED PHASE, II] Effets isotopiques et propriétés thermodynamiques en phase condensée. II, by I. Prigogine and J. Jeener. [1954] [5]p. incl. table. [AF 61(514)635-C] Unclassified

Published in Physica, v. 20: 516-520, Aug. 1954.

The method developed in Part I is extended to real 3-dimensional lattices. The zero-point energy is calculated for isotopic mixtures and pure isotopes. The results obtained for 1-dimensional lattices are shown to remain qualitatively valid for 3-dimensional lattices; the heat of mixing, however, is smaller than in the 1-dimensional case. The stable state at 0°K always requires a separation into pure isotopes. (Contractor's abstract)

FRE. 01:003

Free U. of Brussels (Belgium).

[ISOTOPIC EFFECTS AND THERMODYNAMIC PROPERTIES IN THE CONDENSED PHASE, III] Effets isotopiques et propriétés thermodynamiques en phase condensée. III, by I. Prigogine and J. Jeener. [1954] 5 p. incl. diagrs. tables, refs. [AF 61(514)635-C] Unclassified

Published in Physica, v. 20: 633-654, Sept. 1954.

The basic assumption of this paper is introduced in the following form: the free energy of an isotopic mixture is, for given values of volume per particle and temperature, the sum of the free energy of the pure isotopes and of a term due to the entropy of mixing. This assumption is automatically satisfied in simple statistical models of condensed phases like the cell model or an assembly of anharmonic oscillators, the change on mixing of the zero-point energy not being taken into account. It thus constitutes a satisfactory method of approach for the understanding of the thermodynamic properties of isotopic mixtures. From this hypothesis the free energy of mixing, the excess volume and the heat of mixing can be expressed in terms of properties of the pure isotopes. This theory predicts for isotopic mixtures heat absorption and positive deviations from Raoult's law. Some simple statistical models are considered in some detail in order to understand the thermodynamic properties of the pure isotopes. By applying the fundamental assumption of this paper, the qualitative features of the mixture can then easily be discussed. The effects calculated in this paper and the change in zero-point energy on mixing are compared. (Contractor's abstract)

FRE. 01:004

Free U. of Brussels (Belgium).

THERMODYNAMIC PROPERTIES OF QUANTUM SOLIDS AT ABSOLUTE ZERO, by R. Bingen. [1954] [19]p. (AF 61(514)635-C) Unclassified

Published in Bull. Acad. Roy. de Belgique, Cl. Sci., v. 40: 815-833, 1954.

A chain of anharmonic oscillators is studied, and the effect of the volume on the elastic constants, and of the anharmonicity on the zero-point energy is discussed.

FRE. 01:005

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES IN CRYSTALS, PART I, by I. Prigogine and R. Bingen. 1954, 42p. (AF 61(514)635-C) Unclassified

Published in Physica, v. 21:299-311, Apr. 1955.

This study is concerned with irreversible phenomena in crystals, which are not related to processes involving energy dissipation, e.g., anharmonicity. An infinite 3-dimensional assembly of harmonic oscillators is studied. Their position and velocities are considered as random variables whose probability distributions are known at the initial moment. The asymptotic values of these distribution functions can be calculated by solving the equations of motion of the lattice points in terms of the initial conditions. "Influence functions" are introduced, which are related to the frequency spectrum of the lattice. Some of their asymptotic properties can be established after a long period regardless

of the frequency spectrum. They show that all the local dtstribution functions tend to Gaussian dtstributions, and the crystal ttself to local homogeneity. In constrast with the 1-dimenstonal case, it ts not posstble to ftnd simple linear combtnattons of the second moments which are invartant; however, the second moments are known to be quasi-invariant, t.e., they tend to a definite asymtotic value after a more or less complicated vartatton. No other condition is imposed on the initial distribution function than the absence of correlation at l.. ge distances. If they are such, however, that the equtpartttion of the energy is initially achieved between the normal modes, without any correlation between their phases, all the various moments and local dtstribution functions tend to thetr equtlibrium value. That ts, each finite part of the crystal tends to local thermodynamic equilibrium. This local ergodtcity of the crystal can be considered as a consequence of the central limit theorem of statistics. After a long pertod, the local distribution functions are determined by a very large number of random vartables (owing to the dispersion of the frequency spectrum, this number is proportional to t^3). (Contractor's abstract)

FRE. 01:006

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES AND THE STEADY STATE, PART II, by I. Prigogtne and R. Brout. 1954 [22]p. (AF 61(514)-635-C) Unclassified

The thermodynamic consequences of our previous studtes on the harmonic systems ts examined. It is found that the entrophy, corresponding to the asymptotic distribution in time, (subject to rather broad condttions) is a maximum, defined ob the surface gtven by the mechanical invariants of the system. An H theorem is found in a time smoothed sense, systematic oscillations being due to the second order differential equations of motion. Anharmonicities are then introduced into the system which destroy all mechanical invariants other than the energy, thereby allowing the system to come to the standard canonical ensemble (energy the only mechanical invariant). The evolution of entropy at this stage is then examined using equations previously developed by Peierls in the study of thermal conductivity of solids. Finally, the stationary state of heat flow is examined in the presence of a temperature gradient. This study introduces the concept of an intermediate time scale, which allows the study of the stationary state without introducing extraneous interactions with the external world. Rather, the thermal gradient is propagated from the ends of the system itself. A stationary state exists for times long enough to establish the space smoothed and time smoothed equations of Peierls, and short enough so that the effects of the propagating gradient do not disturb the stationary character of the system. The conditions on this time are given and such times are shown to exist for sufficiently large systems and sufficiently small temperature gradient. The stationary state arises from harmonic propagation of the gradient compensated by local decay of heat flow due to anharmontcttles. It ls further shown to correspond to a state of minimum entropy production for ftxed gradient, thereby corroboratttng a well known theorem in phenomenologtcal trreversible thermodynamtcs. (Contractor's summary)

FRE. 01:007

Free U. of Brussels (Belgium).

THERMAL CONDUCTIVITY OF REAL GASES, PART III, by I. Prtgogine and S. Lafleur. 1954, 15p. incl. table, refs. (AF 61(514)635-C) Unclassified

Published tn Physica, v. 21: 667-675, Aug. 1955.

In a real gas, in the presence of a temperature gradient, the relative concentrations of the molecular cluster vary from point to potnt; this leads to a diffuston of the larger clusters towards the warm regtons and of the smaller clusters, and monomolecules towards the cold parts of the apparatus, where they respectively dissociate or recombtne with the absorption or ltberation of the heat of formation. The tncrease in the thermal conductivtty of the gas resulting from this circulation of the heat of formation of the clusters can be evaluated wtth reasonable accuracy at low pressures when only stmple and double molecules need to be taken into account. This effect is negltgible at htgh temperatures (above Boyle point), where the vartation of thermal conductivity with pressure can be represented to a high degree of accuracy by Enskog's theory; tt increases wtth decreastng temperature, and becomes approximately equal to Enskog's effect in the netghborhood of the critical temperature; it is evaluated that in the case of argon the increase is of the order of 6% per atm at the boiling point. At higher pressures, the larger clusters carrying an important heat of formatton can no longer be neglected; an exact evaluation of their contribution is difficult, but qualttative calculations based on crude models indicate that the calculated value depends strongly on the model assumed, and that for homopolar molecules at high pressures and relatively low temperatures this excess thermal conductivity is largely due to polydimensional clusters with internal cyclic links. (Contractor's summary)

FRE. 01:008

Free U. of Brussels (Belgium).

KINETIC THEORY OF POLYATOMIC GASES, PART IV, by I. Prigogine and S. Lafleur. 1954 [43]p. incl. refs. (AF 61(514)635-C) Unclassified

An extension of the kinetic theory of gases taking into account inelastic collisions is considered, and the effect of these inelastic collisions on transport properties (e.g., thermal conductivity) is investigated. The kinds of inelastic collisions considered are collisions leading to a molecular association or "dimerization" (and inversely decomposition of an associated molecule) and those leading to an excitation (and inversely de-excitation) of one of the colliding molecules, this kind

of process being very likely in polyatomic gases. The Boltzmann's equation of a system consisting of simple molecules, stable and excited double molecules subject to these inelastic processes together with the usual elastic collisions are derived. Following Grad's method of solution the moments equations are written, and from them the thermal conductivity is deduced for a simple case. In this case suppose that the concentrations of the different molecules in local chemical equilibrium and a sufficiently small equilibrium concentration of excited molecules so that it can be neglected. It is shown that this condition is satisfied if the heat of association is larger than a few times the thermal energy kT. The results corroborate the macroscopic theory of Nernst, Dirac, Prigogine, and Meixner, and show that inelastic collisions can give rise to an important increase in the thermal conductivity through a "circulation" process of the heat of association between the hot and cold parts of the system. It is shown that Onsager's reciprocity relations are satisfied by the system. The deviations from local chemical equilibrium are then shortly discussed; it is found by qualitative evaluation, that in usual conditions, these deviations are appreciable, and that the increase in the thermal conductivity due to inelastic collisions is less than in the case of local chemical equilibrium. (Contractor's summary)

FRE. 01:009

Free U. of Brussels (Belgium).

QUANTUM EFFECTS AT ABSOLUTE ZERO IN PURE CRYSTALS AND ISOTOPIC MIXTURES, PART V, by I. Prigogine and R. Bingen. 1954, 1v. incl. diagrs. table, refs. (AF 61(514)635-C) Unclassified

The influence of the anharmonicity of motion is studied, in connection with the properties at very low temperatures of solids such as H_2, He, and their isotopes, which are sufficiently light to display large quantum effects. In Chapter I, the properties of pure crystals at absolute zero were studied. A one dimensional chain of anharmonic oscillators is taken as statistical model, with Lennard Jones' "6-12" interaction between nearest neighbors only. Two effects of quantum origin are taken into account: the change of zero-point energy with volume, due to changes of elastic constants, and on the other hand the additional contribution to the zero-point energy due to the anharmonicity of the interaction potential. The volume, the free energy and the Debye temperature are calculated as functions of de Boer's quantum parameter Λ. The light crystals are found to show important deviations from classical laws. Chapter II is devoted to the mass effect in solid isotopic mixtures, i.e., the influence of the spatial distribution of the two isotopes upon the zero-point energy. The latter is always higher when the two isotopes are mixed than when separated; in the case of equimolecular mixtures, the zero-point energy is the highest for the ordered lattice ABAB... The stable state at $0^{\circ}K$ is thus given by the separation into the pure isotopes. In Chapter III, the volume effect is discussed, i.e., the volume change and the corresponding variation of zero-point energy which occur when two isotopes are mixed. This volume effect is more important than the mass effect, at least for light substances. It is first evaluated in the case of 1-dimenstonal crystals. The calculations are then extended to real 3-dimenstonal crystals, showing that the excess free energy is always positive. This theory indicates that a quantum phase transition must be expected at a sufficiently low temperature, below which the two isotopes are separated. The heat mixing of mixtures such as H_2 - D_2 are found to be in agreement with experimental data on analogous liquid mixtures. (Contractor's summary)

FRE. 01:010

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS, by I. Prigogine. [1955] [26]p. incl. refs. (AF 61(514)635-C; continued by AF 61(514)817) Unclassified

Published in Ann. Rev. Phys. Chem., v. 6: 457-482, 1955.

Recent literature primarily of 1954 on selected topics in statistical mechanics is reviewed. The 166 publications surveyed are concerned with the thermodynamics of irreversible processes, the statistical mechanics of irreversible processes, some equilibrium properties including condensation of imperfect gases, the Monte Carlo method of evaluating partition functions for interacting particles, the cell-cluster model for the liquid state, and the vibration spectrum of perturbed lattices and isotopic mixtures. Also discussed are some recent papers on liquid helium.

FRE. 02:001

Free U. of Brussels (Belgium).

ON THE DIFFERENTIAL PROPERTIES OF ENTROPY PRODUCTION, by P. Glansdorff and I. Prigogine. [1954] [8]p. ([AF 61(514)817] continuation of AF 61(514)635-C) Unclassified

Published in Physica, v. 20: 773-780, Oct. 1954.

The time variation of the entropy production (per unit volume and unit time) is split into two parts. The first is related to the changes of the generalized forces with time and the second to the changes of the rates of the irreversible processes. If some restrictive conditions are satisfied (linear phenomenological laws, Onsager's reciprocity relations, constancy of the phenomenological coefficients) both parts are equal and decrease in time. This does no more hold if these conditions are not satisfied. Postulating only mechanical equilibrium and time independent boundary conditions, it is shown that the first part, related to the change of the generalized forces, is always negative zero. The change of the generalized forces with time is therefore such that

it lowers the value of the entropy production. Some consequences of this theorem are briefly discussed. (Phys. A. abstract)

FRE. 02:002

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS AND THERMODYNAMICS OF IRREVERSIBLE PROCESSES, by I. Prigogine. [1956] 1v. incl. diagrs. refs. (AFOSR-TN-56-417) (AF 61(514)817) AD 96226 Unclassified

A study is made of the statistical mechanics and thermodynamics of irreversible processes, and Poincare's theorem is extended to systems of oscillators. A systematic theory is developed which gives, for simple classes of Hamiltonians, a general procedure for describing the irreversible behavior starting from first principles. The connection between statistical mechanics and thermodynamics is pointed out. The more conventional approach of the thermodynamics of irreversible processes is discussed by using a differential property of the entropy production to study variational principles associated with stationary nonequilibrium situations; the case of 1 and 2 independent variables is solved in a general way, and restrictions which exist for more than 2 variables are discussed. The thermodynamical systems which are described by antisymetrical phenomenological laws are studied in the neighborhood of a stationary nonequilibrium state; an example of such systems is given by Volterra's (Theorie Mathematique de la lutte pour la vie, Paris, Gauther Villars, 1931) model of interacting biological populations. (ASTIA abstract)

FRE. 02:003

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART I. ANHARMONIC FORCES, by R. Brout and I. Prigogine. [1956] 14p. incl. diagrs. (Bound as Chapter 1 of AFOSR-TN-56-417; AD 96226) (AF 61(514)817) Unclassified

Also published in Physica, v. 22: 35-47, Jan. 1956.

The weak coupling mechanism described by the complex amplitudes of the normal modes b_k (with $b_k^* = b_{-k}$) where k is the index for the wave-vector. The branch and chain "phonon processes" are analyzed by the comparison of the roles of certain solutions in the formation of the asymptotic gaussian distribution. A proof is given of the asymptotic gaussian character of the variates.

FRE. 02:004

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART I. GENERAL THEORY OF WEAKLY COUPLED SYSTEMS, by R. Brout and I. Prigogine. [1956] 16p. (Bound as Chapter 2 of AFOSR-TN-56-417; AD 96226) (AF 61(514)817) Unclassified

Also published in Physica, v. 22: 621-636, July 1956.

In this mathematical study, a general procedure for the classical mechanical study of irreversible processes in weakly-coupled multiply periodic systems is presented. By weakly coupled systems, it is meant that the total Hamiltonian may be divided into two units, $H = H^0 + \lambda V$, where $|\lambda V| \ll |H^0|$. λ is a coupling parameter characteristic of the magnitude of the perturbation, and H^0 is taken to be a sum of many sub-Hamiltonians $H^0 = \sum_{1=1}^{N} H_1$. Thus, the dynamical system described by H^0 has N analytic invariants and hence is nonergodic. The small addition λV is taken so as to destroy these invariants which presumably insures ergodicity. At the same time, λV is considered so small that it does not enter into the equilibrium properties of the system. In this it serves the familiar role of rare collision in dilute gases. It is the purpose of this paper to study the irreversible evolution of ensembles of systems governed by the Hamiltonian two units mentioned above.

FRE. 02:005

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART I. BOLTZMANN EQUATION, by R. Brout. [1956] 18p. (Bound as Chapter 3 of AFOSR-TN-56-417: AD 96226) (AF 61(514)817) Unclassified

Also published in Physica, v. 22: 509-524, June 1956.

The transfer from the reversible equation of Liouville to an irreversible "master equation" is effected under the following hypotheses: (1) the transitions of the molecules from one state to another are almost instantaneous events; (2) the system is infinite; and (3) the initial distribution is such that in the dilute gas, all the positions of the molecules are equally likely beyond a certain region of microscopic correlation (Stosszahlansatz). It is also shown that an ulterior reduction of the master equation to the Boltzmann equation can only be realized by initial conditions such that the distribution is already factored.

FRE. 02:006

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART I. CONNECTION WITH THERMODYNAMICS, by I. Prigogine and R. Balescu. [1956] 11p. (Bound as Chapter 4 of AFOSR-TN-56-417; AD 96226) (AF 61(514)817) Unclassified

The connection between statistical mechanics and

FRE. 02:007 - FRE. 02:011

irreversible thermodynamics is studied with emphasis on weakly coupled, multiply periodic systems (of predominantly homogeneous variety). Entropy and entropy production are discussed where neighborhood of equilibrium conditions hold: $P = \sum V_i$, $X_i (V_i, X_i$ conjugate rates and affinities. A variational principle characterized by the extreme of a certain integral is made to describe thermodynamic equilibrium. As a result, Onsager's reciprocal relations occur in the moment equations near equilibrium. Ideal gases and chemical reactions are investigated by the self-adjoint transformations. The self-adjoint operator Ω is used in describing the irreversible evolution towards equilibrium.

FRE. 02:007

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART I. REMARKS ON THE QUANTUM THEORY OF WEAKLY COUPLED SYSTEMS, by R. Brout, I. Prigogine, and J. Jeener. [1956] 5p. (Bound as Chapter 5 of AFOSR-TN-56-417; AD 96226) (AF 61-(514)817) Unclassified

The general Poisson form master equation from the quantum theory analysis of weakly coupled systems is

$$\frac{\delta P(E, \alpha)}{\delta t} = \frac{2\pi\lambda^2}{\hbar^2} \sum_{E', \alpha'} |\langle E, \alpha | V | E', \alpha' \rangle|^2 \, \delta(E - E') \, [P(E', \alpha') - P(E, \alpha)]$$

with the hermitian property $|\langle E \alpha | V | E' \alpha' \rangle|^2 = |\langle E' \alpha' | V | E \alpha \rangle|^2$ and the $\alpha (\alpha_1, \ldots \alpha_n \ldots)$ the constants of motion of unperturbed Hamiltonian H_0. In the limit $t = o$, the equation becomes $\frac{\delta P}{\delta t} = \Omega_P$. The use of single action variables in the quantum mechanical problem is discussed.

FRE. 02:008

Free U. of Brussels (Belgium).

THERMODYNAMICS OF IRREVERSIBLE PROCESSES, PART II. DIFFERENTIAL PROPERTIES OF THE ENTROPY PRODUCTION, by I. Prigogine and R. Balescu. [1956] [7]p. incl. diagrs. (Bound as Chapter 6 of AFOSR-TN-56-417; AD 96226) (AF 61(514)817) Unclassified

Also published in Bull. Acad. Roy. de Belgique, Cl. Sci., v. 41: 917-918, Oct. 1955.

Starting with $d_x P = \sum_1 V_1 dx_1 \leq 0$ for time independent boundary conditions, the possibility of definition of a monotonically decreasing function $\phi (x_1 \ldots x_n)$ is investigated in its evolution toward a stationary state. Chemical reactions are examined and ϕ is found in some cases, but it is unable to be solved in the most general case, which serves to point out the difference between equilibrium states and stationary states not in equilibrium.

FRE. 02:009

Free U. of Brussels (Belgium).

THERMODYNAMICS OF IRREVERSIBLE PROCESSES, PART II. CYCLIC PROCESSES IN IRREVERSIBLE THERMODYNAMICS, by I. Prigogine and R. Balescu. [1956] [7]p. incl. diagrs. (Bound as Chapter 7 of AFOSR-TN-56-417; AD 96226) (AF 61(514)817) Unclassified

Rotation about stationary states far from equilibrium in thermodynamic cases are studied for the consequences of Glansdorff and Prigogine's inequality $d_x P = \sum_1 V_1 dx \leq 0$ where $d_x P$ fixes the sense of rotation. The example given is the population competition of two biological species (Volterra's "struggle for life" problem).

FRE. 02:010

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS AND THERMODYNAMICS OF IRREVERSIBLE PROCESSES. POINCARÉ'S THEOREM FOR AN ASSEMBLY OF OSCILLATORS, by R. Balescu. [1956] 4p. (Bound as Appendix to AFOSR-TN-56-417; AD 96226) Unclassified

A theorem of Poincaré states that the Hamiltonian of a dynamical conservative system $H = H_0 (d_1 \ldots d_n) + \lambda V (d_1 \ldots d_n; \alpha_1 \ldots \alpha_n)$ (d_1, α_1 action-angle variables of the nonperturbed system, λ small dimensionless parameter, V-periodic function of the angle variables) will generally describe a functional relation of every analytic and uniform integral of the motion. This appendix generalizes upon this theorem and determines the conditions which V satisfies in order that the system admits of no analytic and uniform integral of the motion other than H (or any function of H).

FRE. 02:011

Free U. of Brussels (Belgium).

STATISTICAL MECHANICS OF IRREVERSIBLE PROCESSES, PART VI. THERMAL CONDUCTIVITY OF CRYSTALS, by R. Brout and I. Prigogine. [1956] [10]p. [AF 61(514)817] Unclassified

Published in Physica, v. 22: 263-272, Apr. 1956.

It was shown in parts III and IV of this series that under general conditions local distribution functions in an infinite harmonic crystal tend asymptotically to multivariate gaussian distributions. This result has interesting consequences which are discussed in the present paper. The evolution towards equilibrium of a slightly anharmonic crystal can be subdivided into two steps which proceed according to quite different time scales. The first step corresponds to the appearance of the multivariate gaussian distribution and is reached in times of order $1/\omega$ (ω = characteristic

fequency of the harmonic crystaI). The second step ts the disappearance of all second order correlattons (except of course autocorrelations) through the effect of anharmonic forces. This part corresponds to the evolution towards equipartition of energy between normal modes and corresponds to a "long" time scale related to the anharmonictty of the crystaI. It tc shown that if we take account of this initial "preparation" of the system by harmonic forces, the molecular theory of thermaI conductivtty takes a remarkably stmple form. Instead of ustng the full Boltzmann equation for thts problem, it becomes sufficient to use the equatton for the second moments alone. In this way it is easy to obtain an explcit form for the thermal conductivity of the crystal tn terms of molecular quantities. The phenomenologtcal equation for the change of temperature (Fourier's equation) may be justified in the same way. This study is restricted to one-dtmenstonal chains with nearest netghbor tnteractions. An appendtx is attached in which three-dimensional systems are constdered. (Contractor's abstract)

FRE. 03:00I

Free U. of Brussels. Lab. of Molecular Chemistry and Physics (Belgium).

VAPORIZATION OF COMPOUNDS AND ALLOYS AT HIGH TEMPERATURE, by R. E. Honig and J. Drowart. Oct. I956, 32p. incl. dtagrs. tables, refs. (Technical note no. 1) (AFOSR-TN-56-555) (AF 61(514)868) AD 110374 Unclasstfted

Elements of groups IB and IIIB were studted tn a 60°, 20-cm-radius mass spectrometer which was modified to permtt the vaporization of milltgram samples from small, electrtcally heated crucibles made of suttable matertals such as C, Mo, Al_2O_2, and BeO. The matertal was chosen tn order to mtnimtze any interaction between sample and crucible. A pyrex window opposite the crucibte altowed the sample to be vtewed and its temperature to be measured. A fraction of the neutral particles vaporizing from the sample was tonized by a 30 μ a-beam of 70-ev electrons, accelerated, and mass-analyzed in the usual fashion. For Cu, Ag, and Au, the expected atomtc species and small concentrations of the dimers were found. The tonic ratios X_2^+/X_I^+ (about 10^{-3}) were measured over ranges of about 100°K at pressures between 10^{-4} and 10^{-5} mm Hg. Neutral ratios X_2/X_1 were obtained by assuming that the total tonization cross section of a molecule is the sum of the cross sections of the consttuent atoms. For Ga and In, no dtmers were found. Dtssociation energies were computed for Cu_2, Ag_2 and Au_2; the values agreed well with those obtained by the slope method which utiltzes directly measured heats of vaporization of the monomers and dimers. The absotute entropy method was used to obtatn the dtssoctatton energies of the Group lVB molecules (C_2, Si_2, Sn_2, Ge_2, and Pb_2). The mass spectrometer was considered to be an instrument capable of supplying much detailed information concerning the vapor phase of substances which are solid at room temperature. (ASTIA abstract)

FRE. 03:002

Free U. of Brussels. Lab. of Molecular Chemistry and Physics (Belgium).

MASS SPECTROMETRIC STUDY OF COPPER, SILVER, AND GOLD, by J. Drowart and R. E. Honig. [1956] [5]p. incl. tables. (AF 61(514)868) Unclasstfted

Publtshed tn Jour. Chem. Phys., v. 25: 581-582, Sept. I956.

As part of a study of the vaportzation of solids, the Group IB elements Cu, Ag, and Au were investigated tn a 60° mass spectrometer. The instrument was modified to permit the vaporization of mtlligram samples from small, tndtrectly-heated crucibles. Among the cructbles tested (C, Mo, Al_2O_3, and StO_2), no stngle material satisfted completely all requtrements, but C crucibles were best sutted for the sublimation, and Al_2O_3 cructbles for the evaporation of the three elements. A Pyrex window allowed the appearance of the sample to be observed. Temperatures were measured with an optical pyrometer, and the known melting potnts served to standardize the temperature scale. A fractton of the neutral particles vaporizing from the sample was tonized by a 30 μa-beam of 70-ev electrons, accelerated, and mass-analyzed tn the usual fashton. (Contractor's abstract)

FRE. 03:003

Free U. of Brussels. Lab. of Molecular Chemistry and Physics (Belgium).

MASS SPECTROMETRIC STUDY OF GALLIUM AND INDIUM, by J. Drowart and R. E. Honig. Dec. I956, 3p. (AF 6I(514)868) Unclassified

Publtshed tn Bull. Soc. Chim. Belg., v. 66: 4I1-413, May-June 1957.

Galltum and tndium were evaporated from BeO and graphite cructbles into the ion source of a modified 60° mass spectrometer at temperatures ranging from 1035° to I320°K for Ga and from 800° to I130°K for In. Small Ga_2^+ and Ga_2O^+ and In_2^+ and In_2O^+ peaks were observed. The heat of evaporated was calculated to be 59 ± 4 kcal/mole for Ga_1^+ (plot of log (I • T) vs 1/T). Between 1200°and 1320°K durtng the Ga evaporation small peaks appeared at masses 138 and 142. These are interpreted as Ga_1^{++} tons which lose one charge during transit. During the evaporatton of In a small mass 230 peak of nonreproductble intensity was observed between 1020°and 1130°K.

FRB. 01:001

[Fretburg U. Inst. for Mathematics (Germany).]

THEORETICAL INVESTIGATIONS OF THE LAMINAR BOUNDARY LAYER. PROBLEM II: DECAY OF SWIRL IN AN AXIALLY SYMMETRICAL JET, FAR

FRB. 01:002 - FRS. 01:001

FROM THE ORIFICE, by H. Görtler. Final rept. Mar. 10, 1954, 40p. [AFOSR-TN-54-164] (AF 61-(514)627-C) AD 33781 Unclassified

Also published in Rev. Mat. Hispano Americana, Ser. 4, v. 14: 143-193, 1954.

By linearizing the equations of motion of laminar jet flow with respect to the swirl component (the latter being weak relative to the velocity component in the direction of the axis), an eigenvalue problem of a second-order ordinary differential equation is developed. A change of variables reduces it to a Legendre equation, providing a complete and exact solution of the eigenvalue problem. The theory is similarly applied to turbulent jet under the conditions of a hypothesis originally due to L. Prandtl. The theory shows that the swirl in a free jet always decreases according to a higher power of the inverse distance from the orifice than the velocity component of the jet in the direction of the axis. For a given weak swirl distribution in a cross section of the jet, the theory provides a precise evaluation of the progress of the swirl further downstream. (ASTIA abstract)

FRB. 01:002

Freiburg U. Inst. for Mathematics (Germany).

THEORETICAL INVESTIGATIONS OF THE LAMINAR BOUNDARY LAYER. PROBLEM I: GROWTH OF THE LAMINAR BOUNDARY LAYER OF YAWED CYLINDERS STARTING FROM REST, by H. Wundt. Final rept. Apr. 5, 1954, 42p incl. diagrs. tables, refs. [AFOSR-TN-54-165] (AF 61(514)627-C) AD 33782 Unclassified

A system of 3-dimensional boundary-layer equations for incompressible fluids is solved for the case of a yawed cylinder. The method of solution employs power-series expansions in terms of the time as given by Blasius (Zeit. Math. u. Phys., v. 54: 1-37, 1908). Different laws of motion lead to universal coefficient functions of the coordinate representing the distance from the wall. The functions are calculated to a high degree of accuracy for the case of an impulsive start from rest to a state of uniform motion. Calculations are given for: (1) the components of the transverse flow (perpendicular to the axis) as an extension of the results of Görtler (Arch. Math., v. 1: 138-147, 1948 and 1949; v. 3: 216-231, 1952; and Ing. Arch., v. 14: 286-305, 1944); and (2) the additional axial component as a continuation of previous work of Görtler (FIAT Rev. Ger. Sci. 1939-1946, 5, pt. 3: 68, 1948). The circular cylinder is chosen as an example, and the growth of the boundary layer is studied numerically and graphically from the beginning of the motion. The process of separation is investigated. (ASTIA abstract)

FRB. 02:001

Freiburg U. Inst. for Mathematics (Germany).

A NEW SERIES FOR THE CALCULATION OF STEADY LAMINAR BOUNDARY-LAYER FLOWS, by H. Görtler. Sept. 1955, 100p. incl. illus. diagrs. refs. (AFOSR-TN-56-8, vol. 1) (AF 61(514)642-C) AD 82006 Unclassified

A new and general rigorous method was developed to solve problems of plane and incompressible steady laminar boundary-layer flows with arbitrary outer pressure distribution. This method is based on the introduction of the dimensionless quantities

$$\xi = \frac{1}{\nu}\int_0^x U(x)dx, \qquad \eta = U(x)\, y \Big/ \left\{ 2\nu \int_0^x U(x)dx \right\}^{1/2}$$

as new independent space variables, where x and y are the usual boundary layer coordinates, U(x) the given outer velocity distribution, and ν the kinematic viscosity. The solution of the boundary layer problem is then given as a power series with respect to ξ with coefficient functions depending on η. A number of examples were evaluated to show the success and also the limitations of the method. For flows along flat plates the convergence of the new series was very satisfactory, and in most cases (mainly of retarded flows) provided a good approximation by the truncated series (fifth-order approximation) from the leading edge to a point immediately ahead of the separation point. The separation point can then be easily determined by a short extrapolation. Application of the new series to cylinders with rounded noses showed no advantage over the equally applicable Blasius series. However, a one-term zero-order approximation of the new series should be advantageous for certain theoretical investigations involving the separation of variables in a large domain from x = 0 downstream. The quality of convergence appeared to be best for monotone (retarding or accelerating) outer velocity distributions. (For vol. 2 see Harvard U. item no. HAR. 0.001) (ASTIA abstract)

FRS. 01:001

Fresno State Coll. Dept. of Chemistry, Calif.

TERNARY PHASE SYSTEMS OF POLYSTYRENE AND POLYISOBUTYLENE IN CARBON TETRACHLORIDE R. M. Kallo and D. E. Braun. Technical note. June 4, 1954 [29]p. incl. diagrs. tables. (Rept. no. 6) ([AF]OSR-TN-54-222) (AF 18(600)588) AD 55125 Unclassified

The phase diagrams of five ternary systems were determined, consisting of polyisobutylene and polystyrene in carbon tetrachloride. It was found that the region of immiscibility increases as the molecular weights of the two polymers increase, but that the tie line slopes are essentially insensitive to the molecular weights. A new method for the determination of tie lines by osmotic pressures is proposed. This method is especially useful for higher molecular weight polymer pairs, where light scattering effects make difficult any visual means for the determination of the composition of the conjugate phases. (Contractor's abstract)

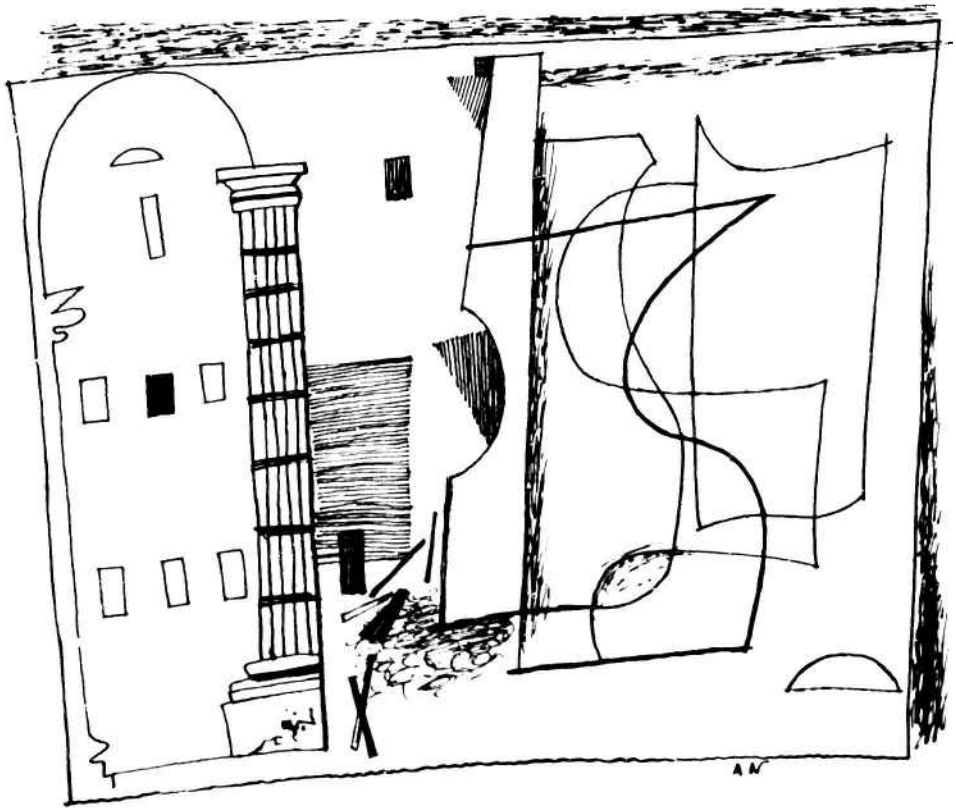
FRS. 01:002

Fresno State Coll. Dept. of Chemistry, Calif.

TERNARY POLYMER SOLUTIONS, by R. M. Kallo and D. E. Braun. Jan. 12, 1956 [31]p. incl. diagrs. tables, refs. (Technical rept. no 8) ([AF]OSR-TR-56-33) (AF 18(600)588) AD 83674 Unclassified

Weight-ratio and osmotic-pressure methods were used to determine the tie lines of polystyrene-polyisobutylene-carbon tetrachloride compositions of different polymer molecular weights. Results showed that the region of immiscibility increases with the molecular weights of the polymer pairs, and that the tie lines dip toward the polystyrene vertex either on a volume- or weight-percentage plot. Ternary phase diagrams were determined for the polystyrene-benzene-methanol and polystyrene-benzene-isopropanol systems. The region of immiscibility was greater for the MeOH system. In both cases, the tie lines slope toward the alcohol vertex either on a weight- or volume-percentage plot. (ASTIA abstract)

Frick Chemical Lab., Princeton, N. J. see Princeton U. Frick Chemical Lab., N. J.



GEC. 01:001 - GEO. 02:001

Gates and Crellin Labs., Pasadena, Calif. see California Inst. of Tech. Gates and Crellin Labs., Pasadena.

GEC. 01:001

Geckler, R. D., Arcadia, Calif.

THE MECHANISM OF COMBUSTION OF SOLID PROPELLANTS, by R. D. Geckler. [Dec. 1953] [51]p. incl. diagrs. tables, refs. (AF 18(600)846) Unclassified

Presented at NATO-AGARD Combustion Colloquium, Cambridge U. (England), Dec. 7-11, 1953.

Published in Selected Combustion Problems, Cambridge U. (England) (Dec. 7-11, 1953), London, Butterworths Scientific Publications, 1954, p. 289-339.

The normal linear burning rate of solid propellants increases with (1) an increase in the pressure of the gases in contact with the burning surface, (2) an increase in the temperature of the solid propellant, and (3) an increase in the velocity of the combustion gases parallel to the burning surface. Experimental data on these phenomena are summarized for both colloidal and composite propellants. An attempt is then made to show the relationship between the concepts and methods developed for the study of deflagration in gases and the theories of solid-propellant combustion. The present status of the theoretical study of solid-propellant combustion is reviewed with particular attention being given to the theories of Professor O. K. Rice and Professor B. L. Crawford, Jr. The values of various kinetic parameters deduced by the application of their theories to experimental burning-rate data are compared with values obtained in other ways. A summary of experimental and theoretical information on unstable combustion is also given. The distinctive feature of this phenomenon is an abnormally high burning rate that accompanies high-frequency pressure oscillations in rocket combustion chambers. It is concluded that the theoretical understanding of the combustion of solid propellants is not sufficient to be of much practical aid to the propellant chemist seeking formulations with improved properties. (Contractor's summary)

GEN. 01:001

General Electric Co., Schenectady, N. Y.

DISLOCATIONS AND MECHANICAL PROPERTIES OF CRYSTALS; AN INTERNATIONAL CONFERENCE HELD AT LAKE PLACID, SEPTEMBER 6-8, 1956, ed. by J. C. Fisher, W. G. Johnston and others. New York, John Wiley & Sons, Inc., 1957, 634p. incl. illus. diagrs. tables, refs. (AF 18(603)101) Unclassified

The 42 papers presented cover much of the recent theoretical and experimental research on dislocations in crystals, reviewing different areas of the subject field and describing new experimental techniques and their findings. The papers are grouped under the following categories: direct observations of dislocations; deformation of pure single crystals; work hardening and recovery; alloy crystals, impurities, yield point phenomena; dislocation damping and fatigue; theory of dislocations; whiskers and thin crystals; and radiation damage.

George Washington Carver Foundation, Tuskegee, Ala. see Tuskegee Inst. George Washington Carver Foundation, Ala.

GEO. 01:001

George Washington U., Washington, D. C.

CRITIQUE ON EVALUATION OF MEDICAL RESEARCH IN WESTERN EUROPEAN COUNTRIES, by N. R. Burch. Final rept. Aug. 1956, 23p. incl. refs. (Rept. no. 56-10-B) (AF 18(600)1180) Unclassified

This report by Dr. N. R. Burch, Dept. of Psychiatry, Baylor U. College of Medicine, represents the second of three reports and is primarily concerned with a survey of the methodology and techniques of investigations in human consciousness, with special reference to the "psycho-chemicals." A review of work being accomplished by persons and laboratories visited is given.

GEO. 01:002

George Washington U., Washington, D. C.

A REVIEW AND COMPARISON OF AERO-MEDICAL RESEARCH EFFORTS IN NATO COUNTRIES; CRITIQUE, by R. Margaria. Final rept. Oct. 1956, 4p. (Project no. 56-16) (AF 18(600)1180) Unclassified

Dr. R. Margaria compares the aero-medical research in the U. S. with that in Europe. The research in the U. S. is of a more practical nature and is developed in response to actual information often urgently needed by engineers and pilots. The research carried on in Europe is generally diversified and is apt to have a single application; but it is also of a basic scientific character. Collaboration is urged between European and U. S. research workers, both civilian and military. An action by the U. S. toward a more intensive exchange of individuals and more collaboration would bring not only greater achievement in the field of aviation medicine, but it would be also of a great social and political importance, for it would constitute a means of cultural penetration of the U. S. in Europe.

GEO. 02:001

George Washington U. [Dept. of Pharmacology] Washington, D. C.

STUDIES ON THE METABOLISM OF RADIOACTIVE PARA-AMINOBENZOIC ACID IN AN ESCHERICHIA COLI MUTANT, by G. Davidson, H. G. Mandel and

others. [Dec. 1955] 11p. incl. tables, refs. (Sponsored jotntly by Atomtc Energy Commission under AT(30-1)1107 and Air Force Offtce of Sctentiftc Researcb under AF 18(600)853) Unclasstfted

Published in Proc. Soc. Exper. Biol. Med., v. 91: 160-164, Jan. 1956.

Radtoactive p-amtnobenzoic acid has been tncubated with an x-ray mutant of Escherichia coli which requires this substance as a growth factor. By column chromatography four soluble radtoactive fractions have been isolated from the cell bodtes of the organtsms, none of them consisting of the ortginal substrate. Two of the fractions possess cttrovorum factor activtty, but none of them are tdentical with foltc actd, cttrovorum factor or certain of its dertvatives. (Contractor's summary)

GEO. 02:002

George Washington U. Dept. of Pharmacology, Washtngton, D. C.

CYSTEAMINE OXIDASE (Abstract), by R. Salvador and R. O. Brady. [1956] [1]p. [AF 18(600)853] Unclasstfted

Presented at meeting of the Amer. Soc. of Btol. Chemists, Atlantic Ctty, N. J., Apr. 16-20, 1956.

Published in Fed. Proc., v. 15: 345, Mar. 1956.

The presence has been observed of an enzyme in soluble extracts of pigeon liver acetone powder which catalyzes the oxidation of 2-mercaptoethylamtne when incubated in the presence of 2, 3, 5-trtphenyltetrazoltum chlortde. The enzyme has been purtfied 15-fold by fractionation with ammonium sulfate (0-30% saturation), alcohol (0-21% ethanol), and elution from calcium phosphate gel. Diphosphopyridtne nucleotide ts required although triphosphopyrtdtne nucleotide shows slight activity in the crude extract. N-acetyl-2-mercaptoethylamine ts oxidized about 1/10 as raptdly as cysteamine, whereas pantetheine, mercaptoethanol, cystetne, glutathione, and cystamine are inactive as substrates for this enzyme. Coenzyme A appears to be oxidtzed only very slightly tn the parttally purified system. When S^{35}-labeled cysteamine was incubated with the enzyme precipitating between 0-21% ethanol, which still exhibited diaphorase activity, one of the major products appeared to be cystamine disulfoxide. Cell-free extracts of C. kluyveri contain a similar enzyme although the product of this reaction has not been identified. This preparation differs somewhat from that obtained from pigeon liver stnce 2-mercaptoethanol as well as cysteamtne was rapidly oxidized by the enzyme system obtained from C. kluyveri. (Contractor's abstract)

GIT. 01:001

Georgia Inst. of Tech. Engineertng Experiment Station, Atlanta.

EFFECT OF VARIATION OF TEMPERATURE AND PRESSURE ON COMPOSITION OF ALLOYS, by W. M. Spicer. Final rept. Jan. 1, 1954-Dec. 31, 1955, 56p. incl. diagrs. tables, refs. [AFOSR-TR-56-6] (AF 18(600)974) AD 81533 Unclasstfied

Expertments were performed on several solid alloys tn an attempt to show that concentration gradtents mtght develop as a result of a pressure gradtent or a temperature gradtent. The results on the pressure effect were tnconclustve. However, the results on the temperature effect, espectally those on the Pb-14.8 per cent Sn and the Al-21.9 per cent Zn alloys, tndtcate strongly that a concentration gradtent dtd develop as a result of the temperature gradient. In the case of the Pb-14.8 per cent Sn alloy, the percentage tin reached a maximum of 15.71 per cent near the hot end and a mtnimum of 13.84 per cent near the cold end. Wtth the Al-21.9 per cent Zn alloy, the percentage of ztnc attained a maximum of 25.57 per cent and a mtnimum of 18.12 per cent in one of the three runs. (Contractor's abstract)

GIT. 02:001

Georgia Inst. of Tech. Engineertng Expertment Station, Atlanta.

BOUNDS ON INFLUENCE COEFFICIENTS FOR CIRCULAR CYLINDRICAL SHELLS, by E. Retssner and M. B. Sledd. Dec. 1, 1956 [33]p. tncl. dtagrs. (Rept. no. 1) (AFOSR-TN-56-575) (AF 18(600)1459) AD 110397 Unclasstfted

Rotationally symmetric deformations of a thtn elastic circular cylindrical shell of variable wall thickness and of finite or semi-infinite axial length are considered. The determination of upper and lower bounds for the dtrect tnfluence coefftctents c and the tnverse influence coefficients k is made by the application of the mtnimum prtnciples for dtsplacements and for stresses of the theory of elasttcity. The bounding of several such coefficients is attempted simultaneously. An application is made to a semi-infinite circular cylindrical shell wtth exponentially varying wall thickness. The results are seen to extend to ranges of thtckness variations over short axial distances.

GIT. 03:001

Georgia Inst. of Tech. Engineertng Experiment Station, Atlanta.

A METHOD OF MEASURING THE MOBILITY SPECTRA OF NEGATIVE IONS IN GAS MIXTURES (Abstract) by E. W. McDaniel and H. R. Crane. Oct. 1956, 1p. (AF 18(600)1524) Unclassified

GOT. 01:001

Prssented at Gaseous Electronics Conference Pittsburgh, Pa., Oct. 31-Nov. 3, 1956.

Prssented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 2, 1957.

Published in Bull. Amer. Phys. Soc., Serter II, v. 2: 82, Jan. 30, 1957.

A new pulse method of measurtng the low-fteld mobility of negative gaseous tons is described. Negative tons are formed by the capture of the electrons produced in the tonization path of an α particle which crosses one end of a long, uniform-field drift tube. The α particls entsrs a proportional counter at the end of tts path. The arrival of each indtvldual negative ion at the other end of the drift tube ts stgnalled by a second proportional counter. The ftrst counter trtggers the sweep of a synchroscope, and the second counter modulates the beam brtghtness. A large number of such sweeps ts integrated photographically. In each run, with a different gas mixture, a sharp line appears in the photographic spectrum. This gives the drift time for the negative ion in that gas. The mobilities of the negative ions in pure oxygen, and in mixtures consisting of varying percentages of oxygen in He, Ne, A, Kr, Xe, CO_2, and H_2 were measured and will be discussed. The mobility of the negative ion in pure SF_6 was found to be .57. This agrees well with the range for SF_6 predicted by the Langevin theory including charge exchange, namely .46 to .58 (Contractor's abstract)

Glenn L. Martin Inst. of Tech., College Park, Md. see Maryland U. Glen L. Martin Inst. of Tech., College Park.

GOT. 01:001

Göttingen U. Inst. of Physiology (Germany).

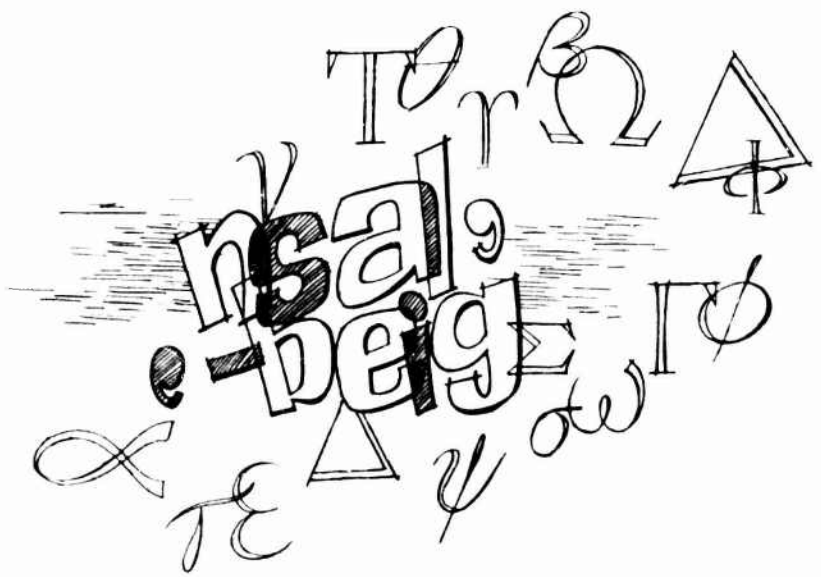
DEVELOPMENT OF NEW TYPES OF OXIMETERS, by K. Kramer. Final rept. Jan. 6, 1956 [28]p. incl. tllus. dtagrs. [AFOSR-TR-56-41] (In cooperation with Marburg U. (Germany)) (AF 61(514)740-C; continuation of AF 61(514)427) AD 96798 Unclassifted

The development and construction of ths following three types of oximeters are descrtbed: (1) ear oximeters self compensating for blood content changes in the ear (etther by bucking red and infrared selsnium cells against each other, or by control of the amplified output of the red photocell); (2) a toe oximeter with separats red and infrared stgnals allowing possible readings of oxygen saturation and blood content of the toe (or finger); and (3) reflexion oximeters conststing of a pair of selenium cells selectively sensttive for red and infrared light placed in a plexiglas housing side by side with a micro tungsten bulb and so constructed that they can be placed on the surface of various organs (brain, kidney, muscle, skin, etc.).

Guggenheim Aeronautical Lab., Pasadena, Calif. see California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena.

Guggenheim Inst. of Flight Structures, New York. see Columbia U. Guggenheim Inst. of Flight Structures, New York.

Guggenheim Jet Propulsion Center, Pasadena, Calif. see California Inst. of Tech. Guggenheim Jst Propulsion Center, Pasadena



HAM. 01:001

[Hamburg U. (Germany).]

FINITE DIFFERENCE METHODS FOR THE FIRST BOUNDARY VALUE PROBLEM OF $\Delta u(x, y) = r(x, y, u)$ AND CURVED BOUNDARIES, by W. Uhlmann. July 1956, 39p. incl. diagrs. (AFOSR-TN-56-390) (AF 61(514)-881) AD 96048 Unclassified

Approximate solutions $u(x, y)$ are sought for the differential equation $\Delta u(x, y) = r(x, y, u(x, y))$ for a given domain G of the x, y plane such that $u(x, y)$ takes on prescribed values on the boundary Γ of G. Mehrstellen formulas are compared with the ordinary formulas of finite difference methods in the numerical computation of the torsion problem for a girder with a semicircular cross section. Relative errors, compared with the exact solution, of the order of 0.05% are obtained for the most favorable Mehrstellen method. (ASTIA abstract)

HAM. 02:001

Hamburg U. Inst. of Applied Mathematics (Germany).

A DIFFERENTIATION TECHNIQUE FOR PARTIAL DIFFERENTIAL EQUATIONS WITH NONLINEAR BOUNDARIES, by J. Albrecht. Jan. 18-July 18, 1954, 7p. incl. diagrs. table. (Technical note no. EOARDC-TN-54-1) (AF 61(514)631-C) AD 74984 Unclassified

Boundary conditions in the cases of curved boundaries and of rectangular ranges are treated, and direct computation of the first partial derivatives u_{10} and u_{01} are given. Approximate numerical solution of the differential equation, $\Delta u = u_{20} + u_{02} = r(x, y)$ in B, by means of the difference method, requires a consideration of the boundary conditions $u = f(s)$ on Γ or $u_n = f(s)$ on Γ, (n = outer normal of the boundary of the range B in the x, y-plane). Some finite expressions are presented for this purpose showing a higher "Taylorabgleich" (equalizing up to terms of h^2 inclusive) than the formula of linear interpolation (equalizing up to h^1 inclusive). The attempt to improve these formulas to correspondence up to terms of h^3 inclusive was not successful. An attempt was also made to approximate the boundary condition $u_n = f(s)$ more accurately in the case of rectangular ranges by considering the values of f and also those of the derivatives of the functions f(s) and $r(x, y)$. Formulas are stated which permit computation of the partial derivatives $\frac{du}{dx}$ and $\frac{du}{dy}$ from the differential equation $\Delta u = r(x, y)$ and the boundary conditions $u = f(s)$ or $u_n = f(s)$ numerically in a direct manner.

HAM. 02:002

Hamburg U. Inst. of Applied Mathematics (Germany).

A DIFFERENTIATION TECHNIQUE FOR PARTIAL DIFFERENTIAL EQUATIONS WITH NONLINEAR BOUNDARIES, by J. Albrecht. July 19, 1954 Jan. 18, 1955, 11p. incl. diagrs. tables. (Technical note no. EOARDC-TN-54-2) (AF 61(514)631-C) AD 74983 Unclassified

The general case of the first boundary value problem for a second order elliptic differential equation in a region with a curved boundary is discussed. The introduction of some kinds of regular nets is described, and computing as well as terminal points are defined. The creation is explained of irregular equations for higher approximation of the special case $\Delta u = r(x, y)$ for triangular and square nets. Some numerical examples demonstrate the greater accuracy thus attained. (Contractor's introduction, modified)

HAM. 02:003

Hamburg U. Inst. of Applied Mathematics (Germany).

[A VARIANT OF THE TECHNIQUE OF SOLUTION OF DIFFERENCE EQUATIONS THROUGH THE METHOD OF "MEHRSTELLENVERFAHREN"] Eine Variante des Mehrstellenverfahrens, by J. Albrecht. [1955] [6]p. [AF 61(514)631-C] Unclassified

A generalization of a technique, attributed to Numerow, in the process of central differences for problems with initial values with differential equation $u''(x) = r(x)u(x)$ is made through the central difference process multiplace method (Mehrstellenverfahren). The formulas attained simplify the computation without affecting the accuracy. The general formulation of a special "Mehrstellenverfahren" for initial and boundary conditions in N^{th} order differential equations follows the method description for ordinary 2nd order differential equation. Examples given are finite equations for heat conduction $\Delta u - Ku_1 = ru$ and $\Delta u = q + ru$ (in addition, the formula for the generalized problem $\Delta u = q$). The "Mehrstellen" procedure of Collatz for eigenvalue problems $\Delta u + \lambda u = o$ arrange themselves.

HAM. 02:004

Hamburg U. Inst. of Applied Mathematics (Germany).

[A FINITE DIFFERENCE METHOD OF PARABOLIC AND HYPERBOLIC DIFFERENTIAL EQUATIONS] Zum Differenzenverfahren bei parabolischen und hyperbolischen Differentialgleichungen, by J. Albrecht. [1955] [34]p. incl. diagrs. tables. [AF 61(514)-631-C] Unclassified

Several general points are of significant importance in the setting up of computation formulas for the finite difference method in parabolic and hyperbolic differential equations, as shown in examples of the heat conduction and rod and membrane vibration equations. These points include (1) verification of the stability of the technique; (2) use of a multiterm Taylor expansion to get a greater accuracy; (3) the step parameter should be as large as possible; and (4) efficient easy and simple numerical methods. Stability and instability expressions are proved and the dependence upon the

HAR. 01:001 - HAR. 02:004

chotce of lattice points is seen for each step value. Regions of the x_1, x_2 - plane bound by curves are studted, with consideration both of "regular finite expressions" and of "irregular finite expressions." Finally the Runge-Ketta method, used on regular differential equations, is applied to partial differential equattons.

Hamilton Coll., Ont. (Canada). <u>see</u> McMaster U. Hamilton Coll., Ont. (Canada).

Hammond Metallurgical Lab., New Haven, Conn. <u>see</u> Yale U. Hammond Metallurgtcal Lab., New Haven, Conn.

HAR. 01:001

Harvard U. Computation Lab., Cambridge, Mass.

DESIGN AND OPERATION OF DIGITAL CALCULATING MACHINERY, by G. Salton. Progress rept. no. 37, Mar. 1955, 1v. incl. tables. (AFOSR-TR-56-8, v. 2) (AF 33(038)9461) AD 59703 Unclasstfied

Forty-stx third order differential equations with two point boundary conditions, submitted by Prof. H. Görtler of the University of Freiburg (Germany) are solved on tlie Mark IV calculator. Two equations are nonlinear of the form $F''' + FF'' + \beta(1-F'^2) = 0$ and the remainder are linear of the form $y''' + Fy'' - 2(n + \beta)F'y' + (2n + 1)F''y = R(\eta)$. $\beta = 0$ and $\beta = 1$ for the computations and the boundary conditions are $F(0) = F'(0) = 0$ and $F'(\infty) = 1$ for the first two equations and for the rest $y(0) = y'(0) = 0 = y'(\infty) = 0$. (For vol. 1 <u>see</u> Item no. FRB. 02:001.)

HAR. 02:001

Harvard U. Cruft Lab., Cambridge, Mass.

THE NATURE OF THE MONTE CARLO METHOD, by J. Kellson. Nov. 5, 1951, 16p. incl. illus. (Technical rept. no. 137) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) ATI-122523 Unclassified

A survey is given of ideas underlying the various numerical approaches to the solution of differential and integral equations based on probability ideas and known as Monte Carlo methods. Evaluation of integrals, differential equations, and an integral equation are identified and discussed.

HAR. 02:002

Harvard U. Cruft Lab., Cambridge, Mass.

DIFFRACTION BY SPHERES AND EDGES AT 1.25 CENTIMETERS, by C. Huang and R. D. Kodis. Nov. 30, 1951, 24p. incl. illus. diagrs. refs. (Technical rept. no. 138) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Atr Force Office of Scientific Research] under N5ori-7601) ATI-130423 Unclassified

Measurements have been made, using an tmage-plane technique, of the diffraction near conducting spheres whose radii are comparable to a wavelength and near the edge of a conducting half-plane. Measured dtstrtbutions of both the phase and amplttude of the electric field were obtained for two self-resonant spheres and for one sphere having a radius correspondtng to a relative maximum of the back-scatterttng cross section. In one case the measurements are compared wtth the theory and are found to be in good agreement. With the diffracttng edge such a compartson shows that considerable error is introduced by the point source. However, the substttutton of the equtvalent of a line source once agatn brtngs the measurements into close agreement with theory. (Contractor's abstract)

HAR. 02:003

Harvard U. Cruft Lab., Cambrtdge, Mass.

A TABULATION OF SELECTED CONFLUENT HYPERGEOMETRIC FUNCTIONS, by D. Middleton and V. Johnson. Jan. 5, 1952, 39p. diagrs. (Technical rept. no. 140) (Sponsored jotntly by Office of Naval Research, Stgnal Corps, and [Air Force Office of Sctentific Research] under N5ori-7601) U21243; ATI-136249 Unclasstfied

A tabulation of the confluent hypergeometric function

$${}_1F_1(\alpha, \beta, z) = 1 + \frac{\alpha z}{1!} + \frac{\alpha(\alpha+1)z^2}{\beta(\beta+1)2!} + \ldots$$

is given for ${}_1F_1(\alpha, \beta, -p)$ in the followtng ranges: half integral values of α $(-1/2, 1/2, 3/2, \ldots)$; tntegral values of β (1 to 10); and $(0 \leq p \leq 2.0)$ for a 0.25 interval, $(2.0 \leq p \leq 10.0)$ for a 0.50 interval. Addtional values are tabulated for p = 20 to 100 in steps of 10. The functions are graphed for the above values of α and β and $(0 \leq p \leq 9.5)$ (TIP abstract)

HAR. 02:004

Harvard U. Cruft Lab., Cambridge, Mass.

RELAXATION EFFECTS IN THE FERROMAGNETIC RESONANCE, by R. W. Damon. Jan. 15, 1952, 73p. incl. illus. diagrs. refs. (Technical rept. no. 136) (Sponsored jointly by Office of Naval Research, Stgnal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U21473 Unclassified

<u>Also published in</u> Rev. Modern Phys., v. 25: 239-245, Jan. 1953.

Ferromagnetic resonance in nickel ferrite was studied at high levels of mtcrowave power. Saturation of the spin system was observed by (1) the decrease in relative energy absorbed by the sample and (2) the change in z-component of magnetization at high power levels. The microwave magnetic field strength required for

saturation differed in these 2 instances. The change in magnetization occurred at the resonant value of static field and extends to smaller fields. These effects were essentially independent of crystallographic orientation although they showed some dependence on crystal imperfections. The calculated spin-lattice relaxation time was 3×10^{-8} sec. Spin-lattice interaction contributed little to the resonance line width. The selection rule for conservation of wave number in a transition did not appear to be rigorously true, but the spin waves of short wave length could be excited by induced transitions. An explanation is offered for the discrepancy between the spectroscopic splitting factor (g), obtained from resonance experiments, and the gyromagnetic ratio (g-), measured by magnetomechanical methods. (TIP abstract)

HAR. 02:005

Harvard U. Cruft Lab., Cambridge, Mass.

AN EXPERIMENTAL INVESTIGATION OF THE SINGLE WIRE LINE, by T. E. Roberts, Jr. Feb. 1, 1952, 25p. diagrs. tables, refs. (Technical rept. no. 139) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U21600; ATI 150036 Unclassified

Also published in Jour. Appl. Phys., v. 24: 57-67, Jan. 1953.

Experiments were performed to check theoretical results concerning the single-wire transmission line. Measurements were made of attenuation and phase velocity of the principal mode, an equivalent circuit for the transition from a coaxial to a single-wire line, and current and charge distributions. The equipment consisted of a stable RF generator, detecting equipment, a straight wire supported at each end, and a traveling probe. A wave length of 3.2 for the RF signal permitted a line length of 80 λ. A current distribution calculated for the case of connecting the wire to a coaxial line of very small outer radius agreed well with experimental results. The theoretical efficiency of exciting the guided mode was verified by observation. Some measurements were obtained to illustrate the loss of power with gradual curves in the wire, and the additional reflection loss with sharp bends. (TIP abstract)

HAR. 02:006

Harvard U. Cruft Lab., Cambridge, Mass.

RAY THEORY APPLIED TO A SPHERICAL IONOSPHERE, by A. T. Waterman, Jr. Feb. 15, 1952, 68p. incl. diagrs. refs. (Technical rept. no. 142) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7628) U22014; ATI-150436 Unclassified

A theoretical analysis was undertaken on the application of simple ray-theory to HF sky-wave propagation over large distances when the curvature of both the earth and the reflecting layers is considered. Limitations in the extension of the plane-ionosphere equivalence theorems to conditions of spherical geometry are discussed. For the interrelationships between distance, equivalent path length, and equivalent virtual height, inequalities are derived which establish bounds within which the exact relations must lie. A method of approximate solution for ray paths is developed for the case of oblique-incidence reflection by a single ionospheric layer having a parabolic distribution of electron-density. Comparison is made between the approximate solutions for a parabolic layer and numerical solutions for a Chapman layer with and without a region of ionization (F_1) beneath that causing the reflection (F_2). The methods used in computing the distance, equivalent path length (or transmission time), focusing effect, and absorption for reflection from a Chapman-type ionosphere are outlined; results are presented in graphical form. Curves are given for these quantities as a function of relative critical frequencies of the ionospheric layers when the distance is kept fixed. (TIP abstract)

HAR. 02:007

Harvard U. Cruft Lab., Cambridge, Mass.

THE COUPLED RECEIVING ANTENNA, I, by C. Moritz. Mar. 5, 1952, 58p. incl. diagrs. refs. (Technical rept. no. 146) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U22651; ATI-155830 Unclassified

Consideration was given, theoretically and by experiment, to the antenna which is immersed in a traveling plane wave. The antenna is comprised of two spaced parallel conducting cylinders, the currents of which are coupled through their mutal proximity. The study examines the behavior of the current excited on the radiators and the properties of the antenna which depend upon these currents. The following are discussed: the theory of two coupled cylinders excited by a plane wave, numerical computations, and natural behavior. (TIP abstract)

HAR. 02:008

Harvard U. Cruft Lab., Cambridge, Mass.

THE COUPLED RECEIVING ANTENNA, II, by C. Moritz. Mar. 5, 1952, 36p. illus. diagrs. (Technical rept. no. 147) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U22811; ATI 158185 Unclassified

The experimental methods and equipment used in investigating the behavior of 2 coupled receiving antennas are described. Basically, the method is an adaptation of single-cylinder practice so that results may be obtained from both antennas simultaneously. The antennas in this setup projected horizontally from a vertical ground plane attached to the side of a building with the

HAR. 02:009 - HAR. 02:012

measuring equipment inside the building. The equipment was designed to operate at 220 to 320 mc. (TIP abstract)

HAR. 02:009

Harvard U. Cruft Lab., Cambridge, Mass.

IONOSPHERIC ABSORPTION OF OBLIQUELY INCIDENT RADIO WAVES, by A. T. Waterman, Jr. Mar. 20, 1952, 69p. incl. illus. diagrs. refs. (Technical rept. no. 143) (Sponsored jotntly by Office of Naval Research, Signal Corps, and [Air Force Offtce of Scientific Research] under N5ori-7628) U22668; ATI-155831 Unclassified

A stable, logarithmic, automatically-calibrating receivtng equtpment was used to record the amplitude of individual sky-wave pulses transmitted over a 1309-km path at 12.9 mc. The arrivtng wave-train was interpreted in terms of the absorption encountered tn the ionosphere. Consistency between computed and measured results at oblique incidence confirmed the naiure of ionosphertc influences on received signal strength. The F-region exhibited negligible absorption, but defocusing strongly influenced the amplitude of Pedersen rays. The E-region had a reverse effect on rays reflected from the F_2-layer. Focusing appeared to be a minor factor (except at longer distances, where it can become critical), and absorption was the major influence. A quantitative determination of these influences was achieved. The procedure provided a means of assessing the collisional frequencies in the E-region. Values obtained were lower than those elicited from ionospheric cross-modulation experiments, though the discrepancy could be removed by a slight adjustment in E-layer height. The resulting distribution of collisional frequency and the dependence of this distribution on the height of the E-layer are summartzed. Implications regarding the frequency of electron-molecule collistons in the ionosphere, and the effective cross section for such collisions are discussed. (TIP abstract)

HAR. 02:010

Harvard U. Cruft Lab., Cambridge, Mass.

THEORY OF ELECTRICALLY SHORT TRANSMITTING AND RECEIVING ANTENNAS, by R. King. Mar. 20, 1952 [48]p. incl. tables, refs. (Technical rept. no. 141) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Offtce of Scientific Research] under N5ori-7601) U22096; ATI-150729 Unclassified

Also published in Jour. Appl. Phys., v. 23: 1174-1187, Oct. 1952.

Complete and quanlitatively accurate solutions of the properties of electrically short transmitting and receiving antennas (of length 2h such that $2\pi h/\lambda_0 \leq 1$) are obtained by determining the distributions of current that actually satisfy the integral equattons. Components of current in phase and in phase-quadrature with the drtving voltage or the incident electric field are evaluated together with the impedance, the effective length, and the gain. It is shown that when the King-Middleton method of solving Hallén's integral equation by iteration is applied correctly, quite accurate results are obtained even in a first-order solution. The greatest error in the first-order formulas is shown to be in the resistance, a small quantity of higher order compared with the reactance. The newly determined values are combined with the King-Middleton second-order results to obtain more complete and more accurate tmpedances and effective lengths in the range of $0 \leq 2\pi h/\lambda \leq 1.4$. (Contractor's summary)

HAR. 02:011

Harvard U. Cruft Lab., Cambridge, Mass.

AN ANALOG COMPUTER FOR CORRELATION FUNCTIONS IN COMMUNICATION SYSTEMS, by R. A. Johnson. Mar. 25, 1952, 28p. incl. illus. diagrs. table, refs. (Technical rept. no. 144) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Atr Force Office of Scientific Research] under N5ort-7601) U22255; ATI-152473 Unclasstfied

The analog computer was designed to measure correlation functions of noise and signal voltages before and after detection in an AM communication system. Variable time delay is achieved by moving a pickup head along a rotating magnetic drum on which the signal under investigation is recorded. A second channel has a fixed delay, so that zero (or negative) delays can be obtained. Multiplication of the 2 signals is accomplished by an analog electronic multiplier. The desired correlation function is then plotted by a recording meter which tndicates the average value of the multiplier output as the time delay is varied. The basic components of the correlator, the multiplier and delay unit, are explained in detail. The associated equipment necessary for the study of noise and signals before and after rectification by a linear detector is discussed. The limitaitons and advantages of the equipment are compared to those of other correlators. (TIP abstract)

HAR. 02:012

Harvard U. Cruft Lab., Cambrtdge, Mass.

RADIATION OF THE BOSS ANTENNA, by C. H. Papas and D. B. Brick. Apr. 1, 1952, 8p. incl. diagrs. refs. (Technical rept. no. 148) (Sponsored jotntly by Office of Naval Research, Stgnal Corps, and [Atr Force Office of Sctentific Research] under N5ori-7601) U22256; ATI-152471 Unclassified

Ideally the boss antenna consists of a conducting hemisphere placed so close to a perfectly conducting image plane that the field distrtbution across the gap between hemisphere and plane can be represented by a Dirac δ function. The problem differs from that of Stratton (Electromagnetic Theory, N. Y., McGraw Hill, 1941, p. 555-557) in that the antenna is driven. The coaxial line which drives the radiator consists of an inner

conductor which connects to the hemisphere and an outer connector of which 1 boundary forms the infinite image plane. The radiation field is derived in spherical harmonics, making use of the image theorem. The apparatus used to measure the radiation pattern consisted of a λ/4 dipole pickup attached to a swinging arm actuated under seisyn control. Good qualitative agreement between theory and experiment was obtained. (TIP abstract)

HAR. 02:013

Harvard U. Cruft Lab., Cambridge, Mass.

A GENERAL THEORY OF PLANE-WAVE SCATTERING FROM FINITE CONDUCTING OBSTACLES WITH APPLICATION TO THE TWO-ANTENNA PROBLEM, by J. Sevick and J. E. Storer. Apr. 10, 1952, 44p. incl. diagrs, refs. (Technical rept. no. 149) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U22914; ATI-158450 Unclassified

Also published in Jour. Appl. Phys., v. 25: 369-376. Mar. 1954.

An approximate procedure is presented for the handling of 3-dimensional electromagnetic scattering by finite, perfectly conducting obstacles where coupling is explicitly taken into account. The variational formulation of Levine and Schwinger (Communications on Pure and Applied Mathematics, III, no. 4, 1950) is used in deriving an expression for the scattered field distribution in the far zone in terms of the currents flowing on the obstacles. An expression obtained for the back-scattering cross sections in terms of stationary quantities is applied to the study of the back-scattering cross section of 2 identical, nonstaggered, unloaded antennas which are oriented parallel to the incident field. The case of broadside radiation is treated for half-wave and full-wave antennas. Curves of back scattering vs antenna spacing are similar in shape for both antennas but greatly different in magnitude. This difference may be explained by the resonant current of the full-wave-length antenna being an odd function and therefore not excitable by an incident plane wave polarized parallel to the antenna. (TIP abstract)

HAR. 02:014

Harvard U. Cruft Lab., Cambridge, Mass.

WAVE PROPAGATION IN A TWO-DIMENSIONAL PERIODIC MEDIUM, by J. E. Storer. May 1, 1952, 29p. diagrs. refs. (Technical repl. no. 152) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U24292; ATI-169954 Unclassified

An approximate solution to the problem of propagation of electromagnetic waves in a 2-dimensional array of perfectly conducting cylinders is presented. The method used to obtain a solution is similar to that employed by Levine and Schwinger (Phys. Rev., v. 74: 958-974, 1948) in diffraction problems. An integral equation is derived for the currents flowing on the cylinders, and a variational principle is used to obtain an approximate solution to this equation. This method can be generalized to 3-dimensional periodic arrays. (Contractor's abstract)

HAR. 02:015

Harvard U. Cruft Lab., Cambridge, Mass.

MICROWAVE DIFFRACTION MEASUREMENTS IN A PARALLEL-PLATE REGION, by R. V. Row. May 5, 1952, 30p. incl. illus. diagrs. (Technical rept. no. 153) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U23775; ATI-165612 Unclassified

Also published in Jour. Appl. Phys., v. 24: 1448-1452, Dec. 1953.

An experimental arrangement for scattering problems was constructed for use in the 3-cm wave-length region. The finite parallel plates support a transverse electromagnetic wave with the electric field normal to the plates. Absorbing wedges at the outer boundary of the plates reduce reflections from these boundaries. The scattered fields may be investigated by means of a dipole penetrating into the region. Measurements of the total field scattered by 0°, 45°, and 90° conducting wedges showed satisfactory agreement with theory. The effect of finite thickness of the diffraction screen (for the 0 wedge) in increasing the amplitude of the scattered wave is noted and compared to theoretical results derived for scattering from a conducting half-plane with a cylindrical edge. (TIP abstract)

HAR. 02:016

Harvard U. Cruft Lab., Cambridge, Mass.

THE RECTIFICATION OF SIGNALS AND RANDOM NOISE BY A LINEAR DETECTOR, by R. A. Johnson. May 5, 1952, 54p. incl. diagrs. tables, refs. (Technical repl. no. 145) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U23404; ATI-161576 Unclassified

Part I presents computed correlation functions of the low-frequency components generated in the rectification of unmodulated carriers and normal random noise for various S/N values of the input. Part II gives measured correlation functions in the threshold region (input signal and noise of comparable power) for combinations of the relevant parameters. Part III discusses the applicability of theoretical results on resistive nonlinear circuits to the linear detector with an RC load. (Contractor's abstract)

HAR. 02:017 - HAR. 02:021

HAR. 02:017

Harvard U. Cruft Lab., Cambridge, Mass.

TANDEM-SLIT DIFFRACTION MEASUREMENTS, by L. R. Alldredge. May 18, 1953, 14p. illus. refs. (Technical rept. no. 176) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-760f) AD 22430
Unclassified

The diffraction of a plane electromagnetic wave by 2 identical slits in tandem was investigated experimentally for normal incidence with polarization parallel to the edges of the slits. The slits were assumed to be infinitely long, a condition which is approximated experimentally by use of a parallel-plate system described by R. V. Row. Measurements were made for tandem separations of slits from 0 to nearly 2 wave lengths and for slit widths from 0 to f.4 wave lengths. For a tandem-slit separation of zero, which corresponds to single slit, the results for the transmission coefficients were in good agreement with established theoretical results. The results showed interesting resonance phenomena as the tandem-slit separation was changed. (ASTIA abstract)

HAR. 02:018

Harvard U. Cruft Lab., Cambridge, Mass.

EXPERIMENTAL AND THEORETICAL RESULTS ON THE BACK-SCATTERING CROSS SECTION OF COUPLED ANTENNAS, by J. Sevick. May 26, 1952, 9p. incl. diagrs. refs. (Technical rept. no. 150) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U22913; ATI-158449
Unclassified

A general theory on the plane-wave scattering of obstacles where coupling is taken into effect was applied to the determination of the back-scattering cross section of 2 identical, nonstaggered, unloaded antennas oriented parallel to the incident radiation. Three aspects of the general problem are the determination of (1) the back-scattering cross section ( ) as a function of the spacing (b) and the angle ( ) between the plane of the antennas and a plane perpendicular to the direction of the incident radiation, (2) as a function of b and the thickness for 0, and (3) as a function of b and the height of the antenna for 0. It was concluded that broadside scattering is greater than that for any other angle; back scattering amplitudes depend on independent scattering of the elements. The shapes of the back-scattering curves are similar for half- and full-wave antennas. A theoretical treatment considering the antennas as independent scatterers is inaccurate even at spacings of 3 .

HAR. 02:019

Harvard U. Cruft Lab., Cambridge, Mass.

AN EXPERIMENTAL METHOD OF MEASURING BACK-SCATTERING CROSS SECTION OF COUPLED ANTENNAS, by J. Sevick. May 28, 1952, 18p. illus. diagrs. (Technical rept. no. f5f) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-760f) U23222; ATI-f59852
Unclassified

A method of measuring back-scattering cross sections is described in which the measuring scheme utilizes an image plane and cancellation procedure. The technique involves measuring the incident field at a point in the far zone with respect to the scattering obstacles before they are in place, canceling out the effect of the incident signal with a signal taken from the transmitter, and then measuring the absolute value of the scattered signal after the obstacles are placed in position. If the distances between the source, testing probe, and scatterer are known, a simple relationship can be obtained for the back-scattering cross section. The system offers a means of obtaining quick experimental results with a knowledge of the errors involved. The method is limited to obstacles containing a plane of symmetry. The derivation of the experimental equation for the back scattering cross section is given as well as the procedure used in the experimental process, a description of the equipment, and a discussion of the possible sources of error.

HAR. 02:020

Harvard U. Cruft Lab., Cambridge, Mass.

ON THE MAGNETIC RESONANCE ABSORPTION IN CONDUCTORS, by N. Bloembergen. June 5, 1952, 20p. diagrs. refs. (Technical rept. no. 156) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) U24190; ATI-169047
Unclassified

Also published in Jour. Appl. Phys., v. 23. 1383-1389, Dec. 1952.

The electromagnetic losses in conductors are analyzed in terms of magnetic absorption and conduction losses. The significance of quantities observed in a magnetic resonance experiment depends on the dimensions of the sample relative to the skin depth. Formulas for electric and magnetic losses are given for a plane sheet and a sphere. The influence of the conductivity on the line shape and saturation effects is discussed for nuclear and magnetic resonance. (Contractor's abstract)

HAR. 02:021

Harvard U. Cruft Lab., Cambridge, Mass.

THE SUSCEPTANCE OF A CIRCULAR OBSTACLE TO

AN INCIDENT DOMINANT CIRCULAR-ELECTRIC WAVE, by L. S. Sheingold. June 15, 1952, 22p. illus. table. (Technical rept. no. 159) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 6566 Unclassified

Also published in Jour. Appl. Phys., v. 24: 414-422, Apr. 1953.

Lower- and upper-bound expresstons were obtained for the susceptance of a circular obstacle excited by the TE_{01} mode tn a circular wave guide. The solutions were obtained by a variational method. Experiments showed the TE_{01} mode to be about 60 db above extraneous modes over a free-space, wave-length range of 7.30 to 11.90 cm. The discrepanctes between theoretical and experimental results are attributed to finite thickness and conductivity of the obstacle, ellipticity of the circular wave guide, presence of lower-order propagating modes, and typical errors involved in the measurement of admittance by the resonance-curve method.

HAR. 02:022

Harvard U. Cruft Lab., Cambridge, Mass.

AN ALTERNATIVE METHOD OF SOLVING HALLEN'S INTEGRAL EQUATION AND ITS APPLICATION TO ANTENNAS NEAR RESONANCE, by R. King. July 1, 1952, 14p. diagrs. (Technical rept. no. 154) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) U24191; ATI-169048 Unclassified

Also published in Jour. Appl. Phys., v. 24: 140-147, Feb. 1953.

Hallen's complex integral equation for the current tn a cylindrical antenna ts separated into 2 real integral equations for the components of current in phase and in phase-quadrature with the driving voltage. Each of these equations ts solved by iteration using zeroth-order currents and vector-potential differences to define expansion parameters. It is shown that for electrical half-lengths near odd multiples of a quarter-wavelength, at least a third-order solution is required in order to determine accurately the component of current in phase with the driving voltage and the conductance. Conductances for a range of radii are evaluated by the new third-order formula and compared with the King-Middleton second-order values and the experimental data of Hartig. The new formula agrees excellently with experimental results at h $\lambda_0/4$, whereas the earlier second-order formula has its largest error (near 8 to 10%) in a small range near resonance It is concluded that for antennas near resonance, just as for very short and very long antennas, adequate account must be taken in the iteration of both components of current. (Contractor's abstract)

HAR. 02:023

Harvard U. Cruft Lab., Cambridge, Mass.

A SIMPLE GRAPHICAL ANALYSIS OF WAVEGUIDE JUNCTIONS, by J. E. Storer, L. S. Sheingold, and S. Stein. Aug. 25, 1952, 34p. diagrs. refs. (Technical rept. no. 160) (Sponsored jotntly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientiftc Research] under N5ori-7601) U25381; ATI-187945 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 41: 1004-1013, Aug. 1953.

A graphical analysis based on the work of Deschamps is presented for obtaining the scattertng matrix of waveguide junctions from standtng-wave measurements. A method is outlined for graphically obtaining the reflection coefficient of a load termtnating the junction from the measurement of the reflection coefficient as seen through the junction. (Contractor's abstract)

HAR. 02:024

Harvard U. Cruft Lab., Cambrtdge, Mass.

MEASUREMENT OF CORRELATION FUNCTIONS OF MODULATED CARRIERS AND NOISE FOLLOWING A NONLINEAR DEVICE, by R. A. Johnson and D. Middleton. Sympostum on Applicattons of Communicatton Theory, London, Sept. 1952 [17]p. tncl. tllus. refs. (Sponsored jotntly by Office of Naval Research, Stgnal Corps, and [Atr Force Offtce of Scienttftc Research] under N5ort-7601) AD 122693 Unclasstfted

An analog electronic device capahle of measurtng auto- and cross-correlatton functions ts descrtbed. A variahle time delay ts achieved by moving a pickup head slowly along a rotattng magnetic drum, on whtch the stgnal under tnvesttgatton is recorded. A second channel has a ftxed delay, so that zero (or negative) delays can he obtatned. Multtpltcatton of the two signals is accompttshed by an analog electrontc multiplter. The desired correlatton function is then plotted by a recordtng meter which indtcates the average value of the multiplier output as the ttme delay is varied. Data recorded in investigating the rectttfication of a modulated carrier and noise are presented. (Contractor's abstract)

HAR. 02:025

Harvard U. Cruft Lab., Cambridge, Mass.

SKY-WAVE FIELD INTENSITY. 1. LOW AND VERY-LOW RADIO FREQUENCIES, by J. A. Pierce. Sept. 1, 1952, 107p. dtagrs. (Technical rept. no. 158) (Sponsored jointly by Office of Naval Research, Signal Corps and Air Force Office of Scientific Research under N5ori-7601) U24899; ATI-185675 Unclassified

A general theory of unabsorbed sky-wave field strength is developed which is applicable to transmission by

either E- or F-layer reflections. The application of the theory is worked out only for low radio frequencies. Based on an expression given to define unabsorbed field strength, the transmission losses at low frequencies fall into a simple and coherent pattern. The logarithm of the losses in these cases is nearly linear. The theory is used in the analysis of measurements of field strength in the frequency region below 100 kc which were made during 1951. The observed variations of atmospheric noise with frequency and time are used as the basis for computing the power requtred to maintain communication and the corresponding S/N's and optimum radio frequencies.

HAR. 02:026

Harvard U. Cruft Lab., Cambridge, Mass.

A COAXIAL MAGIC-T, by T. Morita and L. S. Sheingold. Oct. 10, 1952, 7p. illus. (Technical rept. no. 162) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scienttfic Research] under N5ori-7601) AD 4104 Unclassified

Three dtfferent destgns of coaxial hybrid junctions having performance analogous to a wave-guide magic-T are discussed. The experimental results with each type indicate that SWR's less than 2 looking tnto any arm are easily obtainable over a frequency band of about 10%. With carefully matched loads, decoupltng greater than 70 db can he obtained. An application of the magic-T tn phase measurement is described whtch ts independent of the stgnal amplitude and is similar to the homodyne system of phase measurement. (ASTIA abstract)

HAR. 02:027

Harvard U. Cruft Lab., Cambridge, Mass.

ON THE DIFFRACTION OF ELECTROMAGNETIC WAVES BY ANNULAR, ELLIPTICAL AND RECTANGULAR APERTURES, by C. Huang. Feb. 15, 1953, 34p. illus. refs. (Technical rept. no. 163) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Sctentific Research] under N5ort-7601) AD 10246 Unclasstfted

The derivation of a Kirchhoff-type approxtmation to the transmisston coefftcient of an aperture in an tnftnttely extended, perfectly conducting plane screen of infinitesimal thickness with an incident plane electromagnetic wave, as gtven by Levine and Schwinger (Communtcations on Pure and Appl. Math., v. 3: 4, Dec. 1950), is briefly recapitulated. The resultng integral formula involves only the tangential component of the aperture magnetic field, this is shown to be equal to the tangential component of the magnetic field of the known, incident wave. Using this formula, the approxtmate transmission coefficients of annular, elliotical, and rectangular apertures are evaluated for normal incidence. Results have been computed and plotted for appropriate dimensions of each aperture. (Contractor's abstract)

HAR. 02:028

Harvard U. Cruft Lab., Cambridge, Mass.

CIRCUMFERENTIAL GAP IN A CIRCULAR WAVE-GUIDE EXCITED BY A DOMINANT CIRCULAR-ELECTRIC WAVE, by J. E. Storer and L. S. Sheingold. Mar. 1, 1953, 25p. illus. refs. (Technical rept. no. 166) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 14952 Unclassified

Also published in Jour. Appl. Phys., v. 25: 545-552, May 1954.

The scattering matrix of a 360° circumferential slot in an infinitely long circular wave guide (with an incident dominant circular-electric wave) is obtained by a variational principle. The characteristics of a [illegible] of thts type in 5.775-in. -id brass tubing were measured at a free-space wave length of 10,000 cm. The experimental values of amplttude and phase as determined separately by Deschamps' method were in excellent agreement with the theory for values of 2 g (gap width) up to 1,000 in., corresponding to $g/\lambda = 0.127$. The validity of the theory was only claimed for values of $(g/\lambda)^2 << 1$. (ASTIA abstract)

HAR. 02:029

Harvard U. Cruft Lab., Cambrtdge, Mass.

THE EFFECT OF THE SURFACE ON THE MAGNETIC PROPERTIES OF AN ELECTRON GAS, by H. Brooks and F. S. Ham. Mar. 10, 1953, 46p. illus. refs. (Technical rept. no. 169) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Atr Force Office of Scientiftc Research] under N5ori-7601) AD 6210 Unclassified

Also published in Phys. Rev., v. 92: 1113-1119, Dec. 1, 1953.

A determinatton of the magnetic susceptibility of a system of electrons confined in a box is presented whtch considers the dependence of susceptibtlity on the form of the wall potential. An tmproved argument is given for a cylindrical box in which the balancing of diamagnetic and paramagnettc states is clarifted, and which determines (by means of the WKB approximatton) the nature of the boundary states. A more detailed derivation is given which establishes corrections to the terms in the susceptibility that dominate at htgh field strengths. The derivation is valid only if the radius of the confining box is considerably larger than the classical orhit radius of an electron moving in a plane perpendicular to a magnetic field with energy equal to the Fermi energy of the system. Darwtn's model is shown not to gtve the same results as the electron-in-a-box model when Fermi statistics are used. (ASTIA abstract)

HAR. 02:030

Harvard U. Cruft Lab., Cambridge, Mass.

A TABULATION OF THE FRESNEL INTEGRALS, by R. [D.] Turner and A. F. Downey Mar. 15, 1953, 19p. (Technical rept. no. 173) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 8175 Unclassified

A tabulation of the Fresnel integrals

$$C(x) = \frac{1}{\sqrt{2\pi}} \int_0^x \cos t \frac{dt}{\sqrt{t}} \qquad S(x) = \frac{1}{\sqrt{2\pi}} \int_0^x \sin t \frac{dt}{\sqrt{t}}$$

is given for $0 \leq x \leq 1.00$ by steps of 0.01, and for $1.0 \leq x \leq 30.0$ by steps of 0.10. In addition, values are given for $x = n\frac{\pi}{2}$, $n = 1\text{-}20$. Differences are tabulated, to facilitate interpolation. Some applications of the integrals are listed. Alternative forms and asymptotic expansions valid for large x are given. (Contractor's abstract)

HAR. 02:031

Harvard U. Cruft Lab., Cambridge, Mass.

EXPERIMENTAL AND THEORETICAL IMPEDANCES AND ADMITTANCES OF CENTER-DRIVEN ANTENNAS, by P. A. Kennedy and R. King. Apr. 1, 1953, 1v. incl. diagrs. tables, refs. (Technical rept. no. 155) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 11434 Unclassified

Recent experimental and theoretical results pertaining to the impedance and admittance of center-driven antennas have been consolidated into one report. A complete set of tables and curves with instructions for their use follows a general discussion of the problem. The essentials of the King-Middleton second-order theory and the final equation for the second-order impedance are presented along with necessary spacing and end-effect corrections which must be considered. Experimental results from various sources have been compared with theory. In particular Hartig's experimental results on the effect of circular apertures in a horizontal ground plane on the impedance of a half-dipole have been reevaluated and found to agree well with theory. Special related topics such as the electrically short antenna and the receiving antenna have also been discussed. (Contractor's abstract)

HAR. 02:032

Harvard U. Cruft Lab., Cambridge, Mass.

ELECTROMAGNETIC SCATTERING FROM TWO PARALLEL CONDUCTION CIRCULAR CYLINDERS, by R. V. Row. May 1, 1953, 58p. illus. refs. (Technical rept. no. 170) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 14953 Unclassified

Also published in Jour. Appl. Phys., v. 26: 663-675, June 1955.

The problem of the scattering of an incident cylindrical electromagnetic wave by an arbitrary array of perfectly conducting circular cylinders is solved for the case of the electric vector parallel to the axes of the cylinders. The total field is calculated by the use of a Green's theorem. The application of the boundary conditions results in a set of integral equations for the current on each cylinder; arbitrary excitations and coupling between all the elements are taken into account. The currents are expanded in a complex Fourier series; this transforms the integral equations into an infinite set of linear algebraic equations in the unknown Fourier coefficients. The theory is specialized to the case of 2 identical cylinders. In addition, neglect of the coupling between different current modes yields a simple formula for the scattered field in which the effect of coupling is apparent. For 2 cylinders equidistant and far from the source, the scattered field is computed from these approximations for cylinders as large as a wave length in diameter and for spacings of 1 to 4 λw between the centers. The approximations were confirmed by measurements at 3.185 cm w in a parallel plate region. Both theory and experiment indicate significant departures from the predictions of the independent scattering hypothesis. (ASTIA abstract)

HAR. 02:033

Harvard U. Cruft Lab., Cambridge, Mass.

MODE CONTROL AND OPERATING VOLTAGES OF INTERDIGITAL MAGNETRONS, by A. Singh. May 5, 1953, 13p. illus. (Technical rept. no. 179) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601] AD 12828 Unclassified

Studies were made controlling the frequencies of all the modes up to the second order, and investigations were made to study the electronic operation [illegible]rst- and second-order modes. Experiments with operating tubes show that under given conditions, the first- and second-order modes can operate at more than 1 voltage. The different voltages can be attributed to the excitation of different Fourier components of the field configuration. Variation of resonance frequency of modes of different orders with changes in resonator parameters was studied by using a demountable resonator. It was indicated that an increase of cavity radius reduces the resonance frequency and increases the separation of the different modes; the ratio by which the resonance frequency changes for a given variation of cavity radius is smaller for the higher-order modes. An increase of radial thickness of the fingers, or a decrease of the separation between fingers, reduces the resonance frequency. A mode of separation of the order of 40% is obtained by choosing the ratio of cavity radius to anode radius to be 3:1. Sensitive control over the various modes can be

HAR. 02:034 - HAR. 02:038

obtained by introducing radial vanes in the cavity. The degenerate pairs of modes can be separated out, and the modes can be accurately located at equal intervals if the radial penetration of the vanes is chosen properly. (ASTIA abstract)

HAR. 02:034

Harvard U. Cruft Lab., Cambridge, Mass.

THE RADIATION OF A HERTZIAN DIPOLE OVER A COATED CONDUCTOR, by D. B. Brick. May 10, 1953, 49p. incl. illus. refs. (Technical rept. no. 172) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 16104 Unclassified

The idealized problems of (a) an infinitesimal Hertzian dipole in and over a perfect dielectric coating a perfect conductor and (b) as Abraham dipole lying on the conductor are treated. Unintegrated forms of the Hertz potentials are obtained for both electric and magnetic dipoles. Integrated far-zone forms of the potentials and fields are obtained for electric dipoles by means of asymptotic integrations. Far-zone radiation are given in order to indicate the distortions of the fields and the magnitudes of the residue waves caused by the dielectric coatings. It is proved that the power radiated by the dipole, may be divided into two independent quantities: the power fed to radiation type and that fed to surface or guided type fields. For certain cases numerical results are given for the total power radiated and the relative powers fed to the two types of fields. Formulas are derived and illustrated with numerical examples of the radiation resistances of the dipoles and the attenuation constants of the surface modes due to finite conductivity of the ground plane. (Contractor's abstract)

HAR. 02:035

Harvard U. Cruft Lab., Cambridge, Mass.

SCATTERING OF PLANE ELECTROMAGNETIC RADIATION BY AN INFINTE CYLINDRICAL MIRROR, by R. D. Turner. May 15, 1953, 19p. illus. refs. (Technical rept. no. 161) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-7601) AD 18292 Unclassified

Using a variational principle in conjunction with a suitable trail function, expressions for the far-zone field and scattering cross section of a cylindrical mirror excited by a plane wave are obtained that are valid over a wide range of frequencies. The plane is polarized so that the electric vector is parallel to the axis of the mirror. (Contractor's abstract)

HAR. 02:036

Harvard U. Cruft Lab., Cambridge, Mass.

THE END-CORRELATION FOR A COAXIAL LINE WHEN DRIVING AN ANTENNA OVER A GROUND SCREEN, by R. King. June 1, 1953, 7p. illus. table, refs. (Technical rept. no. 174) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 16103 Unclassified

Theoretical and experimental results obtained by Hartig for the end-correction for a coaxial line driving an antenna over a ground screen are corrected. Improved theoretical and experimental curves of the quantity $-C_T/bc_0$ are obtained, where $-C_T$ is the lumped negative capacitance required as end-correction, c_0 is the capacitance per unit length of the coaxial line, and b is the inner radius of the outer conductor of the line. (ASTIA abstract)

HAR. 02:037

Harvard U. Cruft Lab., Cambridge, Mass.

INJECTION AND DIFFUSION OF HOLES AND ELECTRONS IN A SEMICONDUCTOR, by H. Brooks. June 3, 1953, 30p. (Technical rept. no. 181) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 20495 Unclassified

A small-signal transient solution is obtained for an injected pulse of holes which is applicable to semiconductors that are intrinsic or nearly so, as well as to ordinary n- and p-types. A criterion for the validity of the assumption of space-charge neutrality is discussed. An approximation to take into account the beginning of nonlinear effects for large injected pulses is also derived and discussed. The theory of conductivity pulses resulting from injected carriers in a filament is discussed, and it is shown that the apparent quantum efficiency for photoconductivity in an intrinsic semiconductor can become much larger than b + 1, where b is the mobility ratio.

HAR. 02:038

Harvard U. Cruft Lab., Cambridge, Mass.

VARIATIONAL APPROXIMATIONS TO THE DIFFRACTION BY CIRCULAR AND ELLIPTICAL APERTURES, by C. Huang. June 5, 1953, 34p. illus. refs. (Technical rept. no. 164) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 24680 Unclassified

Different methods are reviewed briefly for attacking the problem of the diffraction of a plane electromagnetic wave by a circular aperture in a plane screen which is infinitesimally thin and perfectly conducting. Specifically, the variational method derived by Levine and Schwinger has been used to evaluate the transmission coefficient of circular and elliptical apertures. For the circular aperture, a high-order vector trail function with undetermined frequency-dependent coefficients is

chosen. By using the stationary property of the expression for the transmission coefficient, equations for the undetermined coefficients are derived. These equations are solved to give a first-order approximation of the transmission coefficient, and the numerical values are compared with previous results. For elliptical apertures, a zeroth-order approximation of the transmission coefficient is evaluated using a one-component trail function. Numerical results are given for ellipses with minor-to-major-axis ratios of 1/2 and 1/3. (Contractor's abstract)

HAR. 02:039

Harvard U. Cruft Lab., Cambridge, Mass.

THE MEASUREMENT OF APERTURE TRANSMISSION COEFFICIENTS, by C. Huang and R. D. Kodis. June 10, 1953, 7p. illus. refs. (Technical rept. no. 165) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 18563 Unclassified

The transmission coefficients of circular, elliptical, and square apertures in a plane conducting screen are determined from measurements of the far-zone scattered field in the direction of incidence. The measurements were carried out at K-band frequencies using an image-plane technique. Experimental values of the transmission coefficient are compared with the results of a number of theoretical formulations. (Contractor's abstract)

HAR. 02:040

Harvard U. Cruft Lab., Cambridge, Mass.

BABINET'S PRINCIPLE FOR PLANE OBSTACLES, by C. Huang. June 15, 1953, 9p. (Technical memo. no. 8) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori 7601) AD 24689 Unclassified

Integral formulas are deduced for representing electric and magnetic fields throughout a region. The formulas are applied to the problem of the diffraction of electromagnetic waves by a perforated plane conducting screen. Integral equations are obtained from which a compact proof of Babinet's principle is obtained for the diffraction by the screen. (ASTIA abstract)

HAR. 02:041

Harvard U. Cruft Lab., Cambridge, Mass.

MODIFICATION OF STANDARD NETWORK SYNTHESIS TECHNIQUES TO USE LOSSY ELEMENTS, by J. E. Storer. June 20, 1953, 7p. incl. illus. (Technical rept. no. 180) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force of Scientific Research under N5ori-7601) AD 16102 Unclassified

A method is presented for adapting standard network synthesis techniques to yield circuits having lossy elements. The usual procedures of synthesizing transfer impedances or transfer functions can be modified so that the final circuit has a resistance in series with each inductance and a resistance in parallel with each capacitance. The procedure used is the inverse of the one outlined by Guillemin (Communications Networks, v. 2, John Wiley, N. Y., 1951) for calculating the effect of lossy elements. (ASTIA abstract)

HAR. 02:042

Harvard U. Cruft Lab., Cambridge, Mass.

IMAGE-PLANE AND COAXIAL-LINE MEASURING EQUIPMENT AT 600 MC, by H. W. Andrews. July 1, 1953, 27p. illus. refs. (Technical rept. no. 177) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 22429 Unclassified

Consideration is given to the construction of the measuring lines and the associated electronic devices for determining the driving point impedance and the current and charge distributions upon antennas. Configurations possessing a plane of symmetry are mounted over an image screen behind which is located the measuring equipment. The measuring line connects into the image screen, and its center conductor may be extended to form an antenna. The conductor is slotted, and the currents and charges distributed on it may be determined by probes sliding within it. An unmodulated source of RF energy is used, and the modulation is introduced in the superheterodyne receiver used to measure the signal level. The frequency of the source is monitored by comparison, in a spectrum analyzer, with a crystal-controlled source of energy.

HAR. 02:043

Harvard U. Cruft Lab., Cambridge, Mass.

THE COLLINEAR ANTENNA ARRAY. THEORY AND MEASUREMENTS, by H. W. Andrews. July 15, 1953, 47p. illus. refs. (Technical rept. no. 178) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628) AD 27101 Unclassified

A theory for the close-spaced collinear antenna array was formulated on the basis that the array is the superposition of a doubly and a singly driven dipole. Values for computation of impedances, comparison of probes, and gap ($0 < \text{gap} < \lambda/10$) capacitance were obtained both theoretically and experimentally. The theory was evaluated for specific configurations typical of the applicable range of the theory as a check of the basic assumptions and of the region of usefulness.

HAR. 02:044 - HAR. 02:047

HAR. 02:044

Harvard U. Cruft Lab., Cambridge, Mass.

FULL-WAVE DETECTION OF SIGNALS IN NOISE, by N. Stone and D. Middleton. Aug. 1, 1953, 62p. illus. table, refs. (Technical rept. no. 182) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 40540 Unclassified

The experimental background for the theoretical problems to be investigated is first reviewed, and then a brief sketch of the classical detection problem is included. A signal-to-noise ratio is defined, and the principal results of the study are summarized and discussed in some detail, with the important quantities in the derivation of the output signal-to-noise ratio after full-wave rectification, for input background noise of gaussian statistics, being obtained from the correlation function for the output. The cases treated are: 1(a) a sinusoidal signal in narrow-band noise; 1(b) a narrow-band noise "signal" in a narrow-band noise background; 2(a) a sinusoidal signal in broad-band noise; and 2(b) a narrow-band noise "signal" in a broad-band noise background. The half-wave and full-wave cases are compared. The important devices, the ideal clipper, linear detector, and square-law detector, are considered, and compared for the extremes of very large and very small input signal-to-noise ratios. Thus, for all varieties of input outlined above if p is the input power signal-to-noise ratio, then for very small p, the output power signal-to-noise ratio, P, is related to p by $P \sim p^2$, for all devices. For sinusoidal signals (large p) and linear and quadratic detectors, P is proportional to p, whereas for the ideal clipper, $P \sim (\ln p)^2 p$. The exact relations are summarized in Part I, sec. 4 of this report. (Contractor's abstract)

HAR. 02:045

Harvard U. Cruft Lab., Cambridge, Mass.

ON THE NUCLEAR MAGNETIC RESONANCE IN METALS AND ALLOYS, by N. Bloembergen and T. J. Rowland. Aug. 20, 1953, 28p. illus. tables, refs. (Technical rept. no. 186) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 19236 Unclassified

Also published in Acta Metallurgica, v. 1: 731-746, Nov. 1953.

A Pound-Knight-Watkins type of RF spectrometer (Rev. Scient. Instruments, v. 21: 219, 1950) was used in measuring the shift of nuclear resonance and the line width in α- and β- Sn, Th, Pb, and several alloys. A permanent magnet with a field of about 6000 gauss in a 1.25-in. gap and with 4-in.-diam pole faces was also used. A few measurements were made with an electromagnet at fields between 2000 and 5500 gauss. The samples were made from powdered metals suspended in mineral oil. Gray Sn showed no shift relative to the resonance in insulating compounds, but white Sn had an anistropic shift of 0.79% along the tetragonal axis and 0.74% perpendicular to it. A theory is given for the anistropy and symmetry of the observed line. Thallium had an anomalously broad resonance line with a shift of 1.54%. The shift in Th alloys varied continuously with composition in each phase and had discontinuities when phase transitions occurred. The intensity of the Cu resonance in pure Cu was increased by annealing and decreased by cold work. The intensity in alloys such as α-brass and Cu-Ag decreased rapidly with increasing Zn or Ag content. These effects are explained in terms of quadrupole interaction. (ASTIA abstract)

HAR. 02:046

Harvard U. Cruft Lab., Cambridge, Mass.

FERROMAGNETIC RESONANCE ABSORPTION IN COBALT SINGLE CRYSTALS, by T. Ohtsuka. Aug. 30, 1953, 18p. illus. refs. (Technical rept. no. 187) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 25240 Unclassified

The ferromagnetic resonance absorption of Co single crystals was measured at about 24,200 mc by using an experimental technique similar to that described by Bloembergen (Phys. Rev., v. 78: 572, 1950). Three crystals cut in different orientations and in the shape of thin rectangular slabs were used. By using experimental values and assuming that the spectroscopic splitting factor g is isotropic, the anisotropy constants K_1' and K_2' were calculated. The line width was determined from relative values of the resonance permeability μ_R. The shift in the easy direction from the hexagonal axis to the hexagonal plane arises from the temperature dependence of the first-order effect of dipolar coupling; the second-order effect tends to suppress the switchover and spread it out over a finite temperature range. The g- value decreased from 2.6 at 180° C to 2.2 at about 240°C, leveled off, and stayed constant up to 380°C. The line widths for all crystals were of the order of a few hundred oersteds. Measurements at 200° to 400°C confirmed the phenomenon of the reversal of sign in K_1'. (ASTIA abstract)

HAR. 02:047

Harvard U. Cruft Lab., Cambridge, Mass.

AN EXPERIMENTAL INVESTIGATION OF THE TRANSMISSION PROPERTIES OF THE DOMINANT CIRCULAR-ELECTRIC MODE, by L. S. Sheingold. Sept. 1, 1953, 31p. illus. refs. (Technical rept. no. 167) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 28258 Unclassified

A novel method of measuring impedance in a circular waveguide supporting only the dominant circular-electric mode is described. A complete description of the experimental arrangements used in the TE_{01}

impedance measurements is presented. Results are given of precise impedance measurements made on circular obstacles ctrcumferential gaps and radtattng gutdes. These expertmental results are compared with theoretical vatues and are found to be tn excellent agreement. It ts demonstrated that application of Deschamp's graphical method in the experimental determination of the scattering parameters of a circumferential-gap-junction results in a rapid determination of the pertinent quantities; i.e., the power reflected by, power transmitted through, and power dissipated in the junction. (Contractor's abstract)

HAR. 02:048

Harvard U. Cruft Lab., Cambrtdge, Mass.

THE POLARIZATION OF RADIO WAVES REFLECTED FROM THE IONOSPHERE AT NONVERTICAL INCIDENCE. I. THEORETICAL BACKGROUND, by G. Inouye. Sept. 1, 1953, 87p. tncl. ittus. refs. (Technical rept. no. 190) (Sponsored jointly by Offtce of Naval Research, Signal Corps, and [Atr Force Oftice of Scientiftc Research] under N5ort-7601 and-7628) AD 31604 Unclassified

The magneto-tonic theory of radio wave propagation in the tonosphere is reviewed towards the understanding of the various features associated with the polarization of the downcoming waves which have traversed a nonvertt-cal path. The dependence of the potarization tn the Appleton coordtnates on the angle between the wave-normal and the earth's magnetic ftetd ts computed assuming a magnetic dip of 68° 30' which applies in the United States. This polarization is then expressed in the propagation coordinates as a function of the vertical angle of arrival with the magnetic bearing of the receiving site from the transmitter as a parameter. (Contractor's abstract)

HAR. 02:049

Harvard U. Cruft Lab., Cambridge, Mass.

THE POLARtZATION OF RADIO WAVES REFLECTED FROM THE tONOSPHERE AT NONVERTICAL tNCtDENCE. tt. MEASUREMENT TECHNtQUES AND EXPERIMENTAL RESULTS, by G. Inouye. Sept. 1, 1953, 46p. tllus. refs. (Technical reot. no. 191) (Sponsored jointly by Office of Naval Research, Stgnal Corps, and [Air Force Offtce of Scientific Research] under N5ort-7601 and -7628) AD 31605 Unclasstfied

The effect of the ground on the total field as measured is discussed as a functton of the ground constants and the vertical angle of arrtval. As part of the determinatton of the polarization, the techniques for measuring the horizontal and vertical angles of arrival are also discussed. Equipment is described for simultaneously recording the phase difference of signals consisting of trains of RF pulses. The amplitude ratio in the polarization determination is recorded in a manner similar to the phase angles. The direction of arrival of downcoming ionospheric radio waves was measured on the 9.1-mc pulsed transmisstons on the Glenville, N.C. to Lexington, Mass. path (1310 km). The angles of arrivat had random vartations of a few degrees about a mean value, wtth pertods ranging from 10 to 30 mtnutes. Aside from these fluctuations, the horizontal angle of arrtval corresponded to propagation vta the great-circle path except for an unexplained deviation of about a degree to the NW. The vertical angle averaged about 5° higher than theoretical predictions for F-layer transmissions. The polarization was as predicted by the theory when the magneto-ionic components were separated in time of arrival so that phase interference was not obscuring the polarization of individual modes. For the particular conditions obtaining in measurements, the polarization was nearly circular with the ordinary ray havtng a left-handed, and the extraordinary ray havtng a right-handed, sense of rotatton looking tn the dtrection of the wave normal. (Extracted from report)

HAR. 02:050

Harvard U. [Cruft Lab.] Cambrtdge, Mass.

RELAXATION EFFECTS IN PARAMAGNETIC AND FERROMAGNETIC RESONANCE, by N. Bloembergen and S. Wang. Sept. 10, 1953 [12]p. incl. diagrs. tables, refs. (Technical rept. no. 188) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 21718 Unctassified

Also published tn Phys. Rev., v. 93: 72-83, Jan. 1, 1954

Magnetic resonance experiments have been carried out at 3-cm wavelength in paramagnetic and ferromagnetic samples at very high microwave power levels in a temperature range between 77° K and 700° K. Changes tn the microwave susceptibtlity and the dc magnettzatton have been observed for mtcrowave amplttudes between 1 and 50 oersted. For a paramagnettc salt, $MnSO_4 \cdot 4H_2O$, these changes are readtly interpreted in terms of a spin-lattice relaxatton mechanism. The value for the spin-lattice relaxatton ttme ts dertved in three different ways and agrees well wtth that obtained by Gorter's nonresonant method. When a large exchange tnteraction occurs between the sptns, the situation above the Curte point can be described in terms of a converston of magnetic into exchange energy. The magnetic and the spin-exchange systems are not always tn thermal equtlibrium. The characteristic time for the transfer of energy between these systems is equal to the tnverse of the line width, whtch is given by the Van Vleck-Anderson formula for exchange narrowing. Experimental results for an organic free radical and some ferrites confirm this potnt of view. Below the Curie temperature the situation is more complicated. The experimental data for several ferrites and supermalloy show quatitatively the same behavior. The absorbed magnetic energy is again converted into exchange energy with a characteristic time which is atways shorter than 3×10^{-8} sec. At high temperatures this time is equal to the tnverse line width and the transitton to the paramagnetic region is continuous. At low temperatures

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the relaxation time increases roughly inversely proportional to the temperature although the width remains constant. The microwave susceptibility has an anomalous decrease at high power levels. No satisfactory explanation has been found for these effects in existing theories. (Contractor's abstract)

HAR. 02:051

Harvard U. Cruft Lab., Cambridge, Mass.

THE MAXIMUM-MINIMUM SHIFT METHOD FOR MEASURING COMPLEX DIELECTRIC CONSTANTS AND PERMEABILITIES, by R. King. Dec. 15, 1953, 21p. illus. refs. (Technical rept. no. 192) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 28257 Unclassified

An absolute method for measuring dielectric constants of solids and liquids (Rev. Scient. Instruments, v. 8: 202, 1937 and Phil. Mag., v. 29: 521, 1940) is generalized to permit the determination of both dielectric constant and permeability of a moderately low-loss or fluid medium. The method is absolute in the sense that only measurements of length are required to determine E_r and μ_r. A special feature is the fact that E_r and μ_r are each determined under conditions of maximum sensitivity. The determination of losses involving complex dielectric constants and permeabilities is also described. (Contractor's abstract)

HAR. 02:052

Harvard U. Cruft Lab., Cambridge, Mass.

THE GAP PROBLEM IN ANTENNA THEORY, by R. King. Dec. 21, 1953, 9p. illus. refs. (Technical rept. no. 194) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 28757 Unclassified

Also published in Jour. Appl. Phys., v. 26: 317-321, Mar. 1955.

The so-called gap problem in antenna theory is considered critically. It is shown that whereas there exist problems related to transmission-line end-effect and coupling between antenna and line, there is no gap and hence no gap problem, when a physically realizable complete transmitting system is considered rather than an antenna with a fictitious mathematically convenient driving mechanism. (Contractor's abstract)

HAR. 02:053

Harvard U. Cruft Lab., Cambridge, Mass.

DIFFRACTION BY APERTURES, by C. Huang, R. D. Kodis, and H. Levine. Feb. 27, 1954. [15]p. incl. diagrs. refs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force] Office of Scientific Research under N5ori-7601) Unclassified

Published in Jour. Appl. Phys., v. 26: 151-165, Feb. 1955.

The diffraction of plane electromagnetic waves by apertures in a plane screen which is infinitesimally thin and perfectly conducting is studied both theoretically and experimentally. The theoretical analysis employs a dyadic Green's function to develop vector formulas for the scattered fields, and from these formulas integral equations are obtained for the aperture distributions. The vector representation makes possible a compact demonstration of the electromagnetic form of Babinet's principle by means of which one may extend the aperture analysis to complementary disks. The integral equations are then used to construct a variational principle for the aperture transmission coefficient. Detailed analysis and numerical computations are carried out for two configurations. For the circular aperture a first-order vector trial function with frequency dependent coefficients is chosen for the aperture distribution. The approximate transmission coefficient is found to agree closely with the exact value in the region $2\pi a/\lambda \leq 3$. For elliptical apertures a zeroth-order approximation is evaluated using a one-component trial function. Numerical results are given for minor-to-major axis ratios of 1/2 and 1/3. Transmission coefficient measurements were carried out in the 24,000 mc band ($\lambda = 1.25$ cm) using an image plane technique. The apparatus was first calibrated with the exact solution of the circular aperture. The approximate results calculated for elliptical apertures are then seen to be in good agreement with the measurements over the accessible range. (Contractor's abstract)

HAR. 02:054

Harvard U. Cruft Lab., Cambridge, Mass.

FOLDED ANTENNAS, by C. W. Harrison, Jr. Mar. 1, 1954, 65p. illus. (Technical rept. no. 193) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628) AD 33389 Unclassified

Also published in Jour. Amer. Soc. Naval Engineers, v. 67: 213; 238, Feb. 1955.

The integral-equation technique for solving electrodynamic problems involving circuits comparable to the wave length in the maximum dimension is employed to develop formulas for the driving-point impedance of various folded-wire structures. The general procedure is to equate the Helmholtz integral for the total vector potential at a point on the surface of a wire to the solution of the differential equation for the total vector potential at the same point. Formulas are developed for the driving-point impedance of 2-, 3-, and 4-wire antenna-transmission lines, and a general theory is advanced for 3-wire antenna-transmission lines whose cross sections are equilateral triangles. A

formula is developed for the driving-point impedance of a structure resembling the conventional 3-wire folded dipole, but consisting of a center-driven wire of a given radius and 2 other wires of another radius. (ASTIA abstract)

HAR. 02:055

Harvard U. Cruft Lab., Cambridge, Mass.

A SHIELDED TWO-WIRE HYBRID JUNCTION, by E. W. Matthews, Jr. Mar. 10, 1954, 26p. diagrs. table. (Technical repl. no. 183) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 34780 Unclassified

A theoretical analysis of the properties of a shielded 2-wire hybrid junction is presented; the use of the junction as the basic element of an impedance bridge is emphasized. The problem of definition and measurement of impedances on this type of line, with 2 propagating modes, is discussed, and the line constants are evaluated for the particular line configuration used.

HAR. 02:056

Harvard U. Cruft Lab., Cambridge, Mass.

A UHF IMPEDANCE BRIDGE FOR SHIELDED TWO-WIRE LINES, by E. W. Matthews, Jr. Mar. 10, 1954, 41p. illus. refs. (Technical repl. no. 184) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 34777 Unclassified

A description is presented of a UHF-range impedance bridge which uses a shielded 2-wire hybrid junction. Design and test data are presented for (1) a balance-unbalance detector used for separating the 2 possible modes and (2) an adjustable impedance standard in 2-wire line. Test results are discussed.

HAR. 02:057

Harvard U. Cruft Lab., Cambridge, Mass.

A THEORETICAL AND EXPERIMENTAL INVESTIGATION OF RADIATION OF A VERTICAL ANTENNA OVER A COATED CONDUCTOR, by D. B. Brick. Mar. 15, 1954 [57]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 195) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 33472 Unclassified

The idealized problem of a base-driven cylindrical antenna over a perfectly conducting dielectric-coated image plane is treated theoretically. An integral equation which is utilized in arriving at an approximation to the current distribution on the antenna is derived. Use is made of the results of a previous report in the derivation. The far-zone fields for the configuration are shown to be composed of two types of waves — those of spherical type, the radiation or compensating field, and those of cylindrical type which attenuate exponentially with height above the dielectric surface, the surface or guided waves. These two are combined at a typical distance to yield theoretical field patterns. The experimental approximation to the idealized configuration is described at length. Measurements made using this apparatus are seen to be in good agreement with theory, thus verifying the theory contained in this and the previous report. Experimental results are also given for partially coated surfaces as an aid towards the understanding of the phenomena. Considerable space is devoted to the choice and the calibration of the measuring antennas. In the course of this study a new concept of the complex effective receiving length is introduced. (Contractor's abstract)

HAR. 02:058

Harvard U. Cruft Lab., Cambridge, Mass.

PRESSURE DEPENDENCE OF THE HALL EFFECT IN GERMANIUM (Abstract), by W. Paul, G. B. Benedek, and H. Brooks. [Mar. 1954] [1]p. (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under [N5ori-601])
Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit and Ann Arbor, Mich., Mar. 18-20, 1954.

Published in Phys. Rev., v. 94: 1415, June 1, 1954.

The pressure dependence of the Hall constant and resistivity of n- and p-type samples of germanium of different impurity concentration has been measured from 0 to 12 000 kg/cm^2. In n-type samples chosen so that the carriers are all of one type and their density remains constant — a condition deducible from the known dependence of energy gap on pressure (Phys. Rev., v. 90: 336, 1952) — the Hall constant increases by some 8 percent to 12 000 kg/cm^2. Assuming constant carrier concentration, this can be interpreted as an increase in the ratio of Hall to drift mobility for electrons. Taken in conjunction with the resistivity data this implies a decrease in both Hall and drift mobility for electrons under pressure. The results for n-type germanium with a considerable number density of minority carrier are not inconsistent with this explanation. The changes in the Hall constant and resistivity in the p-type samples under pressure are smaller than in the n-type but do indicate an increase of both Hall and drift mobility for holes under pressure, with a decrease in their ratio. (Contractor's abstract)

HAR. 02:059

Harvard U. Cruft Lab., Cambridge, Mass.

THE NUCLEAR QUADRUPOLE RESONANCE AND CRYSTAL STRUCTURE OF SOLID IODINE, by K. W.

HAR. 02:060 - HAR. 02:062

H. Stevens. Apr. 20, 1954, 11p. incl. diagrs. (Technical rept. no. 197) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628)
AD 34779 Unclassified

Previous attempts to explain the anisotropy of the quadrupole resonance in solid iodine are critically reviewed and an attempt is made to set up a valence bond description of the iodine molecule which contains the possibility that additional weak bonds are formed in crystalline iodine. This is primarily accomplished by introducing d-hybridization. The observed bond angles are then used to estimate some of the parameters in the orbits. Use is made of knowledge about nuclear quadrupole interaction in solid I_2 and in the iodine atom to determine further parameters, and in this way a picture of the iodine molecules and its behavior in a crystal is obtained. An interesting possibility which then arises is that the lobes of the wave-function of different iodine molecules do not overlap very strongly because a maximum of one molecule seems to be directed towards a minimum of another. This does not correspond to the usual ideas about bonds, but as the theory passes smoothly from the notion of maximum overlap to this new situation, no discussion is given about how it should be described. It is also seen that the observation of the quadrupole resonance in single crystals of iodine (if this becomes possible) would provide very useful information and checks on the theory. (Contractor's abstract)

HAR. 02:060

Harvard U. Cruft Lab., Cambridge, Mass.

THE COLLINEAR ANTENNA ARRAY WITH A SECTION OF TWO-WIRE LINE AS COUPLING ELEMENT, by C. C. H. Tang. May 1, 1954 [30] p. incl. illus. diagrs. (Technical rept. no. 196) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601)
AD 35948 Unclassified

The problem of a symmetrical three-element collinear antenna array with a section of two-wire line as the coupling element between antennas is studied in order to obtain qualitatively the conditions under which the currents in the parasites are in phase with the currents in the driven antenna. The phase of the currents in the parasitic elements is reversed only when (1) the overall length of the section of two-wire line and the parasite is near an odd integral multiple of a quarter-wavelength, and (2) the position of the short-circuiting bar or tandem bridge on the section of line is about a quarter-wavelength away from the array. The reversal of the phase of the current on the parasite is independent of the length of the driver, but the length of the driver is involved in the driving-point impedance. The current on the array as a whole can be decomposed into a main antenna current and a secondary antenna current. The main antenna current due to the driving voltage is excited on the driver and the two-wire line, while the gap voltage produced indirectly by the main antenna current is responsible for the secondary antenna current on the driver and parasite. It is the secondary antenna mode that causes the reversal of the phase of the current on the parasite. The radiation field of the array as a whole is a superposition of the two-fields produced respectively by the current on the two-wire line and that on the driver and parasites. (Contractor's abstract)

HAR. 02:061

Harvard U. Cruft Lab., Cambridge, Mass.

SOME SPIN PROPERTIES OF FERRIMAGNETIC AND ANTIFERROMAGNETIC SIMPLE CUBIC CRYSTALS, by J. S. Kouvel and H. Brooks. May 20, 1954, 36p. illus. tables, refs. (Technical rept. no. 198) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 34778 Unclassified

The model, whose "bulk" spin wave properties (i.e., the temperature variation of the magnetization and of the spin specific heat) at temperatures very low compared to the Curie temperature are derived semi-classically in this paper, is a simple cubic single crystal consisting of two magnetic spin sublattices. Due to nearest-neighbor negative exchange interaction between the sublattices, their associated spin vectors tend to be oppositely directed. Hence, when the magnitudes of the spin vectors of the sublattices are unequal, the structure is ferrimagnetic, and when they are equal, the structure is antiferromagnetic. The magnetization and spin specific heat of the former are found to follow a $T^{3/2}$ law (similar to the results of previous investigations of ferromagnetics) while the spin specific heat of the latter is found to vary as T^3. The effects of magnetic anisotropy, externally applied magnetic fields, and next-to-nearest neighbor exchange interaction on these properties are also considered. (Contractor's abstract)

HAR. 02:062

Harvard U. Cruft Lab., Cambridge, Mass.

RECTIFICATION OF NEARLY GAUSSIAN NOISE, by J. A. Mullen and D. Middleton. June 1, 1954, 85p. illus. tables, refs. (Technical rept. no. 189) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 35947 Unclassified

Nongaussian noise occurs sufficiently often that a study of its points of similarity to and difference from gaussian noise is desirable. This report considers an important sub-class of non-normal statistics, viz., nearly normal noise. A new form for the nearly gaussian probability densities has been found; this is discussed, compared to the conventional Edgeworth series, and related to earlier work. Next a survey of physical noise sources is made in order to classify the statistical nature of the noise that each produces. The rectification of nearly normal noise and a c-w signal in a half-wave 7th-law detector is analyzed and the correlation

functions of the output obtained. The behavior of the output is compared to the corresponding results for gaussian noise of the same input intensity. For the linear and square-law detectors, the cases of prime interest, detailed figures and a number of more tractable formulas are given. Finally, the problem of finite averaging is briefly considered. (Contractor's abstract)

HAR. 02:063

Harvard U. Cruft Lab., Cambridge, Mass.

NUCLEAR MAGNETIC RESONANCE IN IMPERFECT CRYSTALS, by N. Bloembergen. June 18, 1954, 1v. incl. diagrs. table, refs. (Technical rept. no. 199) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 40603 Unclassified

A systematic survey is made of how various kinds of imperfections in a crystalline lattice will affect the position, breadth, shape and relaxation time of the nuclear magnetic resonance. In accordance with Seitz's classification the following imperfections are considered: (a) dislocations; (b) vacant lattice sites and interstitial atoms; (c) foreign atoms in either interstitial or substitutional position; (d) electrons and holes; (e) phonons; and (f) excitons. Their interaction with the magnetic dipole moment and the electric quadrupole moment of the nuclei at the normal lattice sites is discussed and the available experimental information is reviewed. (Contractor's abstract)

HAR. 02:064

Harvard U. Cruft Lab., Cambridge, Mass.

DISCONTINUITIES IN OPEN-WIRE LINES, by R. King. July 10, 1954, 1v. incl. diagrs. tables. (Technical rept. no. 200) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 45400 Unclassified

Also published in Transmission Line Theory, by R. King. N. Y., McGraw Hill, 1955, Sec. 13-21, Chap. V.

Conventional transmission-line theory takes no account of variations in the parameters of the transmission line or of coupling between conductors near a junction or termination. A first-order correction may be made for this omission by introducing junction-zone networks of lumped series and shunt elements which may be evaluated for each discontinuity. Following the general theory developed in earlier work junction-zone networks are obtained for a bend, a shunt T-junction and series T-connections with applications to certain types of antennas in an otherwise uniform two-wire line or single-wire line over an image plane. (Contractor's summary)

HAR. 02:065

Harvard U. Cruft Lab., Cambridge, Mass.

A PROBE SIGNAL STUDY OF THE HULL MAGNETRON DIODE, by J. A. Bradshaw. July 20, 1954, 68p. illus. refs. (Technical rept. no. 185) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 40609 Unclassified

The inner cylinder of the Hull magnetron diode was an Ni sleeve 1/4 in. in diam with an oxide coating 10 cm long. The outer cylinder was a heavy Cu anode. The sleeve could be heated above 1200°K, and a steady voltage could be applied between the sleeve and the anode. Anode and sleeve were also sections integrated in a coaxial transmission line between a HF oscillator and a detector. A TEM wave could pass from the oscillator through the diode to the detector, probing or exciting, as it passed, the space charge of electrons emitted from the hot oxide coating. When a uniform steady magnetic field is imposed on the diode, parallel to its cylindrical axis, the flow of electrons from sleeve to anode may be virtually cut off, and the diode operates as a magnetron. The probe signal suffered a sharp resonance absorption in transmission through the magnetron when the cyclotron frequency was close to the probe frequency. Near this absorption frequency the transmitted signal suffered changes of phase as well as of amplitude. These were observed over wide ranges of probe frequency, anode voltage, magnetic field, and cathode temperature. The changes were correlated with other effects, the disturbance of the residual current by the probe signal, the noise generated in the tube, and the signal at the second harmonic of the probe frequency. An examination of the orbit equations yielded an expression for the conductivity of the space-charge cloud. The conductivity depends on the ratios of probe and orbit frequency to the cyclotron frequency, u and u_0, respectively, on a phenomenological damping parameter τ, and on the average charge density. (ASTIA abstract)

HAR. 02:066

Harvard U. Cruft Lab., Cambridge, Mass.

THE DISTRIBUTION OF SPACE CHARGE IN THE HULL MAGNETRON DIODE, by J. A. Bradshaw. Aug. 15, 1954, 53p. illus. refs. (Technical rept. no. 201) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 45403 Unclassified

An attempt is made to fit TEM probe resonance data into a self-consistent model of the magnetron diode. Consideration is given to the effects of the transit time of electrons in a weak magnetic field in the regime before cutoff. An integral equation is developed as a means of finding the anode current as a function of the ratio of steady anode potential to the square of the magnetic field imposed in a cylindrical tube. A review is given of the characteristics of a virtual cathode without

a magnetic field, and an analysis is made of experimental data on the emission current. A rough calculation is presented of the thermal effects to be expected in the Hull cutoff transition. The results of a numerical calculation provide a means of contrasting some of the features of the cathode region before and after a steady magnetic field is imposed. Studies of the magnetron diode after cutoff result in the conclusion that the space charge entirely fills the interaction space in the diode. The potential function for this model is formulated. An extension is made of the statistical approach of G. Hok (Jour. Appl. Phys., v. 23: 983-989, 1952) to the problem of the charge distribution within a magnetron after cutoff, and consideration is given to the density distribution of electrons in phase space. (ASTIA abstract)

HAR. 02:067

Harvard U. Cruft Lab., Cambridge, Mass.

EXPERIMENTAL STUDY OF COLLINEAR SLOT ANTENNA (AN APPLICATION OF BABINET'S PRINCIPLE), by T. Kaliszewski. Sept. 6, 1954 [18]p. incl. illus. diagrs. (Technical rept. no. 202) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 46918 Unclassified

The effect of a high impedance transmission-line coupling on the current and phase relationship on a three-element, center-driven, collinear slot array at 10 cm wavelength is studied. A brief summary of theoretical results is followed by a detailed description of apparatus and the measuring procedures. Use is made of Babinet's principle in carrying out the measurements in an attempt to assess the validity of complementary slot techniques. Results thus obtained are compared with the theory and with alternative measurements made on a similar structure employed at much lower frequency. (Contractor's abstract)

HAR. 02:068

Harvard U. Cruft Lab., Cambridge, Mass.

ANTENNAS OF DISCONTINUOUS RADIUS, by C. Faflick. Sept. 7, 1954, 41p. incl. illus. refs. (Technical rept. no. 171) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force] Office of Scientific Research under N5ori-7601) AD 53607 Unclassified

A transmission-line analogy method is described which utilizes the known input impedance of the uniform antenna and the analogy between an antenna and a corresponding transmission line to approximate the input impedance and current distribution of an antenna with discontinuous radius. Comparisons made with the experimental values indicate that this method is more accurate than previous methods, and that for sufficiently thin antennas the results are acceptable for most engineering purposes.

HAR. 02:069

Harvard U. Cruft Lab., Cambridge, Mass.

PARASITIC SLEEVE ANTENNA, by C. Faflick. Sept. 7, 1954, 45p. illus. refs. (Technical rept. no. 157) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 51174 Unclassified

This research treats theoretically and experimentally the problem of the parasitic sleeve antenna, consisting of a coaxial sleeve mounted on a cylindrical antenna center driven over an image plane. It is first shown that the problem of the parasitic sleeve antenna can be resolved into two problems: (1) the center-driven cylindrical antenna of discontinuous thickness; and (2) the sleeve antenna of discontinuous radius. Equipment is described for measuring both the input impedance and the current distribution of a parasitic sleeve antenna. Current distributions on the outside of the sleeve are measured by a separate probe connected to the detecting system by miniature cable coiled inside the sleeve wall and threaded down the inside of the antenna. The errors in impedance measurement are discussed and it is shown that the measurements are accurate to within a 1% circle on a Smith Chart. Errors in phase measurements using a slotted matched line are considered and a method of minimizing errors due to a poorly matched line is presented for the case when it is impossible to adjust the relative amplitude of the two comparison signals. Graphs of input impedance vs sleeve tuning of an integral sleeve antenna in which case the sleeve is contained within the cylindrical antenna are shown for several positions of the sleeve mouth. As predicted the locus is a circle on a Smith Chart. Curves of the measured input impedance of a large number of parasitic sleeve antennas are given for various antenna lengths, sleeve positions, sleeve lengths, and sleeve diameters. Several representative current distributions are shown and the general behavior of the current is shown succinctly in a novel presentation. Finally the effectiveness of the parasitic sleeve antenna in reversing the current in the outer portion of the antenna is compared with that of the phase reversing stub. (Contractor's abstract)

HAR. 02:070

Harvard U. Cruft Lab., Cambridge, Mass.

MOVEMENT OF THE F-REGION, by K. Toman. Sept. 24, 1954 [30]p. incl. illus. diagrs. refs. (Technical rept. no. 207) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-760t) AD 47116 Unclassified

In the course of a fixed-frequency ionospheric study, employing a pulse-triggered transmitter operating on 3.5 mc/s and three spaced-receivers, the transmission-delay was continuously recorded. Aside from a vertical-

incidence transmission two oblique transmissions were thus available with 62 and 109 km as base-linee, the latter being correspondingly oriented in an approximate west-east and north west-south east direction. An analysis of the echoes from the F-region was made for the period between Aug. 1952 and Dec. 1953. Successive irregularitiee observed simultaneously on three records displayed frequently consistent time displacements. Assuming the mid-pointe of the transmissions to be characteristic and preferred areas for the reflection of the hf-pulsee, the time-displacements were interpreted as being due to a mechanical motion of the F-region. Direction and speed of this movement was thus obtained and semiannual and annual periods of these components became apparent. (Contractor'e abstract)

HAR. 02:071

Harvard U. Cruft Lab., Cambridge, Mass.

NUCLEAR SPIN EXCHANGE IN SOLIDS. THE Tl^{203} AND Tl^{205} MAGNETIC RESONANCE IN THALLIUM AND THALLIC OXIDE, by N. Bloembergen and T. J. Rowland. Oct. 5, 1954, 46p. illus. tables, refs. (Technical rept. no. 205) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 51264 Unclassified

Also published in Phys. Rev., v. 97: 1679-1698, Mar. 15, 1955.

The line width of the Tl^{203} and Tl^{205} nuclear magnetic resonance in thallium and thallium oxide greatly exceeds the dipolar width, and is a function of the abundance of the other isotope. The results can be interpreted in terms of an exchange interaction $AI_1 \cdot I_2$ between a pair of nuclear spins which exceeds the normal dipolar interaction. The exchange between different isotopee leade to broadening. Exchange between like nuclei should lead to narrowing, but it was found that samples containing 98.7 per cent Tl^{205} still exhibit linee broader than the dipolar interaction. Two causee are shown to exist; anisotropy of the chemical shift and pseudo-dipolar exchange interaction. Analysis with the method of the moments givee for the exchange interaction constant Ah^{-1} = 15.5 kc/sec with a 30% anisotropic pseudo-dipolar character in the hexagonal metal, and Ah^{-1} = 12 kc/sec with less than 10% pseudo-dipolar character in thallic oxide. The oxide has a chemical shift of +0.55% with an anisotropy of 34% of thie amount. The metal exhibits a shift of 1.56% with 16% anisotropy. Ramsey'a theory of nuclear spin exchange via exctted etectron statee in molecules, is extended to solide. Most heavy tsotopee in metals and insulators should exhibit exchange effects. From the anisotropy of the exchange information about the relative amount of p- or d-character of the electron wave function in the solid can be obtained. It is predicted that thallic oxide has a nuclear Curie point at 3.5×10^{-6}°K. Whether tt will become nuclear ferro- or antiferromagnetic depende on detaile of the electronic band structure. (Contractor'a abstract)

HAR. 02:072

Harvard U. Cruft Lab., Cambridge, Mass.

THE DIURNAL CARRIER-PHASE VARIATION OF A 16-KILOCYCLE TRANSATLANTIC SIGNAL, by J. A. Pierce. Oct. 10, 1954, 10p. illus. (Technical rept. no. 209) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628) AD 53753 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 584-588, May 1955.

The diurnal variation of the time of arrival of a 16 kilocycle signal traversing a transatlantic path has been found to be about 40 microseconds. This variation is presumably caused by a day-to-night change in the equivalent height of reflection of 10 to 12 km, and appeare to be very predictable. The great phase stability of very low-frequency transmission permits intercontinental frequency comparison to a precision of at least 1 part in 10^{10}. Variatione of the frequency of the arriving signal are apparently alwaye less than ±3 parts in 10^9; a figure to be compared with estimatee of the order of ±2 parts in 10^7 for high-frequency transmission. With such stability of propagation, extremely narrow receiving bandwidths are attainable. These bandwidths, in turn, make possible highly reliable networking of frequencies for communication station allocation and for navigational purposee. (Contractor'a abstract)

HAR. 02:073

Harvard U. Cruft Lab., Cambridge, Mass.

CAUSALITY AND RADIATION CONDITION, by T. T. Wu. Nov. 24, 1954, 15p. (Technical rept. no. 211) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 53606 Unclassified

The Sommerfeld radiation condition is obtained from the requirement of classical causality under quite general conditions. (Contractor'e abstract)

HAR. 02:074

Harvard U. Cruft Lab., Cambridge, Mass.

A NOTE ON STRAY LOADING OF PHASE BRIDGES, by J. C. Williams. Jan. 5, 1955, 11p. incl. diagrs. (Technical rept. no. 208) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628) AD 56734 Unclassified

The quadrature voltagee derived by means of phase bridgee are subject to error in relative magnitude or phase angle because of loading of the bridge output points

HAR. 02:075 - HAR. 02:077

by stray impedances. Two resistance-capacitance bridges with either resistance-capacitance or purely capacitive loading are considered, and it is shown that output voltages can be made errorless. For one configuration it is sufficient to satisfy certain relationships among the values of bridge and loading elements alike, while in the case of the other circuit constraint equations must be supplemented by attenuation, without phase shift, of one voltage in each quadrature pair. When the phase bridge is connected to the quadrants of a capacitor-type continuous phase shifter, it becomes desirable to augment the resultant loading. (Contractor's abstract)

HAR. 02:075

Harvard U. Cruft Lab., Cambridge, Mass.

A SPIN WAVE ANALYSIS OF THE MAGNETITE STRUCTURE, by J. S. Kouvet. Feb. 1, 1955, 26p. incl. diagrs. tables, refs. (Technical rept. no. 210) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-760t) AD 60834 Unclassified

A semiclassical spin wave treatment is applied to the ordered spin configuration that magnetite is believed to have below its transition temperature of about 120°K. All nearest neighbor AB, AA, and BB exchange interactions are considered. Expressions are obtained for the dispersion equation (for very long wavelengths compared to the lattice spacings) and for the magnetization and spin specific heat. They are compared quantitatively with the expressions previously derived by Kaplan for the inverse spinel having no long-range spin order in the B-sites. Some antiferromagnetic cases for this structure are also discussed. (Contractor's abstract)

HAR. 02.076

Harvard U. Cruft Lab., Cambridge, Mass.

NUCLEAR MAGNETIC RESONANCE SATURATION AND ROTARY SATURATION IN SOLIDS, by A. G. Redfield. Feb. 15, 1955, 57p. incl. diagrs. refs. (Technical rept. no. 206) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 60147 Unclassified

Nuclear spin-lattice relaxation times of Al^{27} in pure Al and Cu^{63} in annealed pure Cu have been measured with a nuclear induction spectrometer, by the method of saturation. The experimental values of T_1 are 4.1 ± .8 msec for Al^{27} and 3.0 ± .6 msec for Cu^{63}, in reasonable agreement with theory. The dispersion mode of the nuclear resonance was also observed, and it was found that χ' (the real part of the rf susceptibility) does not saturate at the same level as the absorption, χ'', but remains roughly constant out to a radio-frequency field intensity of about 2 gauss. Both χ' and χ'' become narrower and nearly Lorentzian in shape above saturation. When the dc magnetic field modulation is increased from 14 to 41 cycles the phase of the dispersion signal lags behind the modulation, presumably because the modulation frequency is then comparable to T_1. Large dispersion signals above saturation have also been observed for the Na^{23} resonance in NaCl. This behavior of the dispersion mode is in conflict with the predictions of Bloembergen, Purcell, and Pound and of the Bloch equations. The validity of these theories is reexamined, and it is concluded that although they are applicable to nuclear resonance in liquids and gases, and to solids at small rf intensities, they contain incorrect assumptions as applied to solids at high rf power levels. The theory of Bloembergen, Purcell and Pound is based on an assumption equivalent to that of a spin temperature. It is shown that the spin state cannot be strictly described by a spin temperature because the phases of the spin quantum states are not incoherent, as required by the temperature concept. The transverse decay of the nuclear magnetization predicted by the Bloch equations is shown to be partially forbidden by energy and entropy considerations if a large rf field at the resonance frequency is continuously applied to the solid. A theory is developed which is applicable only to solids at rf magnetic field intensities well above the saturation level and which is in reasonable agreement with the experimental observations. The Hamiltonian is transformed to a coordinate system rotating at the frequency of the rf field. The resulting time-dependent parts of the spin-spin interaction are non-secular perturbations on the time-independent part, and can therefore be ignored. Statistical mechanics is applied to the remaining stationary spin Hamiltonian; specifically it is assumed that the spin system is in its most probable macrostate (a canonical distribution of quantum states) with respect to the transformed spin Hamiltonian. This assumption is justified because the transformed spin Hamiltonian is effectively time independent and the spin-lattice interaction is small, and it is analogous to assumptions basic to classical acoustics and fluid mechanics. The spin-lattice interaction merely determines the expectation value of the transformed spin Hamiltonian, which can be readily calculated under the assumption that the expectation value of the spin angular momentum of each spin is relaxed independently to its thermal equilibrium value by the lattice in time T_1. Both fast and slow modulation of the dc magnetic field can be treated. "Rotary saturation" is observed by applying an audio-frequency magnetic field to the sample in the dc field direction while observing the dispersion derivative at resonance with a large rf field H_1. When the audio-frequency approaches γH_1 the dispersion signal decreases and goes through a minimum. The effect is easily treated theoretically in solids, liquids and gases by using a rotating coordinate system, and is a rotary analogue of ordinary saturation. It is a convenient method for calibrating rf magnetic fields and appears potentially capable of providing useful information on the solid state. Experimental data on rotary saturation are presented and discussed. (Contractor's abstract)

HAR. 02:077

Harvard U. Cruft Lab., Cambridge, Mass.

INTENSITY SPECTRA AFTER HALF-WAVE DETECTION

OF SIGNALS IN NOISE. I. THEORETICAL DISCUSSION, by G. E. Fellows and D. Middleton. Feb. 20, 1955 [33 p. incl. diagrs. refs. (Technical rept. no. 217) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 66276 Unclassified

When narrow-band noise centered about a frequency f_0 and an unmodulated carrier of frequency f_0 are added and passed through a nonlinear device, the intensity spectrum of the output wave consists of zones centered about harmonics of the frequency f_0. The spectral shape and the carrier and noise power in the first six harmonic zones have been determined both theoretically and experimentally for half-wave νth-law rectifiers (ν = 1/2, 1, 2) over a wide range of input carrier-to-noise ratio. The theoretical aspects of this problem are presented in this report, along with a number of computed results. (Contractor's abstract)

HAR. 02:078

Harvard U. Cruft Lab., Cambridge, Mass.

INTENSITY SPECTRA AFTER HALF-WAVE DETECTION OF SIGNALS IN NOISE. II. EXPERIMENTAL DISCUSSION, by G. E. Fellows. Feb. 20, 1955, 1v. incl. illus. (Technical rept. no. 218) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 66277 Unclassified

This report describes the experimental measurement of the intensity spectrum at the output of a half-wave νth-law detector fed by narrow-band noise and an unmodulated carrier. Included is a discussion of the design of the analyser, based upon an analysis of expected statistical and system errors. Experimental results are presented for detectors with ν = 1/2, 1, and 2, and for a wide range of input carrier-to-noise ratio. The spectral shape, the peak intensity in the continuum, and the intensity of the carrier component are determined for the first six spectral zones in the output of the nonlinear device. The relative error is less than two per cent for almost all measurements. (Contractor's abstract)

HAR. 02:079

Harvard U. Cruft Lab., Cambridge, Mass.

THE RECTIFICATION OF LOW-DENSITY NOISE, by J. A. Mullen and D. Middleton. Mar. 1, 1955, 48p. incl. diagrs. tables, refs. (Technical rept. no. 219) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 66274 Unclassified

This report considers the rectification by a half-wave power law detector of a c-w signal in noise made of randomly occurring pulses which overlap only slightly. It is shown that for this problem, though not in general, the distributions may be approximated by a form of Edgeworth series. The mean square and correlation function of the output of the rectifier have been obtained. If the law of the detector is greater than 1, the output power is greater for low density noise than for gaussian noise of the same input power. The correlation in the output relative to gaussian noise of the same input correlation function depends on the shape of the noise pulses. Figures are presented showing the effect of signal-to-noise ratio and detector law on the correlation of the output. (Contractor's abstract)

HAR. 02:080

Harvard U. Cruft Lab., Cambridge, Mass.

CAUSALITY AND FREQUENCY-RESPONSE FUNCTIONS, by T. T. Wu. Apr. 1, 1955, 45p. incl. refs. (Technical rept. no. 223) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 66291 Unclassified

A general system is studied under the assumptions of linearity, passivity, reproducibility, and causality. Under essentially no further assumption, frequency-response functions are defined for such systems and identified with positive functions, suitably defined. Through the Lebesque decomposition theorem, any frequency-response function may be decomposed to be the sum of a minimum-reactive part and two reactive parts, one of which is of unfamiliar nature. This procedure is carried through for a system with one input-output and again for a system with multiple input-outputs. As an illustration, the result is applied to the study of the Kronig-Kramers relations. One of the relations is proved to be true under very general conditions, but not the other. (Contractor's abstract)

HAR. 02:081

Harvard U. Cruft Lab., Cambridge, Mass.

COHESIVE ENERGY OF NOBLE METALS, by K. Kambe. Apr. 5, 1955, 9p. incl. tables, refs. (Technical rept. no. 227) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 62656 Unclassified

The method, developed by Kuhn and Van Vleck, and later simplified and extended by Brooks, for calculating the cohesive energy of monovalent metals, is here further extended to include the effects of the deviation of the effective ion core potential from pure hydrogenic form in the vicinity of the surface of the s-sphere. A formula is derived for calculating the logarithmic derivative of the wave function at the surface of the s-sphere. From the logarithmic derivatives of the s- and p-functions the ground state energy and the Fermi energy can be evaluated. The method thus extended is applied to the calculation of the cohesive energy of the monovalent noble metals. For these metals, the repulsion between ion-cores is important. Combining the repulsive energy, which is calculated by Fuchs with a modified Thomas-

Fermi method, with the energy of valence electrons calculated by the present method, we obtain the total cohesive energy of copper. Since there is no calculation of the repulsive energy for silver and gold, the ion cores are assumed to be rigid and the energies of the valence electrons at the observed lattice spacings are determined and considered as the approximate total energies. The cohesive energies calculated at the observed lattice spacings with the rigid ion-core assumption are 61.7 for Cu, 55.8 for Ag, and 49.2 for Au in comparison with the experimental values of 81.2, 68.0, and 92.0 respectively. Here the energy unit is K cal/mole. (Contractor's abstract)

HAR. 02:082

Harvard U. Cruft Lab., Cambridge, Mass.

IMPEDANCE OF THIN WIRE LOOP ANTENNA, by J. E. Storer. May 1, 1955 [39]p. incl. diagrs. tables. (Technical rept. no. 212) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 69089 Unclassified

Also published in Trans. Amer. Inst. Elec. Engineers, v. 75: 606-619, July 1956.

The Hatlen integral equation for the current and impedance of a thin wire loop antenna is solved using a Fourier Series. Extensive tables of theoretical loop antenna impedances are presented which (for the one case tested) are in satisfactory agreement with experiment. Some graphical results are also given which facilitate the evaluation of the current distribution. (Contractor's abstract)

HAR. 02:083

Harvard U. Cruft Lab., Cambridge, Mass.

LOOP ANTENNA MEASUREMENTS, by P. A. Kennedy. May 1, 1955 [63]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 213) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 67832 Unclassified

Experimental measurements on three loop antenna configurations have been completed. The experimental technique for obtaining impedance and current distributions using a single-wire transmission line over an image plane is described with particular attention given to the difficulties encountered. The experimental impedance and current distributions are reproduced in graphical form and the impedances are tabulated. For loops where theoretical results are available, curves comparing theory and experiment are presented. (Contractor's abstract)

HAR. 02:084

Harvard U. Cruft Lab., Cambridge, Mass.

VARIATIONAL CALCULATIONS ON RIDGE WAVE GUIDES, by J. M. Osepchuk. May 5, 1955, 17p. incl. diagrs. table. (Technical rept. no. 224) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 66273 Unclassified

A particular trial function is presented which is useful in variational calculations of ridge guide properties. Such calculations for rectangular ridge guides are seen to agree well with earlier work by S. B. Cohn. The cutoff wavelength λc and a characteristic impedance Z_0 are calculated for the ridge guide with circular envelope. The results of λc agree well with experimental measurements. (Contractor's abstract)

HAR. 02:085

Harvard U. Cruft Lab., Cambridge, Mass.

THE MEASUREMENT OF ELECTRIC CONSTANTS AT A WAVELENGTH OF FOUR MILLIMETERS, by T. Morita, R. D. Kodis, and C. Shafer. May 25, 1955, 17p. incl. illus. diagrs. tables, refs. (Technical rept. no. 228) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 66275 Unclassified

This report deals with the extension of conventional microwave cavity techniques for measuring electrical constants to the 4 mm wavelength region of the electromagnetic spectrum. Results are presented of measurements at this frequency of (1) the conductivity of machined silver and (2) the dielectric constant of polystyrene. The theoretical basis for the measurements is developed, and an estimate is made of the accuracy of the results. (Contractor's abstract)

HAR. 02:086

Harvard U. Cruft Lab., Cambridge, Mass.

CHARACTERISTICS OF SPORADIC-E IONIZATION AT MIDDLE LATITUDE, by D. Davidson. June 15, 1955, 90p. incl. illus. diagrs. tables, refs. (Technical rept. no. 230) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 80003 Unclassified

Operation of a system of triangulating pulse-sounding stations for 3 yr during the declining phase of the sunspot cycle showed that clouds of ionization which display apparent movement occur very infrequently in the E region and are confined to periods of elevated geomagnetic activity. Speeds between 400 and 1000 km/hr were observed, and the favored motion appeared as an approach from an east-northeasterly direction. The clouds occurred primarily about midnight local time.

Vertical motion of ionization was observed, but with less frequency than the other clouds of ionization. The predominant form of sporadic-E ionization was marked by multiple reflections from a thin layer in the 100- to 120-km region. Comparison of the records of 3 stations indicated that this layer is distributed over a wide geographical area. An inverse correlation exists between the occurrence of sporadic-E ionization and the sunspot number; this correlation is best during Oct. through Dec., is fair during the summer months, and is practically absent around the equinoxes. An improved correlation is obtained if the square of the F2-layer critical frequency is used instead of the sunspot number. (ASTIA abstract)

HAR. 02:087

Harvard U. Cruft Lab., Cambridge, Mass.

SEQUENTIAL DETECTION OF SIGNALS IN NOISE, by J. [J.] Bueegang and D. Middleton. Aug. 31, 1955 [101]p. incl. illus. refs. (Technical rept. no. 175) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 88055 Unclassified

The sequential test and the sequential method of analysis which were devised by A. Wald (Sequential Analysis, John Wiley, N. Y., 1947) are applied to the problems of detecting signals in noise. Sequential detection is discussed within the framework of the general statistical decision theory. The role of a priori information is examined. The following special examples are studied which are frequently encountered in communication problems: the incoherent detection of a sine wave in noise, coherent sequential detection of casual signals in normal noise, and the sequential detection of normal random signals in normal noise. The importance is emphasized of the correction of the square law term. The operating characteristic function of a sequential test for normal noise is independent of the correlation matrix, the specified signal waveform, and the number of observations. The treatment of correlated samples and its application to continuous processes is illustrated on RC-filtered noise. Detection can be performed in an arbitrarily short time in sequential detection of variation with a Gaussian random signal and noise. The saving in the minimum detectable signal level caused by sequential operation is discussed. Exact expressions for the error probabilities which result from truncation of the sequential processes are derived and compared with the original approximations of Wald. Distribution functions of the sample size are considered. Symmetry properties of the distributions are obtained for the case where the random variable is normally distributed. (ASTIA abstract)

HAR. 02:088

Harvard U. Cruft Lab., Cambridge, Mass.

OPTIMUM DECISION SYSTEMS FOR THE RECEPTION OF SIGNALS IN NOISE: PART I, by D. Van Meter and D. Middleton. Oct. 5, 1955 [77]p. incl. illus. table, refs. (Technical rept. no. 215) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 92755 Unclassified

Also published in part in Jour. Soc. Indus. and Appl. Math., v. 3: 192-253, Dec. 1955. (Title The Deception and Extraction of Signals in Noise from the Viewpoint of Statistical Decision Theory)

The techniques of the decision theory of A. Wald (Statistical Decision Functions, Wiley, N. Y., 1950) are used in the design of detection and extraction systems. A general criterion is supplied for the solution of any statistical-inference problem which calls for a decision. Desirable properties are demonstrated of solutions based on the criterion. Reception is discussed as statistical inference. The formulation of reception problems is treated in general terms as a decision problem. The reception situation is analyzed to determine what system inputs are possible and what decisions are required. A loss is assigned to each possible combination of input and decision in accordance with the constraints of the problem. Bayes and Minimax decision rules for average and conditional loss ratings are discussed. The general properties are described of optimum decision rules. Detection systems are presented that minimize average risk. Risk theory is applied to the general binary detection problem. Fixed sample size or nonsequential decision rules alone are considered. The Bayes system is a generalized likelihood-ratio detector when the preliminary cost assignment is such that the signals are weighted according to the class of input which they represent (null, alternative, or overlapping class), except when the hypothesis classes overlap. The use of decision curves which relate the Bayes risk to signal amplitude is discussed as an aid to defining the detectable signal of a detection system. (ASTIA abstract)

HAR. 02:089

Harvard U. Cruft Lab., Cambridge, Mass.

STATIONARY FORMS FOR THE SCATTERING CROSS SECTION OF AN OBSTACLE, by I. Stakgold. Oct. 10, 1955, 11p. (Technical rept. no. 231) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-7601) AD 80717 Unclassified

Two new stationary forms for the scattering cross section of an obstacle are presented. These forms involve the field everywhere in space, whereas the Schwinger-Levine principle uses only the current on the obstacle. The advantage of the new forms is the simplification in integration (the Green's function is absent); the disadvantage is that trial fields are three-dimensional instead of two-dimensional, thereby requiring more guessing in the trial functions. These new stationary principles are derived by analogy with the capacity problem. After these principles have been surmised, it is easy to show by direct computation that they are actually stationary. (Contractor's abstract)

HAR. 02:090 - HAR. 02:093

HAR. 02:090

Harvard U. Cruft Lab., Cambridge, Mass.

BIASED LINEAR AND QUADRATIC DETECTION OF SIGNALS IN NOISE, by G. E. Fellows. Oct. 25, 1955 [12]p. incl. diagrs. (Technical rept. no. 229) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 89314 Unclassified

Experimental results are presented for the cases of biased linear and quadratic detectors. The noise power and the carrier power in each of the first 6 spectral zones were measured over a wide range of bias and input carrier-to-noise ratio. For a given output zone, the curves of carrier power vs bias have the same general form as the curves of noise power vs bias. As a result, the zonal carrier component power-to-noise power ratio p_1 is not a sensitive function of the bias. Values of bias exist for which the carrier component in a given zone disappears (for a given value of p). No corresponding bias values exist which enhance the ratio p_1 significantly over its value for zero bias. For biased linear and quadratic detectors, it is not possible to obtain values of p_1 for $1 > 1$ which exceed, or approach, p_1 for a given input carrier-to-noise power ratio p. (ASTIA abstract)

HAR. 02:091

Harvard U. Cruft Lab., Cambridge, Mass.

OPTIMUM DECISION SYSTEMS FOR THE RECEPTION OF SIGNALS IN NOISE: PART II, by D. Van Meter. Oct. 25, 1955 [54]p. incl. illus. refs. (Technical rept. no. 216) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 90935; PB 104046 Unclassified

Also published in part in Jour. Soc. Indus. and Appl. Math., v. 4: 86-119, June 1956. (Title The Deception and Extraction of Signals in Noise from the Viewpoint of Statistical Decision Theory)

Statistical decision theory is applied to extraction problems. Discussions are presented of extraction systems that minimize average risk and on information loss as a criterion for optimum detection and extraction. The classical maximum likelihood estimate maximizes the probability of a correct decision. It is a Bayes estimate either (1) when unit loss is assigned to every incorrect decision and zero loss to a correct one or (2) when the loss is proportional to the square of the decision error and the joint distribution of signal and noise has a certain symmetry. The general characterization of Bayes estimates for the squared error-loss function is discussed. Specific cases are examined of (1) coherent and incoherent extraction with Gaussian and Rayleigh statistics and (2) Minimax extraction with additive signal and noise. The relevance of optimum predetection filters to extraction is indicated. Optimum smoothing and prediction of structurally determinate and indeterminate signals is treated; previously known results are exhibited as special cases of the general solutions. Sufficient statistics and their relation to information loss are discussed. The information measure of Shannon (Bell System Tech. Jour., v. 27: 397, 623, 1948) and is compared with that of Fisher (Proc. Cambridge Phil. Soc., v. 22: 700, 1925). Optimum detectors for the information loss function are also likelihood ratio detectors. Universal curves are given for determining the optimum detection threshold. The general condition under which an estimate minimizes information loss is satisfied by a sufficient statistic. (ASTIA abstract)

HAR. 02:092

Harvard U. Cruft Lab., Cambridge, Mass.

TABLES FOR THE CALCULATION OF COULOMB WAVE FUNCTIONS, by F. S. Ham. Nov. 5, 1955, 84p. incl. illus. tables, refs. (Technical rept. no. 204) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 83437 Unclassified

Tables of the coefficients in the series expansions of Coulomb wave functions in powers of the energy $\varepsilon = -1/n^2$ are given, and the theory of these expansions is reviewed and extended. It is shown that the series used by Kuhn to calculate the irregular Coulomb function (Quart. Appl. Math., v. 9: 1, 1951) diverges but represents this function asymptotically in the limit $|n| \to \infty$, $|\arg(n)| \leq \pi - \Delta < \pi$. A convergent series is derived which may be used to calculate this function to greater accuracy than is possible with the asymptotic series. The coefficients in the series for both the regular and irregular functions and their derivative with respect to the radial parameter z are tabulated for $L = 0$, $z = 3.5(0.1)7.5$. Coefficients in both the asymptotic and convergent series for the irregular function are given, together with tables of a function $G_n(0, n)$, needed in calculating the irregular function $(z/2)N_1^n(z)$ from the convergent irregular series. Tables of the coefficients for the regular function and its z-derivative for $L = 8$ are also given for the same range of z. Related tables of an appropriate power of $(z/2)$ times the series coefficients for both $L = 0$ and $L = 8$ are given which make possible interpolation in z. Recurrence relations given by Infeld are put in a form suitable for use in calculating the functions of $0 \leq L \leq 8$ from functions of $L = 0$ or 8 obtained from these tables. The present tables extend those given by Kuhn and correct several errors in his tables. Both sets of tables make possible the calculation of Coulomb functions for an attractive Coulomb potential only. (Contractor's abstract)

HAR. 02:093

Harvard U. Cruft Lab., Cambridge, Mass.

ELECTROMAGNETIC RADIATION OVER AND INTO AN IMPERFECT DIELECTRIC, by S. Stein. Dec. 1, 1955, 1v. incl. illus. tables, refs. (Technical rept. no. 226) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research]

under N5ori-7601) AD 105487 Unclassified

The electromagnetic fields are studied in relation to a vertical electric point dipole source located above a horizontal plane interface between two distinct but individually homogeneous media. A general saddle-point method of evaluation of the resulting integrals is used, leading to asymptotic (far-zone) results. Specific formulas are derived for the case where both media are "imperfect dielectrics" subject only to the lower medium being electrically denser, and computational results are presented for the specific case where the upper medium is air. Various ranges of the material parameters are considered and the corresponding changes in the character of the wave complex are shown to be related mathematically to the behavior of the singularities of the integrands. The transition to well-known limiting cases is also described. (Contractor's abstract)

HAR. 02:094

Harvard U. Cruft Lab., Cambridge, Mass.

DIURNAL ROTATION OF THE IONOSPHERE, by K. Toman. Dec. 5, 1955 [9]p. incl. illus. diagrs. table. (Technical rept. no. 233) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601 and -7628) AD 88056 Unclassified

Ionospheric transmission-delay irregularities were recorded at Concord, Gloucester, and Sandwich, Mass. from 2 simultaneous oblique transmissions (with baselines of about 61 and 109 km) and 1 vertical transmission from Concord. The receiving arrangement was previously used by Toman (Jour. Geophys. Research, v. 60: 57, 1955). The F-region transmission-delay records from 0600 to 1600 EST on Oct. 24, 1952 were sampled from minute to minute. Two-hour correlation periods which overlapped by 1 hr were chosen and correlation coefficients (r) were obtained for variable time lags between records. The time displacements with maximum r's between the F-region traces of the Concord to Gloucester and Concord to Sandwich transmissions were evaluated and the direction and speed of movement were deduced. Straight frontal irregularities within the reflecting region were assumed which move perpendicularly to their orientation. The mean direction of movement, mean speed of movement, and maximum values of r are tabulated. Plots are given of the diurnal variation of the mean direction and mean speed of the movement of the ionosphere. The mean values of r diminished as the day advanced. The over-all movement was a clockwise rotation from about 85° to 220° east of north between 0800 and 1500 EST. The speed behavior suggests a transition from observed irregularities in the F-region reflection level to those in the E-region retardation level. The mean speed (expressed in km/hr) decreased until the 0800- to 1000-hr interval, increased until noon, decreased, and increased starting in the 1300- to 1500-hr interval. (ASTIA abstract)

HAR. 02:095

Harvard U. Cruft Lab., Cambridge, Mass.

FIELD EMISSION FROM GERMANIUM IN A MUELLER FIELD EMISSION MICROSCOPE, by F. G. Allen. Dec. 5, 1955 [32]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 237) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 91606 Unclassified

Attempts were made to use single-crystal Ge tips as emitters in studying the work function, its variation with crystal direction, and gas contamination processes on a clean Ge surface. One end of a small rod of Ge 0.030 in. square in cross section and cut with a (110) axis was turned to a tapered conical tip with emery paper. The tip was etched electrolytically in a CF-4 solution (25 cc concentrated HNO_3, 15 cc glacial HAc, 15 cc concentrated HF, and several drops of Br). Electron-microscope profiles were taken at 3500X and 7000X magnification by an MIT-built microscope similar to the RCA-type UMT. Magnification was computed for each tip from the image size of a fine 0.0003-in.-diam W wire. Field emission-producing visible spots on the fluorescent screen was obtained with all the Ge tips at initial anode voltages of 1500 to 10,000 v. Scatter in the data was caused by a slight instability of the emitting surface. Electron microscope profiles of the tips after field-emission use and cleaning by A bombardment revealed that bombardment, when excessive, can sputter away the entire tip. Field emission was obtained from intrinsic and n- and p-type Ge tips. Results are summarized with respect to the effect of applied field on energy levels at the surface for no surface states; modifications introduced by surface states; field strength at tips for emission; the effect of the penetration of field into surface on the field strength at the tip; the effects of finite emission densities; field strengths required for Ge field emission; the slope of the field-emission curve and the absolute value of the work function; and reasons for failures to obtain good emission patterns. (ASTIA abstract)

HAR. 02:096

Harvard U. Cruft Lab., Cambridge, Mass.

GERMANIUM SURFACE POTENTIAL STUDIES AT HIGH VACUUM, by F. G. Allen. Dec. 15, 1955, 73p. incl. illus. diagrs. tables, refs. (Technical rept. no. 236) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 91809 Unclassified

In this study, the following subjects are discussed: I. Dependence of the work function ϕ on crystal face orientation. (a) Previous results with metals; (b) variation of the work function with crystal face orientation for germanium; and (c) an attempt to measure the work function variation with face orientation on a single nickel crystal. II. Variation of the work function of germanium with temperature and doping. (a) Theoretical predictions for

HAR. 02:097 - HAR. 02:101

the simple surface model; (b) previous experimental evidence; (c) experimental methods used; (d) results of observations on variation of germanium work function with temperature; (e) results on the variation of germanium work function with doping; and (f) absolute value of the work function for germanium. III. Photovoltage at a free semiconductor surface. (a) Apparatus and techniques used in change in contact potential with light $(\Delta CP)_L$ measurements; and (b) results of $(\Delta CP)_L$ measurements in germanium. IV. Some observations on the changes in contact potential of germanium surfaces produced by gas contamination. Appendixes present the correction for the thermoelectric voltage in CPD (contact potential difference) circuit and the applicability of the Schottky exhaustion layer theory to a sample.

HAR. 02:097

Harvard U. Cruft Lab., Cambridge, Mass.

SOME NOTES ON HIGH-VACUUM APPARATUS AND TECHNIQUES, by F. G. Allen. Dec. 15, 1955 [17]p. incl. illus. diagrs. (Technical rept. no. 238) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 91810 Unclassified

Some of the apparatus and techniques used in the high-vacuum studies on single crystal germanium surfaces are described. A schematic diagram and a photograph of the apparatus are presented. The combination of 2 mercury diffusion pumps, patterned after a design of W. B. Nottingham (Massachusetts Inst. of Tech.), utilizes a divergent jet to produce the high vacuum (5×10^{-10} mm Hg or less) and a convergent jet to serve as its backing pump. Pumping speed is 5 to 10 l/sec. In addition observations are presented on the rate of deposition of gas contamination on a tungsten-surface in a high vacuum, on the use of argon-ion bombardments for cleaning germanium surfaces, and on the application of a conducting-transparent coating for the pyrex vacuum apparatus.

HAR. 02:098

Harvard U. Cruft Lab., Cambridge, Mass.

ON THE DYNAMIC TEMPERATURE RESPONSE OF A VACUUM CALORIMETER, by J. S. Kouvel. [1955] [4]p. incl. diagrs. table, refs. (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-7601) Unclassified

Published in Jour. Appl. Phys., v. 27: 639-642, June 1956.

A simple graphical method is described for computing the heat capacity of a specimen in a vacuum calorimeter system from the temperature response in the after-heating period. The applicability of this method when there are appreciable time lags due to thermal gradients in the specimen or due to the characteristics of a galvanometer, is discussed. (Contractor's abstract)

HAR. 02:099

Harvard U. [Cruft Lab.] Cambridge, Mass.

NUCLEAR SPIN-LATTICE RELAXATION TIME IN COPPER AND ALUMINUM, by A. G. Redfield. [1956] [2]p. incl. diagr. refs. (Sponsored jointly by Office of Naval Research [Signal Corps, and Air Force Office of Scientific Research] under N5ori-7601) Unclassified

Published in Phys. Rev., v. 101: 67-68, Jan. 1, 1956.

Nuclear spin-lattice relaxation times of Al^{27} in pure Al and Cu^{63} in annealed pure Cu have been measured at 2 and 4.2°K, using the adiabatic fast-passage technique suggested by L. E. Drain. At 4.2°K, $T_1 = 260 \pm 100$ milliseconds for copper and 370 ± 40 milliseconds for aluminum. The relaxation time is apparently inversely proportional to temperature, as predicted by Korringa, from 2 to 300°K. (Contractor's abstract)

HAR. 02:100

Harvard U. Cruft Lab., Cambridge, Mass.

A HIGH-SENSITIVITY PARAMAGNETIC RESONANCE SPECTROMETER, by R. H. Silsbee. Jan. 5, 1956 [26]p. incl. diagrs. refs. (Technical rept. no. 221) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 90931 Unclassified

A paramagnetic resonance spectrometer capable of detecting the order of 10^{12} spins at room temperature with a line width of one gauss is described. The report includes a description of the principles of operation of the spectrometer, details of its construction, and notes on auxiliary equipment used in conjunction with the spectrometer. (Contractor's abstract)

HAR. 02:101

Harvard U. Cruft Lab., Cambridge, Mass.

COMPLEMENTARY LOOP ANTENNAS, by T. Kaliszewski. Feb. 1, 1956 [20]p. incl. illus. diagrs. tables. (Technical rept. no. 241) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 103263 Unclassified

Measurements of the transverse electric field distribution and of the driving-point impedance have been performed on a set of complementary (slot) circular and square loops at a wavelength of ten centimeters. It has been established that the transverse field distribution on both the circular and square loops approximates that of

the current on a uniform, short-circuited transmission lins of comparable slectrical length. Application of Babinet's principle to the complementary impedance msasured here permits direct comparison with the thsory and alternativs image-plane measurements carried out on the conventional wire loops of idsntical size. Such a comparison shows excellent agrsement but only between the real components of the driving-point impedance. The unbalance inherent in the used msthod of measurements and the end-sffect which could not be estimated here are believed to account for the discrepancies observed between the imaginary componsnts. It is suggested that the use of the so called twin-slot transmission line, for ths purpose of impedancs measursmsnt, may result in slimination of the above difficulties. (Contractor's abstract)

HAR. 02:102

Harvard U. Cruft Lab., Cambridgs, Mass.

AN EXPANSION OF THE KUMMER FUNCTION $_1F_1(\alpha; \frac{1}{2}; \beta x^2)$, by G. Kent. Mar. 5, 1956, 5p. (Technical repl. no. 234) (Sponsored joinly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601) AD 92752

Unclassified

An expansion of ihe Kummer function, $_1F_1(\alpha; \frac{1}{2}; \beta x^2)$, is given in terms of elemenlary functions. The first 4 lerms of this expansion are

$$\cosh kx + \left(\frac{\beta x^2}{2}\right)\left\{\cosh kx - \frac{\sinh kx}{kh}\right\}$$

$$+ \frac{1}{2!}\left(\frac{\beta x^2}{2}\right)^2\left\{\left[1 - \frac{1}{(kx)^2}\right]\cosh kx - \left[\frac{2}{3} - \frac{1}{(kx)^2}\right]\frac{\sinh kx}{kx}\right\} + \frac{1}{3!}\left(\frac{\beta x^2}{2}\right)^3\left\{\left[1 - \frac{7}{(kx)^2} - \frac{15}{(kx)^4}\right]\cosh kx + \left[1 + \frac{12}{(kx)^2} + \frac{15}{(kx)^4}\right]\frac{\sinh kx}{kx}\right\} + O(\beta^4),$$ where $k^2 = 4\alpha\beta$. The terms in the $\{\ \}$ brackets vanish uniformly as $x \longrightarrow 0$. For small values of x, these lerms, in the order given in the expansion, approach the forms $\frac{2}{3}(kx)^2$, $\frac{7}{18}(kx)^2$, and $\frac{107}{120}(kx)^2$ so that in the neighborhood of the origin the approximation is very good. (ASTIA abstract)

HAR. 02:103

Harvard U. Cruft Lab., Cambridge, Mass.

THE HALL EFFECT IN FERROMAGNETIC METALS AND SEMICONDUCTORS, by J. M. Lavine. Mar. 10, 1956, iv. incl. illus. diagrs. tables, refs. (Technical repl. no. 225) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-7601) AD 93442

Unclassified

Hall measurements on Ni wsre made between room temperature and 568°C using an a-c measurement technique. The ordinary Hall coefficient of Ni is roughly constant between room temperature and 300°C. The data suggest that the extraordinary Hall effect persists into the paramagnetic region. The strong temperature dependsncs of the observed effect does not exhibit a temperature dependsncs similar to the susceptibility and hence thsre is ambiguity in the dstsrmination of the ordinary Hall coefficient above the Curie tsmperature. Hall measurements on a 70 Ni - 30 Cu alloy also suggest the presence of the extraordinary Hall sffect above the Curie temperature, but in this alloy, ths observed effect possesses a $1/T-\theta$ temperaturs dependence. The ordinary Hall coefficient of the 70 Ni - 30 Cu alloy is smaller in absolute value above the Curis temperature than at liquid air tsmperaturs. These data are discussed using Pugh's two-band and four-band models. Hall measurements at room temperaturs were made on a synthetic crystal of Fe_3O_4 and on a synthetic single crystal of $(NiO)_{75}(FeO)_{25}(Fe_2O_3)$. The ordinary Hall measursment on Fe_3O_4 suggests that ths number of conduction electrons at room temperature is large, in rough agreemsnt with Vsrwey's hypothesis. The ordinary Hall coefficient of $(NiO)_{.75}(FeO)_{.25}(Fs_2O_3)$ also suggesis a largs carrier concentration. Ths conductivities of $(NiO)_{.75}(FeO)_{.25}(Fe_2O_3)$ and of a synthetic single crystal of $(NiO)_{.56}(ZnO)_{.14}(FeO)_{.30}(Fe_2O_3)$ are compared with the conductivity of Fe_3O_4 employing a simple model for the mobility and associating the activation energy obtained from resistivity data with the number of conduction slecirons. The observed datc are in good agreement with the simpls modsl. Extraordinary Hall measuremsnts wsre made on Grade A Ni(99.4 Ni), 499 Alloy (99.9 Ni), and R-63 Alloy (95 Ni, 4 Mn, 1 Si) between liquid air temperature and their Curie tsmperaiures, and on the 80 per cent Ni-Fe alloys, Supermalloy, Mumetal, and Carpenter Hymu 80 between liquid air temperaturs and room temperaturs. The extraordinary Hall coefficients of these materials do not generally exhibit the resistivity dependence predicted by Karplus-Luttinger theory, but they do suggest thai ihe essential features of the theory are probably correci. The extraordinary Hall coefficienis of Fe_3O_4 and $(NiO)_{.75}(FeO)_{.25}(Fe_2O_3)$ between - 100° and their Curie tsmperaiures indicate no resistivity dependence, and their magnitude, temperaiure dependence, and sign reversal have not beeu explained. Auxiliary measuremenis of resistivity as a function of tsmperaiure, for all samples, and the thermoelectric power of Fe_3O_4 against Cu are also reported. (Contractor's absiract)

HAR. 02:104

Harvard U. Cruft Lab., Cambridge, Mass.

FERROMAGNETIC RESONANCE ABSORPTION IN A NICKEL SINGLE CRYSTAL AT LOW TEMPERATURES, by K. H. Reich. Mar. 15, 1956, 4p. incl. table, refs. (Technical repl. no. 244) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-7601;

HAR. 03:001 - HAR. 03:004

continued by Nonr-186616) AD 98094 Unclassified

The g-value and line width of the ferromagnetic resonance in nickel is found to be the same at 4°K as at room temperature. A small effect due to inhomogeneous magnetization in the skin depth, predicted by Kittel and Herring, has been observed. Values for the anisotropy constants at 4.2°K are $K_1 = -8.3 \times 10^5$ ergs/cm^3, $K_2 = -1.4 \times 10^5$ ergs/cm^3. (Contractor's abstract)

HAR. 03:001

Harvard U. Cruft Lab., Cambridge, Mass.

NUCLEAR INDUCTION SPECTROMETER FOR USE AT HIGH rf INTENSITIES AND LOW TEMPERATURES, by A. G. Redfield. Apr. 1956 [3]p. incl. illus. (Technical rept. no. 239) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [Nonr-186616]; continuation of N5ort-7601 and -7628) AD 101010 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 230-232, Apr. 1956.

A nuclear induction spectrometer for the measurement of short relaxation times and the study of saturation and related phenomena is described. Radio-frequency intensities of up to 10 gauss are attainable from four to ten megacycles. Novel features of the apparatus are an rf head for use in a liquid helium cryostat, transmitter output level stabilization circuit, and a calibration circuit for comparing the intensity of the absorption at different rf levels. (Contractor's abstract)

HAR. 03:002

Harvard U. Cruft Lab., Cambridge, Mass.

THE ELECTROLYTIC TANK: DESIGN AND APPLICATIONS, by P. A. Kennedy and G. Kent. May 1, 1956 [48]p. incl. illus. diagrs. (Technical rept. no. 214) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 98096 Unclassified

The theory of the electrolytic tank analogue as a device for the solution of potential problems is reviewed, and some of the more important applications are discussed. The mechanical requirements of an electrolytic tank design are stated. A description of the Harvard tank is given, indicating how these problems were met. The figure of mechanical uncertainty for the Harvard tank is estimated to be .01 inch. A discussion of experimental error in tank measurements covers problems of electrode and electrolyte materials as well as difficulties resulting from surface tension. Control experiments for determining the accuracy of level and tilted tank measurements are described, and the results presented. Although high accuracy is possible in the level tank, only great care can produce results in the tilted tank which are reliable to within three per cent. (Contractor's abstract)

HAR. 03:003

Harvard U. Cruft Lab., Cambridge, Mass.

ON HIGH ENERGY POTENTIAL SCATTERING I, by T. T. Wu. May 10, 1956, 12p. (Technical rept. no. 246) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 98092 Unclassified

Asymptotically in the limit of high energies, successive approximations are obtained for the problem of potential scattering where the total phase shift through the potential is not small. Only the Schrodinger wave equation is treated. The method consists of first applying the stationary-phase approximation to the integral equation and then solving the resulting equation by iteration. (Contractor's abstract)

HAR. 03:004

Harvard U. Cruft Lab., Cambridge, Mass.

HIGH-FREQUENCY SCATTERING, by T. T. Wu. May 25, 1956 [49]p. incl. diagrs. refs. (Technical rept. no. 232) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 98093 Unclassified

Also published in Phys. Rev., v. 104: 1201-1212, Dec. 1, 1956.

In recent years, there has been a revival of interest in the phenomena of scattering at high frequencies. The simplest problems of this sort are treated here, where the obstacle is either a circular cylinder or a sphere. The treatment is limited to the total scattering cross sections, even though the method is by no means restricted in this way. The specific problems treated here include the scattering of a plane electromagnetic wave by a perfectly conducting circular cylinder (two possible polarizations) or a perfectly conducting sphere, the acoustic scattering by a rigid sphere, and the quantum-mechanical scattering by an impenetrable sphere. By considering the creeping waves as defined on the universal covering space, the scattering cross sections of a circular cylinder may be expressed by asymptotic expansions for vanishingly small wavelengths. Analogous calculations yield the corresponding results for a sphere. It turns out, as expected, that the resulting expressions are accurate even for fairly large wavelengths. The numerical results are summarized in Section 7. In conclusion, the application of the method to the determination of the approximate current distribution on the obstacle is considered briefly; also some generalizations about the scattering cross section are conjectured. (Contractor's abstract)

HAR. 03:005

Harvard U. Cruft Lab., Cambridge, Mass.

ON THE THEORY OF RELAXATION PROCESSES, by A. G. Redfield. June 25, 1956, rev. Aug. 17, 1956 [13]p. refs. (Technical rept. no. 240) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [Nonr-186616]) AD 120545 Unclassified

Also published in IBM Jour. Research and Development, v. 1, 19-31, Jan. 1957.

A general procedure is given for finding the equation of motion of the density matrix of a system in contact with a thermal bath, as for example a nuclear spin system weakly coupled to a crystal lattice. The thermal bath is treated both classically and quantum mechanically, and the theory is similar to, and a generalization of, conventional theories of time proportional transition probabilities. Relaxation of the system by the thermal bath is expressed by a linear matrix operator, and it is stressed that elements of this operator can be regarded as secular or nonsecular perturbations on the equation of motion and can be treated accordingly. When the motion of the system is slow compared to that of the thermal bath, the equation of motion can be expressed in an operator form which is independent of representation. If the system has a time-dependent Hamiltonian which varies slowly compared to the motion of the thermal bath, the same equation of motion is obeyed and the system is relaxed by the bath toward a Boltzmann distribution with respect to its instantaneous Hamiltonian. If the time variation of the Hamiltonian is more rapid, higher order corrections to the equation of motion must be applied. The theory is applied to spin-lattice relaxation of a coupled nuclear spin system in a metal, for arbitrary externally applied fixed magnetic field. (Contractor's abstract)

HAR. 03:006

Harvard U. [Cruft Lab.] Cambridge, Mass.

SPECIFIC HEAT OF A MAGNETITE CRYSTAL AT LIQUID HELIUM TEMPERATURES, by J. S. Kouvel. [1956] [2]p. incl. diagr. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [Nonr-186616]) Unclassified

Published in Phys. Rev., v. 102: 1489-1490, June 15, 1956.

The heat capacity of a large natural crystal of magnetite was measured between 1.8 and 4.2°K. The specific heat, as a function of temperature, is resolved into two parts: a T^3 term that presumably is the lattice heat, and a $T^{3/2}$ term that may be identified as a spin-wave contribution to the specific heat. (Contractor's abstract)

HAR. 03:007

Harvard U. Cruft Lab., Cambridge, Mass.

THE APPROXIMATE PARAMETERS OF SLOT LINES AND THEIR COMPLEMENT, by G. H. Owyang and T. T. Wu. July 5, 1956, 20p. incl. diagrs. (Technical rept. no. 247) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 116143 Unclassified

An approximate attenuation coefficient due to ohmic loss is derived for both parallel slots and parallel strip lines. The capacitance per unit length, as well as the inductance per unit length of the lines are also obtained. The properties of a transmission line immersed in a lossless dielectric are thus completely determined. The attenuation coefficient due to lossy dielectric may be approximated by similar procedure. (Contractor's abstract)

HAR. 03:008

Harvard U. Cruft Lab., Cambridge, Mass.

PROPOSAL FOR A NEW TYPE SOLID-STATE MASER, by N. Bloembergen. July 5, 1956, 4p. incl. refs. (Technical rept. no. 254) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under Nonr-186616) AD 118573 Unclassified

Also published in Phys. Rev., v. 104: 324-327, Oct. 15, 1956.

The Overhauser effect may be used in the spin multiplet of certain paramagnetic ions to obtain a negative absorption or stimulated emission at microwave frequencies. The use of nickel fluosilicate or gadolinium ethyl sulfate at liquid helium temperature is suggested to obtain a low noise microwave amplifier or frequency converter. The operation of a solid state maser based on this principle is discussed. (Contractor's abstract)

HAR. 03:009

Harvard U. Cruft Lab., Cambridge, Mass.

THE DEPENDENCE OF THE PURE QUADRUPOLE RESONANCE FREQUENCY ON PRESSURE AND TEMPERATURE, by T. Kushida, G. B. Benedek, and N. Bloembergen. Aug. 10, 1956 [48]p. incl. diagrs. tables, refs. (Technical rept. no. 250) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 108262 Unclassified

Also published in Phys. Rev., v. 104: 1364-1377, Dec. 1, 1956.

Measurements of the pure quadrupole resonance frequency (ν) of the Cu^{63} nucleus in cuprous oxide, and the

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Cl^{35} nucleus tn potassium chlorate and paradichlorobenzene have been made as a function of pressure in the range 1 to 10,000 kg/cm^2 for temperatures between -77°C and 100°C. A theory is presented in which the static value of the electric field gradient tensor (ϕ^o_{ij}) and the amplitudes ξ^o_t of the normal modes of the lattice vibrations play a central role. The volume dependence of these quantities can be deduced from v-versus-v volume isotherms which are constructed from the experimental data by using the equation of state. Information on the latter is augmented by theory. It ts found that the temperature variation of the resonance frequency at atmospheric pressure can be understood by considering not only the explictt temperature dependence of the vibration amplitudes, but also by including the appreciable effects of the volume expansion on q_o and ξ^o_t. Furthermore, the pressure dependence is found to be explicable tn terms of the volume dependence of q_o and ξ^o_t. In Cu_2O, tt ts found that q_o depends on volume roughly as V^{-1}, thereby indicating an ionic character for this crystal. On the other hand, in paradichlorobenzene, $q_o \propto V^n$, with $0 < n < .04$, thus exhibiting the effect of an increase tn the intermolecular hybridization of the C-Cl covalent bond. (Contractor's abstract)

HAR. 03:010

Harvard U. Cruft Lab., Cambridge, Mass.

SPIN RELAXATION PROCESSES IN A TWO-PROTON SYSTEM, by N. Bloembergen. Aug. 10, 1956, 19p. incl. refs. (Technical rept. no. 249) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 108888 Unclassified

Also published in Phys. Rev., v. 104: 1542-1547, Dec. 15, 1956.

The general theory of nuclear spin relaxation, based on the Boltzmann transport equation for the density matrix, is applied to the very simple, non-trivial system of two identical spins I = 1/2. A proton pair undergoing hindered rotation around one axis shows a resolvable doublet. The relaxation processes in this doublet are investigated. Explicit formulae for the longitudinal and transverse relaxation times are derived, which display a dependence on the angles of the axis of rotation with the external magnetic field and the radius vector. Experimental evidence for this dependence is discussed. General expressions for the Overhauser and saturation effects with two applied radiofrequency fields are given, which may also be applied to a magnetic ion or nucleus with I > 1 and crystalline field splitting. (Contractor's abstract)

HAR. 03:011

Harvard U. Cruft Lab., Cambridge, Mass.

F-BAND OSCILLATOR STRENGTH DETERMINATION IN NaCl AND KCl, by R. H. Silsbee. Sept. 1956 [7] p. incl. diagrs. table, refs. (Technical rept. no. 252) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [Nonr-186616]) AD 115935 Unclassified

Also published in Phys. Rev., v. 103: 1675-1681, Sept. 15, 1956.

The F-band oscillator strengths tn an x-irradiated NaCl crystal and an x-irradiated and an additively colored KCl crystal have been determined by a new method. The density of centers ts determined by measuring the intensity of the paramagnetic resonance of the centers. Expressing the results in the usual way, using Smakuta's equation, gives f = 0.87 for NaCl and f = 0.85 for KCl. Some of the assumptions involved in the use of Smakula's equation are criticized. (Contractor's abstract)

HAR. 03:012

Harvard U. Cruft Lab., Cambridge, Mass.

THEORY OF THE MICROSTRIP, by T. T. Wu. Oct. 10, 1956, 7p. incl. diagrs. (Technical rept. no. 248) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 118572 Unclassified

An iterative procedure is proposed for finding the current distribution, and thus the electromagnetic field, of the lowest mode of the microstrip transmission line. This line consists of a thin metallic strip pasted on a dielectric layer which is in turn a coating on a ground plane. Each iteration involves solving 2 electrostatic problems. Exact coupled integral equations are set up for the 2 components of the current density, and approximations are made tn their kernels. The analysis is not rigorus, but it is valid if the strip is not too wide and the dielectric sheet not too thick. (ASTIA abstract)

HAR. 03:013

Harvard U. Cruft Lab., Cambridge, Mass.

A PRECISE NUCLEAR RESONANCE THERMOMETER, by G. B. Benedek and T. Kushida. Nov. 5, 1956, 8p. incl. diagrs. refs. (Technical rept. no. 253) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-186616) AD 118571 Unclassified

Also published in Rev. Scient. Instruments, v. 28: 92-95, Feb. 1957.

The properties of a thermometer based upon the temperature variation of the pure quadrupole resonance frequency (ν_0) of the Cl^{35} nucleus in granular $KClO_3$ has been investigated. In the range ~10°K < T < 300° K, the thermometer has a very high sensitivity, being better than ± 0.002° at 273°K and ± 0.004° at 77°K. The accuracy at 20°K is estimated as at least ± 0.02° The thermometer is exactly reproducible if care is taken that the $KClO_3$ is of high chemical purity. No

hysteresis effects were observed. Establishment of the thermometer requires a single precise determination of v_0 vs temperature curve using the fundamental temperature standards to measure the temperature. (Contractor's abstract)

HAR. 04:001

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON APPROXIMATION BY RATIONAL FUNCTIONS AND BY BOUNDED ANALYTIC FUNCTIONS, by J. L. Walsh. Sept. 1955, 17p. ([AF]OSR-TN-54-340) (AF 18(600)-998) AD 73278) Unclassified

Also published in Ann. Math. Pura Appl., v. 39: 267-277, 1955.

A series of interpolation is defined and studied which is a natural generalization of Taylor's series and which concerns a relatively general kind of multiply-connected region. A conformal transformation is used to obtain results on approximation in an arbitrary multiply connected region by bounded analytic functions. (ASTIA abstract)

HAR. 04:002

[Harvard U. Dept. of Mathematics, Cambridge, Mass.]

[ON APPROXIMATION BY BOUNDED ANALYTIC FUNCTIONS] Sur l'approximation par fonctions analytiques bornées, by J. L. Walsh. [1954] [3]p. [AF 18(600)998] Unclassified

Published in Compt. Rend. des Séances Acad. des Sciences, v. 239: 1339-1341, Nov. 22, 1954.

Previous results of the author on the degree of approximation by bounded analytic functions, with respect to domains of analyticity, can be made precise by considering their behavior on the boundary.

HAR. 04:003

[Harvard U. Dept. of Mathematics, Cambridge, Mass.]

[ON THE CONFORMAL REPRESENTATION OF MULTIPLE CONNECTED REGIONS] Sur la représentation conforme des aires multiplement connexes, by J. L. Walsh. [1954] [3]p. [AF 18(600)998] Unclassified

Published in Compt. Rend. des Séances Acad. des Sciences, v. 239: 1572-1574, Dec. 8, 1954.

A connected region bounded by disjoint Jordan curves admits a biequivalent conformal representation on an area limited by the inequalities $m < |S(Z)| < M$, $S(Z)$ being the characteristic form of a rational function except that the linear factors can be irrational.

HAR. 04:004

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

DETERMINATION OF AN ANALYTIC FUNCTION BY ITS VALUES GIVEN IN A COUNTABLE INFINITY OF POINTS, by J. L. Walsh. Sept. 1955, 22p. refs. ([AF]OSR-TN-55-269) (AF 18(600)998) AD 73277 Unclassified

Also published in Bull. Soc. Math. Belgique, 1954, p. 52-70 (1955).

A necessary and sufficient condition for the existence of an analytic function $f(z)$ of bounded norm is derived for a given multiply-connected region D of the z-plane, where $\alpha_1, \alpha_2, \ldots$ are given points of D and values $w_1, w_2, \ldots$ are prescribed with $f(\alpha_k) = w_k$ for $k = 1, 2, \ldots$. The principal result is given by the following theorem: let $f(z) \sim c_1\psi_1(z) + c_2\psi_2(z) + \ldots$, whose coefficients are calculated by $c_n = (f, \bar{\psi}_n)$ and $f(\alpha_k) = w_k$, $k = 1, 2, \ldots$; a necessary and sufficient condition that there exist a function $f(z)$ of class H such that

$\iint_D |f(z)|^2 \, dS$ exists and which satisfies $f(\alpha_k) = w_k$, $k = 1, 2, \ldots$ is the convergence of the series $\sum_1^\infty |c_n|^2$.

The $\psi_n(z)$ are normalized functions of $\varphi_n(z)$ which is a unique function in H; among all functions $f(z)$ in H satisfying $f(\alpha_1) = f(\alpha_2) = \ldots = f(\alpha_{n-1}) = 0$, $f(\alpha_n) = 1$, this unique function possesses the least norm. If the convergence of $\sum_1^\infty |c_n|^2$ is satisfied, the series

$f(z)$ $c_1\psi_1(z) + c_2\psi_2(z) + \ldots$ converges in the mean in D to the function of class H of minimum norm which satisfies $f(\alpha_k) = w_k$, $k = 1, 2, \ldots$. (ASTIA abstract)

HAR. 04:005

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON THE CONFORMAL MAPPING OF MULTIPLY CONNECTED REGIONS, by J. L. Walsh. Oct. 55 [33]p. refs. ([AF]OSR-TN-55-391) (AF 18(600 , AD 102141 Unclassified

Also published in Trans. Amer. Math. Soc., v. 82: 126-146, May 1956.

Proofs are presented for the following theorem:
Theorem 1: Let D be a region of the extended z-plane whose boundary consists of mutually disjoint Jordan curves $B_1, B_2, \ldots, B_\mu; C_1, C_2, \ldots, C_\nu$. There exists a conformal map of D onto a region Δ of the extended Z-plane, 1:1 and continuous in the closures of the 2 regions, where Δ is defined by $1 < |T(Z)| < e^{1/\tau}$,

$$T(Z) \equiv \frac{A(Z-a_1)^{M_1}(Z-a_2)^{M_2}\ldots(Z-a_\mu)^{M_\mu}}{(Z-b_1)^{N_1}(Z-b_2)^{N_2}\ldots(Z-b_\nu)^{N_2}}, \quad \sum M_j = \sum N_j = 1,$$

$\tau > 0$. The exponents M_j and N_j are positive but need not be rational. The locus $|T_n(Z)| = 1$ consists of μ mutually disjoint Jordan curves, respective images of

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the B_j, which separate Δ from the a_j; the locus $|T_n(Z)| = e^{1/\tau}$ consists of ν mutually disjoint Jordan curves, respective images of the C_j, which separate from the b_j. A limiting case of the theorem is also established, and proofs are presented that the maps given by the theorems are uniquely determined except for a possible linear transformation. (ASTIA abstract)

HAR. 04:006

[Harvard U. Dept. of Mathematics, Cambridge, Mass.]

LEAST pTH POWER POLYNOMIALS ON A REAL FINITE POINT SET, by T. S. Motzkin and J. L. Walsh. [1955] [14]p. incl. refs. [In cooperation with California U., Los Angeles] (Sponsored jointly by [National Bureau of Standards, Office of Naval Research, and Air Force Office of Scientific Research under [AF 18(600)-998]) Unclassified

Published in Trans. Amer. Math. Soc., v. 78: 67-81, Jan. 1955.

The authors consider polynomials $T_{n+1}(z) = z^{n+1} + \sum_{t}^{n+1} b_r z^{n+1-r}$ which minimize a deviation from zero of the form $\Delta(|T_{n+1}(z_1)|, \ldots, |T_{n+1}(z_m)|)$ and the z_k form a finite real point set E; in most of the cases the T_{n+1} are not unique. For a general class of Δ, between two zeros of a T_{n+1} lies a point of E; numerous other properties are proved. In the case $\Delta = \sum u_k |T_{n+1}(z_k)|$, $u_k > 0$, the totality of T_{n+1} form a convex set generated by basic polynomials having their zeros at points of E; the set of T_{m-1} can be found explicitly, even if E is not real. If $\Delta = \sum u_k |T_{n-1}(z_k)|^p$, $p > 1$, a separation property holds for the zeros of T_n, T_{n-1}. Other results connect best approximations with interpolation, covering also cases of approximation by families of functions more general than polynomials. (Math. Rev. abstract)

HAR. 04:007

[Harvard U. Dept. of Mathematics, Cambridge, Mass.]

THE LEAST pTH POWER POLYNOMIALS ON A FINITE POINT SET, by T. S. Motzkin and J. L. Walsh. [July 28, 1955] [26]p. (In cooperation with California U., Los Angeles) (Sponsored jointly by Office of Naval Research, Office of Ordnance Research and Air Force Office of Scientific Research under [AF 18(600)998]) AD 134807 Unclassified

Also published in Trans. Amer. Math. Soc., v. 83: 371-396, Nov. 1956.

Let $E:(z_1, \ldots, z_m)$ be a set of points of the complex plane, and let $\mu_1, \ldots, \mu_m$ be positive. The first section of this paper is devoted to the explicit determination of polynomials $T_{m-1}(z) = z^{m-1} + \ldots$ minimizing (*) $\sum_{1}^{m} \mu_k |T_{m-1}(z_k)|^p$. Having previously [same Trans. 78 (1955), 67-81; MR 16, 585] solved the case $p = 1$, they treat separately the cases $p > 1$ and $0 < p < 1$, with uniqueness for $p > 1$. §§2-3 deal mainly with the distribution of the zeros of $T_n(z)$ minimizing more general deviations (cf. the previously cited paper and also L. Fejér, Math. Ann., v. 85: 41-48 (1922)); one such result concerns the separation of E by an arbitrary equilateral hyperbola with the join of two zeros as diameter. §4 deals with the effect on the $T_n(z)$, for the deviation(*), of adding points to E or removing them; under various conditions the same $T_n(z)$ may be extremal for the modified set, or may be so after the addition or removal of factors. In §5 the aim is to characterize the set of T_n for deviation (*), where E (now real) is fixed but not the μ_k; for $0 < p < 1$ and $n < m$ they are the polynomials of the above form which vanish in n points of E; for $p > 1$ they are the polynomials whose zeros are simple, lie in the smallest closed interval containing E, and separate strongly a set of $n + 1$ points of E on which $T_n \neq 0$, while for $p = 1$ the set of T_n can be identified with two other sets. §6 gives certain consequences of the orthogonality condition appropriate to (*) for $p > 1$. Finally §7 deals with best approximation to a continuous f(z) over a closed bounded set E containing infinitely many points by means of a polynomial p(z) of a fixed degree. It is shown that the polynomials $p_k(z)$ corresponding to a suitable sequence of finite point sets E_k converge to p(z), using the deviation $\max |\mu_k(f(z) - p(z))|$. The same holds for the deviation corresponding to (*) if $p > 1$, while for $0 < p < 1$ result is qualified on account of nonuniqueness. (Math. Rev. abstract)

HAR. 04:008

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON RESTRICTED INFRAPOLYNOMIALS, by M. Fekete and J. L. Walsh. June 1956, 31p. refs. (AFOSR-TN-56-263) (AF 18(600)998) AD 88983 Unclassified

Also published in Jour. Analyse Math. (Jerusalem), v. 5: 47-76, 1956/57.

Polynomials $A_n(z; \gamma_1, \ldots, \gamma_k; N; S)$ minimizing a given monotonic norm $N[A_n(z), S]$ on a given compact point set S among all $A_n(z) \equiv z^n + a_{1n}z^{n-1} + \ldots + a_{jn}z^{n-j} + \ldots + a_{nn}$ with prescribed values γ_j for a_{jn}, $1 \leq j \leq k \leq n-1$ have at most k zeros exterior to the inflated convex hull $H_k(S)$ of order k of S. This geometric property is shared by all nth degree infrapolynomials $A_n(z)$ on S subject to the restriction $a_{jn} = \gamma_j$. Locating the zeros relative to S is made more precise if this set and the polynomials exhibit common symmetry properties. This geometry of the zeros is linked with the analytic (structure) properties of the polynomials considered. (Contractor's abstract)

HAR. 04:009

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

UNDERPOLYNOMIALS AND INFRAPOLYNOMIALS, by

T. S. Motzkin and J. L. Walsh. Technical rept. July 13, 1956, 32p. (AFOSR-TN-56-359) (Sponsored jointly by Office of Naval Research, Office of Ordnance Research, and Air Force Office of Scientific Research under AF 18(600)998) AD 95445 Unclassified

Also published in Ill. Jour. Math., v. 1: 406-426, Sept. 1957.

The properties of the class of infrapolynomials of given degrees on a bounded set are investigated, including those which have zeros on the given point set. In § 1 the relation of $|g(z)| < f(z)|$ on E where $f(z) \neq 0$ to the inequality $|g(z)| \leq f(z)|$ on E. § 2 and 3 show that the class of infrapolynomials on a closed bounded set E is closed and connected. § 4 studies some special properties and § 5, the finite generation (on finite subsets of E) of such polynomials. Convexity of the class is proved whenever it exists in § 6, and factorization is discussed in § 7. Infrapolynomials on a real set have special properties of separation § 8, analogous to those previously established for a linite set and of finite generation.

HAR. 04:010

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON APPROXIMATION BY BOUNDED ANALYTIC FUNCTIONS, by J. L. Walsh. Sept. 1956, 30p. refs. (AFOSR-TN-56-440) (AF 18(600)998) AD 96783 Unclassified

Recently proved results on conformal mapping (Trans. Amer. Math. Soc., v. 82: 128-146, 1956) and on series of interpolation of rational functions permit the study of problem [illegible] in the subject of the title. A function f(z) analytic in a region D bounded by Jordan curves is approximated on a portion B of the boundary of D by functions $l_n(z)$ analytic, and in modulus not greater than M_n in D. Degree of convergence on B in terms of M_n is investigated, depending not merely on regions of analyticity of f(z), but also on the continuity properties (Lipschitz conditions, etc.) of f(z) on the boundaries of such regions. (Contractor's abstract)

HAR. 04:011

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

NOTE ON DEGREE OF APPROXIMATION TO ANALYTIC FUNCTIONS BY RATIONAL FUNCTIONS WITH PREASSIGNED POLES, by J. L. Walsh. Nov. 1956, 7p. (AFOSR-TN-56-481) (AF 18(600)998) AD 97365 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 927-930, Dec. 1956.

Results are sought relative to degree of approximation to analytic functions and their boundary values. The results can be applied to degree of approximation by bounded analytic functions.

HAR. 04:012

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON INFRAPOLYNOMIALS WITH PRESCRIBED CONSTANT TERM, by J. L. Walsh. Oct. 1956, 28p. refs. (AFOSR-TN-56-582) (AF 18(600)998) AD 115006 Unclassified

The class of infrapolynomials with prescribed constant term $z^n + \ldots$ in the complex variable z are investigated with respect to the geometry of the zeros of the polynomials. The use of convex sets, orthogonality relations for infrapolynomials and the general theory of zeros of polynomials are utilized. The infrapolynomials are prescribed for the first and the last or last several coefficients. Among the topics considered are the existence and uniqueness of restricted infrapolynomials, orthogonality relations, real infrapolynomials, disc containing E, special configurations and additional geometric results. Theorem 6 is given concerning the zeros of polynomials in general without reference to infrapolynomtals.

HAR. 04:013

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

ON THE LOCATION OF THE ZEROS OF CERTAIN ORTHOGONAL FUNCTIONS, by J. L. Walsh and J. P. Evans. [1956] [6]p. [AF 18(600)998] Unclassified

Published in Proc. Amer. Math. Soc., v. 7: 1085-1090, Dec. 1956.

Results are established on the location of zeros of the functions of $\varphi_n(z)$. The following theorem is proved. Let R be a finite region of the z-plane which contains in its interior the points $\beta_1, \beta_2, \beta_3, \ldots$ and all limit points of the β_n. Then any circle which together with its interior lies in R and which contains in its interior all limit points of the β_n, contains in its interior no zero of $\varphi_n(z)$ (other than β_k, $k = 1, \ldots, n-1$) for n sufficiently large.

HAR. 04:014

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

BEST-APPROXIMATION POLYNOMIALS OF GIVEN DEGREE, by J. L. Walsh. [1956] [6]p. (Sponsored jointly by Office of Naval Research, and Air Force Office of Scientific Research under [AF 18(600)998]; continued by AF 18(600)1461) Unclassified

Published in Proc. of the Symposia in Applied Math. VI. Numerical Analysis, 1956, p. 213-218.

It is the purpose of this paper to consider the properties of individual extremal polynomials of given degree, of best approximation according to various measures of

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approximation. Emphasis is placed on the real domain, with special attention given to results of Kirchberger, Tonelli, de la Vallée-Poussin, Fejér, Fekete, and von Neumann. The present results of this author are to be considered basic research but are significant both in the computation and geometric properties of approximating polynomials.

HAR. 05:001

Harvard U. [Dept. of Mathematics] Cambridge, Mass.

SQUARE-INTEGRABLE DIFFERENTIALS ON OPEN RIEMANN SURFACES, by L. V. Ahlfors. July 26, 1956 [3]p. [AFOSR-TN-56-319] [AF 18(600)1461; continuation of AF 18(600)998] AD 94855 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 758-760, Oct. 1956.

The author considers various decompositions of the space Γ_h of quadratically integrable harmonic differentials on an open Riemann surface W, which generalize the fact that on a finite Riemann surface every harmonic differential decomposes orthogonally into the sum of a differential of an analytic function, the differential of a harmonic measure, and a harmonic differential whose normal component on the boundary vanishes. The Schottky differentials of W are defined as the limits of the Schottky differentials of finite Riemann surfaces which exhaust W, and it is proved that the orthogonal complement in Γ_h of the space of Schottky differentials of W is the space of harmonic differentials which are both exact and coexact. This implies that all harmonic differentials of W are Schottky if and only if $W \in O_{AD}$. If the "harmonic measures" of W are defined to be the limits of differentials of the harmonic measures of an exhaustion of W, then they are the orthogonal complement in Γ_h of the space of harmonic differentials whose duals have no periods around dividing cycles of W. Let Γ_{h0} denote those harmonic differentials which are orthogonal to all coexact differentials. Then to each cycle c on W there is a unique differential $\omega_c \in \Gamma_{h0}$ such that for each closed square-integrable σ

$$\int_c \sigma = \iint_W \sigma \wedge \omega_c.$$

The differentials ω_c span Γ_{h0} and those for which c is a dividing cycle span the harmonic measures. The author then goes on to discuss conditions under which the generalized Riemann bilinear relation holds for W. (Math. Rev. abstract)

HAR. 06:001

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

NOTE ON THE VIBRATIONAL SPECTRA OF $SiHCl_3$, SiH_2Cl_2, AND SiH_2Br_2, by J. A. Hawkins, S. R. Polo, and M. K. Wilson. Mar. 27, 1953, 1p. incl. diagr. tables. (AF 18(600)590) Unclassified

Published in Jour. Chem. Phys., v. 21: 1122, June 1953.

Measurements of gaseous $SiHCl_3$ were made. The absorption spectrum between 450 cm^{-1} and 700 cm^{-1} is plotted on a graph, and the observed frequencies and their assignments are presented. Investigations were also carried out with SiH_2Cl_2 and SiH_2Br_2. Thermodynamic functions are given for SiH_2Cl_2 and fundamental frequencies are given for SiH_2Cl_2 and SiH_2Br_2.

HAR. 06:002

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE INFRARED SPECTRUM OF $S^{16}O^{18}O$ AND THE FORCE CONSTANTS OF SO_2, by S. R. Polo and M. K. Wilson. Feb. 1954 [22]p. incl. illus. tables. (Rept. no. 1) ([AF]OSR-TN-54-37) (AF 18(600)590) AD 28816 Unclassified

Also published in Jour. Chem. Phys., v. 22: 900-903, May 1954.

An investigation of the infrared spectrum of $S^{16}O^{18}O$ results in the following frequency assignment: $\nu_1 = 1122 \pm 1\ cm^{-1}$, $\nu_2 = 506.8 \pm 0.5\ cm^{-1}$, $\nu_3 = 1341 \pm 0.5\ cm^{-1}$. These data combined with the fundamental frequencies of $S^{16}O_2$ have been used to calculate the potential constants for sulfur dioxide. These are $f_d = 10.02$, $f_{dd} = 0.63$, $\frac{1}{d}f_{d\alpha} = 0.20$, $\frac{1}{d^2}f_\alpha = 0.793$. (Contractor's abstract)

HAR. 06:003

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE ROTATIONAL CONSTANTS OF SiH_3D, by S. R. Polo and M. K. Wilson. Feb. 1954, 11p. incl. illus. tables. (Rept. no. 2) ([AF]OSR-TN-54-38) (AF 18-(600)590) AD 28815 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1559-1561, Sept. 1954.

The analysis of the rotational structure of the Si-D stretching fundamental yields the following values: $B'' = 2.11 \pm 0.01\ cm^{-1}$, $B''-B' = 0.019\ cm^{-1}$, $\nu_0 = 159.4 \pm 0.1\ cm^{-1}$. The value of the Si-H distance obtained under the assumption that it remains unchanged by isotopic substitution is $^dSi\text{-}H = 1.47_7 \pm 0.003$ A. (Contractor's abstract)

HAR. 06:004

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE ROTATIONAL CONSTANTS OF GeH_3D AND $GeHD_3$,

by L. P. Lindeman and M. K. Wilson. Apr. 1954, 9p. illus. (Rept. no. 3) ([AF]OSR-TN-54-71) (AF 18-(600)590) AD 29386 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1723-1727 Oct. 1954.

The analysis of the rotational structure of the Ge-D stretching fundamental of GeH_3D yields the following values: $\bar{B}'' = 1.95_7$, $B''-B' = 0.014_2 \pm 0.0017$, $\nu_0 = 1520.4 \pm 0.2\ cm^{-1}$. The germanium-hydrogen distance obtained under the assumption that it is unchanged by isotopic substitution is $1.52_9 \pm 0.003$ and $1.52_5 \pm 0.005$ in GeH_3D and $GeHD_3$, respectively. (Contractor's abstract)

HAR. 06:005

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

INFRARED INTENSITIES IN LIQUID AND GAS PHASES, by S. R. Polo and M. K. Wilson. Mar. 1955, 4p. (Rept. no. 4) ([AF]OSR-TN-55-82) (AF 18(600)590) AD 79871 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2376-2377, Dec. 1955.

Two equations which are relative to a theory of dielectric polarization,

$$\frac{A_l}{A_g} = \frac{1}{n}\left(\frac{n^2+2}{3}\right)^2 \quad \text{and} \quad \frac{A_l}{A_g} = \frac{1}{n}\left(\frac{3n^2}{2n^2+1}\right)^2,$$

the first Debye (Polar Molecules, The Chemical Catalog Co., N. Y., 1929) and the second given by Onsager (Jour. Amer. Chem. Soc., v. 58: 1486, 1936), are shown to lead to the same expression for the relation between the intensities of an IR absorption band in the liquid and in the gas phases. In the formulas, A_l and A_g denote the integrated absorption coefficients in the liquid and in the gas, respectively, and n is the refractive index. (ASTIA abstract)

HAR. 06:006

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE INFRARED SPECTRA OF SOME DEUTERATED SILANES, by J. H. Meal and M. K. Wilson. Apr. 1955, 21p. incl. diagrs. tables. (Rept. no. 5) ([AF]OSR-TN-55-111) (AF 18(600)590) AD 79872 Unclassified

Presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 1953.

Also published in Jour. Chem. Phys., v. 24: 385-390, Feb. 1956.

The spectra SiD_4, $SiHD_3$, and SiH_2D_2 in the 2- to 16μ region were measured with a Baird Associates spectrophotometer equipped with NaCl optics and with a Perkin-Elmer model 12-C spectrograph with CaF_2, NaCl, and KBr prisms. Values of ζ obtained for the 851 cm^{-1} band of $SiHD_3$ and the 1597 cm^{-1} band of SiD_4 are 0.76 and 0.10, respectively. Assignments are given for the observed bands, and force constants are calculated. (ASTIA abstract)

HAR. 06:007

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE MATRICES D^{-1} AND G^{-1} IN THE THEORY OF MOLECULAR VIBRATIONS, by S. R. Polo. May 1955, 15p. incl. diagrs. (Rept. no. 6) ([AF]OSR-TN-55-153) (AF 18(600)590) AD 79873 Unclassified

Presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 1954.

Also published in Jour. Chem. Phys., v. 24: 1133-1138, June 1956.

A vector method is given by which to determine the elements of the matrices D^{-1} and G^{-1} which occur in the study of the vibration-rotation spectra of polyatomic molecules. D^{-1} is the matrix of the transformation giving the mass-weighted Cartesian displacements in terms of the internal coordinates, and G^{-1} has as elements the coefficients in the expression of the vibrational kinetic energy in terms of the velocities. The determination of the elements of D^{-1} is reduced to finding by inspection a set of displacement vectors to which is added an appropriate rigid translation and rotation of the whole molecule. The G^{-1} matrix elements are obtained from the equation. (ASTIA abstract)

HAR. 06:008

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

VIBRATION-ROTATION INTERACTION IN POLYATOMIC MOLECULES. 1. THE ZETA MATRICES, by J. H. Meal and S. R. Polo. June 1955, 19p. table, refs. (Rept. no. 7) ([AF]OSR-TN-55-189) (AF 18(600)590) AD 79874 Unclassified

Presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 1954.

Also published in Jour. Chem. Phys., v. 24: 1119-1125, June 1956.

The theory of the Coriolis coupling coefficients is developed in a general form. They are shown to satisfy a number of relations which do not depend on the potential constants. Methods of obtaining relationships which depend only on the atomic masses and the

HAR. 06:009 - HAR. 06:012

geometry of the molecule are given. Additional simplification is introduced by the use of symmetry arguments. (ASTIA abstract)

HAR. 06:009

Harvard U. [Mallinckrodt Chemical Lab.] Cambridge, Mass.

VIBRATION-ROTATION INTERACTION IN POLYATOMIC MOLECULES. II. THE DETERMINATION OF CORIOLIS COUPLING COEFFICIENTS, by J. H. Meal and S. R. Polo. July 1955 [27]p. incl. diagrs. tables, refs. (Rept. no. 8) ([AF]OSR-TN-55-207) AD 79875 Unclassified

Presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 1953.

Also published in Jour. Chem. Phys., v. 24: 1126-1133, June 1956.

A general method for the analytical treatment of vibration-rotation interaction in polyatomic molecules is presented. The method is especially adapted to carry out the calculation of the Coriolis coupling coefficients along with the normal coordinate treatment in terms of any chosen set of internal coordinates. The relations existing among the ζ-elements and the potential constants are established in a general and convenient form. Particular attention is given to symmetric top molecules, and the effect of vibration-rotation interaction on band structure is discussed. Approximate methods for the calculation of ζ values are considered also. (Contractor's abstract)

HAR. 06:010

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

INFRARED SPECTRA AND MOLECULAR STRUCTURES OF SiH_3F, SiH_3Cl, AND SH_3Br, by C. Newman, J. K. O'Loane and others Jan. 1956 [25]p. incl. diagrs. tables, refs. (Rept. no. 9) (AFOSR-TN-56-5) (AF 18-(600)590) AD 85509 Unclassified

Also published in Jour. Chem. Phys., v. 25: 855-859, Nov. 1956.

The structure of the e-type fundamentals of SiH_3F, SiH_3Cl, and SiH_3Br has been resolved and analyzed. The values of the small amount of inertia thus obtained has been combined with microwave measurements to yield the dimensions of the SiH_3 group in these molecules. It is shown that the differences in the structure of the SiH_3 group are probably within experimental error. Several revisions have been made in the vibrational assignments for SiH_3F and SiH_3Cl. (Contractor's abstract)

HAR. 06:011

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE INFRARED SPECTRA OF SOME DEUTERATED GERMANES, by L. P. Lindeman and M. K. Wilson. Mar. 20, 1956 [39]p. incl. diagrs. tables, refs. ([AF]OSR-TN-56-123) (AF 18(600)590) AD 82519 Unclassified

Infrared and Raman spectra have been obtained for GeD_4, GeD_3H, GeD_2H_2, and $GeDH_3$ and an assignment of fundamentals has been made. Coriolis coupling coefficients and potential constants have been calculated for this series of compounds. (Contractor's abstract)

HAR. 06:012

Harvard U. [Mallinckrodt Chemical Lab.] Cambridge, Mass.

THE VIBRATIONAL SPECTRUM OF BORINE CARBONYL, by G. W. Bethke and M. K. Wilson. June 11, 1956, 1v. incl. diagrs. tables, refs. (AFOSR-TN-56-245) (AF 18(600)590) AD 88365 Unclassified

Also published in Jour. Chem. Phys., v. 26: 1118-1130, May 1957.

The complete IR gas spectra of BH_3CO, $B^{10}H_3CO$, BD_3CO, and $B^{10}D_3CO$ were examined, and the solid IR and partial gas Raman spectra were investigated. The BH_3 rock and B-C-O bend symmetry coordinates, S_7 and S_8, respectively, mix to a large extent. The actual normal vibrations are neither BH_3 rocking nor B-C-O bending motions. If the normal vibrations (Q_7 and Q_8) are estimated from the approximate $B^{11}H_3CO$ equations ($Q_7 = \frac{1}{2}S_7 - \frac{1}{2}S_8$ and $Q_8 = \frac{1}{3}S_7 - \frac{2}{3}S_8$), the actual vibrations are found to be an unsymmetrical body bend ($\downarrow H_3B \uparrow C \downarrow O\uparrow$) for Q_7, and a type of symmetrical body bend ($\downarrow H_3BC\uparrow O\downarrow$) for Q_8. In the deuterated compound, Q_8 is more of a symmetrical body bend than that shown for the H compound. From the actual vibration forms, Q_7 should have a much larger B^{10}-B^{11} isotope shift and a slightly smaller H-D isotope shift than Q_8. In the hydrogenated and the deuterated borine carbonyls, a shift of about 10 cm^{-1} B^{10}-B^{11} occurs for assignment ν_7 but essentially none occurs for ν_8; also, $\nu_7(H)/\nu_7(D) = 1.14$ and $\nu_8(H)/\nu_8(D) = 1.18$. Results indicated that ν_7 is Q_7 (the antisymmetrical body bend) and that ν_8 is Q_8 (the symmetrical body bend). The large interactions between S_7 and S_8 should cause ν_7 and ν_8 to strongly repel each other resulting in the low ν_8 and high ν_7 frequencies which were observed. Ionic or other repulsive terms apparently have a greater effect on the interaction constants than those arising from the changing hybridization of the B atom; this effect is expected from the number of contributing structures which exhibit charge separation.

HAR. 06:013

Harvard U. [Mallinckrodt Chemical Lab.] Cambridge, Mass.

THE VIBRATIONAL SPECTRUM OF DISILANE, by G. W. Bethke and M. K. Wilson. June 11, 1956, 1v. incl. diagrs. tables, refs. (AFOSR-TN-56-246) (AF 18(600)590) AD 88366 Unclassified

Presented at the Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Abstract published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 10.

Also published in Jour. Chem. Phys., v. 26: 1107-1117, May 1957.

Complete IR gas spectra and Raman liquid spectra were obtained for Si_2H_6 and Si_2D_6. The IR and Raman spectra of Si_2H_6 and Si_2D_6 agreed well with the assumption of D_{3d} symmetry. The resolved Q branch structure of all the perpendicular E_u fundamentals showed that the disilane molecule hindered internal rotation. These two considerations mean that disilane has the staggered C_2H_6-type configuration. The IR and Raman spectra of Si_2H_6 and Si_2D_6 were similar to the spectra of the corresponding ethanes. The results were true for the zeta constants of the E_u fundamentals in Si_2H_6 and C_2H_6. The decomposition products include much silane and traces of higher silanes which interfere with the disilane bands of interest. The main spectral impurity, silane, interfers with the ν_7 and ν_8 assignments of disilane, but not with the ν_9. Since the hot bands of ν_9 in disilane are already strong at room temperature, they contribute to give a very complex ν_9 band at higher temperatures. If the transition from hindered to free internal rotation is to be observed in the vibration-rotation bands of disilane, a high-resolution grating spectrometer is necessary. (ASTIA abstract)

HAR. 06:014

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE TIN-HYDROGEN BOND DISTANCE, by G. R. Wilkinson and M. K. Wilson. Aug. 29, 1956, 2p. refs. (AFOSR-TN-56-365) (AF 18(600)590) AD 95801 Unclassified

Also published in Jour. Chem. Phys., v. 25: 784, Oct. 1956.

An analysis was made of the Sn-H stretching vibration (ν_3) of $SnHD_3$ using a sample of SnD_4 containing a small percentage of $SnHD_3$. The Sn-H stretching vibration spectrum was recorded with a grating spectrometer in the 2nd order – lines separated by 0.1 cm^{-1} being resolved. Because of the many isotopes of Sn H was necessary to measure the position of maximum absorption of the many components making up each "line." The usual combination plots lead to the following molecular constants: $\nu_0 = 1905.91\ cm^{-1}$; $B_0 = 1.3373\ cm^{-1}$; $B_1 = 1.3327\ cm^{-1}$; $B_0 - B_1 = 0.00425\ cm^{-1}$; $D^J \approx 10^{-1}\ cm^{-1}$. Under the assumption of tetrahedral angles, equality of the Sn-H and Sn-D bond distances, and a mean atomic weight for Sn of 119, the Sn-H bond length was calculated to be 1.701 ± 0.001Å. This value compares with 1.700 ± 0.015 Å reported by Lide (Jour. Chem. Phys., v. 19: 1605, 1951) from an analysis of the microwave spectra of CH_3SnH_3.

HAR. 06:015

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

THE PREPARATION OF GERMANE, by T. S. Piper and M. K. Wilson. Sept. 25, 1956, 4p. (AFOSR-TN-56-424) (AF 18(600)590) AD 96506 Unclassified

In this study, pure germane, GeH_4, (germanium tetrahydride) (I) was prepared in 60 to 75% yields by reducing aqueous acidic GeO_2 solutions with $NaBH_4$. Digermane, Ge_2H_6, formed 6% by volume of the total, as determined by trapping out at -140° C. With 45% D_2O solvent, 25% of the I contains a D atom. This indicates that hydride transfer from borohydride is not a unique mechanism. Pure GeH_3D (II) was prepared by reducing sodium germanyl with DCl in Bu_2O. Its IR spectrum is like that of II prepared from the $GeCl_3H$-$LiAlD_4$ reaction of Lindeman and Wilson (Zeit. für Physik Chem. (Frankfort), v. 9: 29-48, 1956). Plumbane was not formed by action of $NaBH_4$ on bivalent Pb.

HAR. 06:016

Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

INFRARED SPECTRA OF $GeCl_4$, $GeHCl_3$ AND $GeDCl_3$, by L. P. Lindeman and M. K. Wilson. Oct. 22, 1956 [6]p. incl. diagrs. tables, refs. (AFOSR-TN-56-492) (AF 18(600)590) AD 110306 Unclassified

Also published in Spectrochimica Acta, v. 9: 47-50, Mar. 1957.

The spectra obtained from $GeCl_4$, $GeHCl_3$ and $GeDCl_3$ are investigated from 300 cm^{-1} to 4000 cm^{-1}. The results obtained are in good agreement with those previously found.

HAR. 07:001 - HAR. 07:004

HAR. 07:001

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

THE EFFECT OF DIFFERENT ATMOSPHERES ON ELECTRODE TEMPERATURES IN THE DC ARC (Abstract), by B. L. Vallee and M. R. Baker. Sept. 1953 [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at Thirty-Eight annual meeting of the Opt. Soc. of Amer., Oct. 15-17, 1953.

Published in Jour. Opt. Soc. Amer., v. 43: 817, Sept. 1953.

Marked differences in volatilization rates, intensities of spectral lines, and their signal-to-noise ratio have been noted in the dc arc burning in air, argon, helium, and their mixtures. In the present study the electrode temperatures and voltage drop across the arc column have been observed using an arcing chamber with standardized geometry. This chamber may be employed with gas pressures varying from 1 mm of mercury to twice atmospheric. A continuously recording optical pyrometer employing thermistors as sensitive elements has been constructed for the measurement of temperatures. Marked differences in temperatures have been noted when the dc arc is burned in different gases; but with any particular gaseous environment, high reproducibility of temperature conditions is exhibited. The details and significance on the data will be discussed. (Contractor's abstract)

HAR. 07:002

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

THE EFFECT OF ARGON ATMOSPHERES ON THE INTENSITY OF CERTAIN SPECTRAL LINES, by B. L. Vallee and S. J. Adelstein. Feb. 1954 [5]p. incl. diagrs. tables. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Spectrochimica Acta, v. 6: 134-138, Feb. 1954.

The use of argon as an environment for the direct current arc results in the enhancement of the lines of many elements when compared with helium and argon-helium mixtures. This is particularly true of the more volatile elements. A number of lines have been studied in this regard and the results have been qualitatively grouped as lines definitely, equivocally, and not at all enhanced. In some instances the use of an argon environment for the direct current arc markedly increases the sensitivity of analysis with this source. (Contractor's summary)

HAR. 07:003

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

FUNDAMENTAL CONSIDERATIONS IN FLAME PHOTOMETRY (Abstract), by B. L. Vallee. Feb. 1954, 1p. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Mar. 1-5, 1954.

Published in Anal. Chem., v. 26: 432, Feb. 1954.

The achievement of high signal-noise ratios, sensitivity, precision, accuracy, and lack of interference between different elements have been the subject of considerable controversy in flame photometry, and the factors influencing them are ill defined. A multichannel flame photometer has been devised and operated to elucidate these phenomena which are illustrated by a discussion of the performance of this instrument. A grating was found much superior to other monochrometers; the source and detector were found to be critical. At present Na, K, Ca, and Mg can be determined simultaneously. (Contractor's abstract)

HAR. 07:004

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

STUDIES ON METALLOPROTEINS. SOLUBLE ZINC-CONTAINING PROTEIN EXTRACTED FROM HUMAN LEUCOCYTES, by B. L. Vallee, F. L. Hoch and W. L. Hughes, Jr. [1954] [14]p. incl. diagrs. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Arch. Biochem. and Biophys., v. 48: 347-360, Feb 1954.

Studies are presented on the purification of soluble zinc-containing proteins from human leucocytes. The criterion for purification is an increase in the zinc to protein ratio, and conditions are defined under which this criterion is valid. Carbonic anhydrase is present in erythrocytes contaminating the leucocytes from which it can be separated by fractional precipitations with ammonium sulfate. This is shown by measurements of carbonic anhydrase activity, zinc, and protein. Further purification of the leucocyte proteins having high zinc to protein ratios was achieved by variations of pH, μ, and ethanol concentration. The maximum zinc to protein ratio attained was 3000 μg Zn/g protein. This content of zinc in leucocyte protein is comparable to the magnitude of the metal contents of other metalloproteins. (Contractor's abstract)

HAR. 07:005

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

DETERMINATION OF ZINC BY DITHIZONE IN A MONOPHASE WATER-GLYCOL SYSTEM, by B. L. Vallee. May 1954 [4]p. incl. diagrs. tables. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Mar. 1953.

Published in Anal. Chem., v. 26: 914-917, May 1954.

A monophase system was developed with dithizone and methylcellosolve. Transfer a 1.5 ml sample to a 15 ml centrifuge tube and titrate with 6N NH_4OH or 6N HCl to pH 4 or a color change of thymol blue paper. Add 0.2 ml of 25% citrate solution and 2 ml of acetate buffer at pH 4. Mix and adjust the volume to 4 ml. Add 3.5 ml of methylcellosolve, cool, and mix. Add 0.5 ml of 0.01% dithizone in methylcellosolve solution. Mix and read absorbance within 10 min at 525 μ. (C. A., 1955:776g)

HAR. 07:006

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CENTRIFUGAL SUBFRACTIONATION OF POLYMORPHONUCLEAR LEUCOCYTES, LYMPHOCYTES, AND ERYTHROCYTES, by B. L. Vallee, B. W. Agranoff, and D. F. Waugh. [1954] [6]p. incl. illus. diagr. (In cooperation with the Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under N5ori-07660]) Unclassified

Published in Blood, v. 9: 804-809, Aug. 1954.

The separation of polymorphonuclear leucocytes from lymphocytes and erythrocytes has been accomplished by employing a method which takes advantages of their density differentials. During a single centrifugation the lymphocytes accumulate at a plasma-albumin interface (albumin I, density = 1.065 to 1.085), the polymorphonuclear leucocytes accumulate at an albumin I—albumin II interface (albumin II, density = 1.094) and the erythrocytes pass to the base of a Wintrobe tube. The yields are over 90 per cent pure cell types. All layers are isosmotic with blood. (Contractor's abstract)

HAR. 07:007

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CARBOXYPEPTIDASE, A ZINC METALLOPROTEIN, by B. L. Vallee and H. Neurath. [1954] [2]p. incl. table. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under N5ori-07660]) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 5006-5007, Oct. 5, 1954.

Examination of several crystalline preparations of pancreatic (bovine) carboxypeptidase by use of quantitative emission spectrography indicated the presence of large amounts of Zn, while all other metals were either completely absent or present in minute amounts. For a carboxypeptidase of molecular weight 34,000, the mole ratio of Zn-carboxypeptidase is 1:1. O-Phenanthroline inhibited the enzymic activity of the carboxypeptidase and removed Zn from it. Zn was not removed by dialysis. (C. A., 1955:9505h)

HAR. 07:008

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

SIMULTANEOUS DETERMINATION OF SODIUM, POTASSIUM, CALCIUM, MAGNESIUM AND STRONTIUM BY A NEW MULTI-CHANNEL FLAME-SPECTROMETER, by B. L. Vallee. June 23, 1954 [2]p. incl. diagrs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) ([Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research] under N5ori-07660]) U72411 Unclassified

Published in Nature, v. 174: 1050-1051, Dec. 4, 1954.

Design, construction and operation are described of a direct-reading multi-channel flame-spectrometer for the simultaneous analysis of Na, K, Ca, Mg, and Sr. The instrument components include an oxy-hydrogen burner, a Wadsworth stigmatic mounting grating spectrograph, photomultiplier tubes at the grating focal plane on the Mg line at 3838.258A, the CaO bandhead at 5495A, the Na line at 5889.953A, the Sr line at 4607.331 A, and the K line at 7664.907A, with 0-200 μamp microammeters as recorders at each channel, as well as null and sensitivity adjustment controls. Calibration curves for all five elements are included and discussed, and sensitivity limits noted. Study of "interference" in light intensity measurements indicate these effects can be attributed to the superposition of cation monochromatic emission upon heterochromatic background radiation which has been found to increase in direct proportion to the concentration of each radiating species. As the apparatus can be corrected readily for this background contribution, more accurate and precise flame spectrophotometry is possible.

HAR. 07:009

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

[GENERAL PRINCIPLES CONCERNING METALLO-

HAR. 07:010 - HAR. 07:013

ENZYME INTERACTION], by R. J. P. Williams and B. L. Vallee. [1955] [3]p. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Faraday Soc. Discussions, No. 20: 262-264, 1955.

The activation and inhibition of enzymes having a firmly-bound metal content are briefly discussed with regard to analysis and to coordination chemistry of cations. The cation in the enzyme is considered to act mainly as a center of orientation without binding any reacting groups, as a Lewis acid for the substrate, or as a redox catalyst with change of valency.

HAR. 07:010

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

[GLUTAMIC DEHYDROGENASE], by S. J. Adelstein, B. L. Vallee, and J. A. Olson. [1955] [2]p. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Faraday Soc. Discussions, No. 20: 298-299, 1955.

Several preparations of crystalline glutamic dehydrogenase have been examined. The enzyme has been found to contain 4-5 g atoms of zinc/mol of protein. Quantitative emission spectroscopy of beef liver fractions obtained in the preparation of GDH shows the disappearance of all metals except zinc with progressive purification. The ratio, activity/[zinc], increased with purification reaching its highest value in the third crystals. The rate of conversion of DPN to DPNH at pH 7.7 in the presence of glutamate is inhibited significantly when the enzyme is pre-incubated with a number of metal-binding agents including sodium sulfide, sodium diethyldithiocarbamate, and 1,10-phenanthroline. With the first and the last of these agents, the inhibition was successfully inhibited by the prior addition of 2×10^{-2} M DPN.

HAR. 07:011

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

[KINETICS OF ALCOHOL DEHYDROGENASE], by F. L. Hoch and B. L. Vallee. [1955] [2]p. incl. diagrs. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Faraday Soc. Discussions, No. 20: 299, 1955.

Study was made of the effect of DPN on the inhibition of yeast ADH activity by 1,10 phenanthroline (OP). It was determined that when 4×10^{-3} M OP is added to ADH, a time-dependent inhibition occurs which is complete in 20 min. Addition of 5×10^{-2} M DPN to the OP-inhibited ADH does not restore activity. When 5×10^{-2} M DPN is added to ADH before 4×10^{-3} M OP is added, 55% of the initial activity remains after 32 min. DPN reduces the degree of inhibition by OP when the coenzyme is added to ADH before the inhibitor, but not when it is added after the inhibition has occurred. The kinetics involved were also studied in order to determine quantitatively the relationship between the zinc binding inhibitor and the coenzyme. It seems that DPN and OP compete for the "same" enzymatic site of yeast ADH. Since OP combines with the zinc atoms of $[(ADH)Zn_4]$, it appears that one molecule of DPN binds with each zinc atom of the enzyme, to form the enzyme-coenzyme complex, $[(ADH)Zn_4](DPN)_4$.

HAR. 07:012

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

ZINC AND METALLOENZYMES, by B. L. Vallee. [1955] [68]p. incl. diagrs. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Advances in Protein Chemistry, v. 10. Ed. by M. L. Anson, K. Bailey, and J. T. Edsall. N. Y., Academic Press, Inc., 1955, p. 317-384.

In a review article on zinc and metalloenzymes, the following topics are discussed: (1) metalloproteins and metalloenzymes; (2) carbonic anhydrase; (3) leucocyte zinc protein; (4) carboxypeptidase; (5) yeast alcohol dehydrogenase; and (6) coordination chemistry of zinc. Included are 254 foreign and domestic references covering a time period from 1886 to 1955.

HAR. 07:013

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

EFFECTS OF INERT GASES ON DC ARC DISCHARGE, by B. L. Vallee and S. J. Adelstein. Jan. 1955 [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] U72413 Unclassified

Published in Jour. Opt. Soc. Amer., v. 45: 63, Jan. 1955.

The significant enhancement of emission spectral lines, obtained under certain circumstances by use of inert atmospheres (A, He) in spectrum analyzers, is discussed.

HAR. 07:0f4

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

ANODE TEMPERATURES IN THE NOBLE GAS DIRECT CURRENT ARC WITH ALKALI AND ALKALINE EARTH METALS (Abstract), by B. L. Vallee and R. E. Thiers. [1955] [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 32f, Feb. 1955.

Marked differences in temperature of the electrodes were noted previously in the dc arc when operating in He, Ne, and A, and data have now been obtained in Kr. Marked differences in the voltage drop across the arc were also observed. Pure graphite rods and a constructed recording pyrometer were used. These studies have been extended to temperature and voltage measurements in He and A with the anode containing a sample. The chlorides of the elements from groups I and II of the periodic system were arced individually. Preliminary data analysis indicates a correlation of the temperature to the boiling points of the salts and the position of the cation in the periodic table. Similarly, there was good correlation between the temperatures observed and the disappearance of the salt from the electrode. The presence of all salts depresses the voltage, more in column IA than in column IIA in a given gas, but the magnitude of the depression differs between He and A. The implications and experimental detail are discussed. (Contractor's abstract, modified)

HAR. 07:015

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CONDITIONS IN DENSITOMETRY (Abstract), by R. E. Thiers. [1955] [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 323, Feb. 1955.

Erratic precisions and accuracies when using 103-0 plates in quantitative spectrochemical trace analysis led to an investigation of the densitometric methods used. Data obtained with 3 densitometers — 2 of these of the same make — were found interconvertible only when calibration curves of each instrument were constructed. While this aided the analytical performance, it was not deemed satisfactory until plates were developed to constant gamma. This required a development time of f2 instead of 3 min as recommended by the manufacturer. The characteristics of this emulsion imply that further changes in the evaluation of photometric data may become necessary.

HAR. 07:0f6

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CYANOGEN-OXYGEN FLAME AS A SPECTROSCOPIC SOURCE (Abstract), by B. L. Vallee and M. R. Baker. Feb. 1955 [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 320, Feb. 1955.

The cyanogen-oxygen flame with an approximate temperature of 4700°K was studied as a source of spectral excitation. In this flame the spectra of many elements are excited where under similar conditions they cannot be discerned in an oxygen-hydrogen flame. This source shows great promise for analytical spectroscopy. Details of the findings are reported. (Contractor's abstract, modified)

HAR. 07:017

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

A MULTICHANNEL FLAME SPECTROMETER EMPLOYING AUTOMATIC BACKGROUND CORRECTION (Abstract), by M. Margoshes and B. L. Vallee. [1955] [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 320, Feb. 1955.

The spectrometer used a grating monochromator and separate exit slits and detectors for Na, K, Ca, and Sr. An auxiliary exit slit is placed 1/4 in. to one side of the main exit slit for each analysis line of an element. Front surface mirrors reflect the light onto a photomultiplier tube placed slightly to the side and to the rear of the exit slit. The signals from the photomultipliers, placed on the line and background exit slits, respectively, are amplified separately. The amplified signals

HAR. 07:018 - HAR. 07:021

are subtracted electrically before being presented on a microammeter which thus indicates the corrected line intensity. This correction system enables the direct determination of one element in the presence of considerably larger concentrations of other elements. Good precision is obtained when background intensity is as much as 7 times the value of the line intensity. (Contractor's abstract, modified)

HAR. 07:018

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

PHYSICAL BASIS OF SPECTRAL LINE ENHANCEMENT IN THE NOBLE GAS CURRENT ARC (Abstract), by M. R. Baker, S. J. Adelstein, and B. L. Vallee. [1955] [2]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 320-321, Feb. 1955.

Studies have confirmed the enhancements of spectral lines previously noted in A and He and have newly demonstrated a similar effect in Kr. The enhancement is the greater the lower the concentration in which the elements occur in the sample. The largest enhancements for a fixed concentration of elements are observed for lines, the excitation potentials of which are in the vicinity of the first excited levels of the noble gas atmosphere employed. It is concluded that a mechanism of excitation in these sources is as follows. The noble gas is energized to its lowest excited levels by the arc discharge. Through collisions of the 2nd kind, this energy is transferred to neutral metal atoms present. The metal atoms are thus ionized and excited. The ion lines of the metal atoms whose excitation potential occurs in the vicinity of the lowest excited levels of the gas employed are consequently strongly enhanced. The excitation of lines of the neutral atoms primarily occurs through thermal collisions. The experimental findings and the physical basis of these phenomena are documented and discussed. (Contractor's abstract, modified)

HAR. 07:019

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

THE USE OF AN ANION EXCHANGE RESIN FOR THE SEPARATION OF ALKALI EARTHS FROM ALKALI METALS (Abstract), by R. Hara and B. L. Vallee. [1955] [2]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Pa., Feb. 28-Mar. 4, 1955.

Published in Anal. Chem., v. 27: 315-316, Feb. 1955.

Na and K were separated completely from Ca and Mg by the use of Dowex 1-10 exchange resin in the presence of an ethylene-diaminetetraacetic acid derivative. The transition elements were separated from the above four. The experimental procedures and their application are discussed. (Contractor's abstract, modified)

HAR. 07:020

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

YEAST ALCOHOL DEHYDROGENASE, A ZINC METALLOENZYME, by B. L. Vallee and F. L. Hoch. [1955] [2]p. incl. refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07660) AD 92310; U72412 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 821-822, Feb. 5, 1955.

Crystalline alcohol dehydrogenase of yeast was shown by emission spectrography to be a Zn metalloenzyme. The Zn is an integral and enzymically functional component of the apoenzyme molecule. Various crystalline preparations showed large amounts of Zn, lesser and variable amounts of Mg, and insignificant amounts of all other metals. Upon recrystallization, the protein: Zn ratio increased, but the protein:metal ratio decreased for all other elements. Both the rate of appearance of reduced diphosphopyridine nucleotide (DPNH) at pH 8.8 in the presence of EtOH and the disappearance of DPNH at pH 6.5 in the presence of AcH are strongly inhibited by preincubation of the enzyme with 1,10-phenanthroline. (C.A., 1955:10402a)

HAR. 07:021

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

YEAST ALCOHOL DEHYDROGENASE, A ZINC METALLOENZYME (Abstract), by B. L. Vallee and F. L. Hoch. [1955] [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07660) Unclassified

Presented at meeting of the Amer. Physiol. Soc., San Francisco, Calif., Apr. 11-15, 1955.

Published in Fed. Proc., v. 14: 154, Mar. 1955.

Crystalline alcohol dehydrogenase (ADH) of yeast

contains firmty-bound zinc as an integral and enzymatically functional component of the apoenzyme motecute. Qualitative and quantitative emission spectrography and microchemical determinations of zinc were employed to anatyze crystalline preparations, which were uniformty found to contain targe quantities of zinc, tesser and variabte quantities of magnesium, and insignificant amounts of all other elements. A purified and dialyzed crystatline preparation of alcohol dehydrogenase contained 3.9 mot of zinc/mot of protein based on a motecutar weighi of 150,000. Fractionation of ADH from yeasi demonstraied an increase in the zinc:protein ratios in fractions in which the activity:protetn ratio was increased. The zinc was shown to be a functionat component of the apoenzyme by inhibition studies emptoying chetating agents. Both the dehydrogenation of ethanol and the hydrogenation of acetaldehyde were inhibited markedty. The inhibttion by chetating agenis appears to be competitive with the co-enzyme, indicating thai the 4 molecules of DPN may be bound io the apoenzyme through zinc. These data establish yeast ADH as a zinc metaltoenzyme and may be used to explain the known high zinc conteni of animal liver and retina, organs known to have a high ADH conteni. The mechanism of action of ADH based on these findings witt be discussed. (Coniractor's absiraci)

HAR. 07:022

Harvard U. Medical Schoot. Btophysics Research Lab., Bosion, Mass.

AUTOMATIC BACKGROUND CORRECTION ON A MULTICHANNEL FLAME SPECTROMETER (Absiract), by M. Margoshes and B. L. Vallee. [1955] [1]p. (In cooperation with Peter Beni Brigham Hospital, Bosion, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Sctentific Research under N5ori-07660] Unclassified

Published in Jour. Opt. Soc. Amer., v. 45: 406, May t955.

A multichannet flame specirometer for the simuttaneous deiermination of five elemenis has been described previousty (B. L. Vallee, Naiure, v. 174: 1050-1051, Dec. 4, t954). The deiermination of one of the alkali metals or alkaline earths in the presence of excess concentrations of the others has been difficuli in the past due to "inierference" caused by superposition of the monochromatic radiation io be measured on heierochromatic background radiation, which ts additive and increases in tniensity in direci proportion io the concentration of each radiating species. The multichannel flame specirometer has been modified io include an automatic background correction. An auxiliary exit slit and photomuliiplier are used to observed the background ai a position io one side of the line or band io be measured. The signal from the phoiocell receiving the background radiation and from the one receiving line plus background are amplified separaiely. The amplified signals are subtracied electricaly. The difference between the two signats, the line intensity, is measured by a microammeter. With this arrangemeni, accurate analyses are obtained with background intensities as high as ten times the line iniensity. (Contracior's abstract)

HAR. 07:023

Harvard U. Medical Schoot. Biophysics Research Lab., Boston, Mass.

ZINC, A COMPONENT OF YEAST ALCOHOL DEHYDROGENASE, by B. L. Vallee and F. L. Hoch. [1955] [12]p. incl. diagrs. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07660) AD 92430 Unclassified

Also published in Proc. Nat't. Acad. Sciences, v. 41: 327-338, June 15, 1955.

Study was made of the chemicat composition, physical-chemical interactions, and enzymotogical behavior of yeasi ADH. The foltowing facts were determined. The ADH of yeasi ts a zinc metalloenzyme containing four moles of zinc firmty bound to one mote of protein. The activity of the enzyme is directly dependent on zinc. Enzymatic action is inhibited by dithizone, 1,10-phenanthroline, 8-hydroxyquinoline, 8-hydroxyquinoline-5-sulfonic acid, α,α'-dipyridyt, and thiourea. The inhibition is reversibie and probabty is competitive with DPN. The mechanisms of the enzymatic reaction, inactivation, and reversal of inhibition have been formulated in terms of the exisience of a structural metalloenzyme entity. This has been assigned the empiricat formula $[(ADH)Zn_4]$ tn conformity with a general scheme of notation of metaltoenzyme structure. The active meialtoenzyme-coenzyme complex is represenied by $[(ADH)Zn_4](DPN)_4$. (Coniractor's summary)

HAR. 07:024

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

EFFECTS OF ADENOSINE TRIPHOSPHATE AND METALS UPON AN ELECTRON TRANSPORT SYSTEM IN MITOCHRONDRIA, by F. L. Hoch and B. L. Vattee. [t955] [2]p. incl. diagrs. (In cooperation with Peter Bent Brigham Hospital, Bosion, Mass.) (Sponsored joinily by Office of Navat Research and [Air Force Office of Scientific Research] under N5cri-07660) Unclassified

Published in Nature, v. 176: 256-257, Aug. 6, 1955.

In the course of oxidative phosphoryiation coupled with the succinic oxidase sysiem of rai-liver mitochrondria, adenosinetriphosphaie (ATP), alone and with certain metals, significantty acceleraied reduction of iripheny1-ietrazolium chloride io iriphenylformazan. The presence of Mn or Mg tncreased the activation bui the maximum effeci occurred when metal and ATP concenira-tions were equal. Ca, Ba, Sr, and Cr neither produced

HAR. 07:025 - HAR. 07:028

additional activation nor interfered with the action of ATP in activating this reduction mechanism. Beryllium, Al, Zn, Cu, Fe, V, and Mo not only had no stimulating effect but also abolished the stimulation due to ATP. (C. A., 1955:14846b)

HAR. 07:025

[Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.]

THE FUNCTIONAL ROLE OF ZINC IN ALCOHOL DEHYDROGENASE (Abstract), by F. L. Hoch and B. L. Vallee. [1955] [1]p. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660]
Unclassified

Published in Third International Congress of Biochemistry, Brussels (Belgium), 1955. Abstracts of Communications, p. 52, Aug. 1955.

Yeast alcohol dehydrogenase (ADH), containing 4 moles of zinc, is reversibly inhibited by chelating agents with high affinity for zinc. The degree of inhibition varies with the chemical characteristics of the agent and with the conditions of exposure of ADH to it. The effects of pH, temperature and time of incubation have been studied. ADH activity, markedly inhibited by 1, 10-phenanthroline are preincubated before activity is measured, the inhibition is competitive between chelating agents and DPN. When ADH and 1, 10-phenanthroline are preincubated alone, and DPN and ethanol are added only at the time at which activity measurements are started, the inhibition is noncompetitive with either substrate. It thus appears that zinc is a site of binding between DPN and ADH. (Contractor's abstract)

HAR. 07:026

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

YEAST ALCOHOL DEHYDROGENASE, A ZINC METALLOENZYME (Abstract), by B. L Vallee and F. L. Hoch. [1955] [1]p. [In cooperation with Peter Bent Brigham Hospital, Boston, Mass.] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Third International Congress of Biochemistry, Brussels (Belgium), 1955. Abstracts of Communications, p. 52, Aug. 1955.

The crystallized enzyme (mol wt 150, 000) contains 4 atoms of Zn, which are not removed by dialysis with water, though other metals (mainly Mg) are removed. The functional role and firm attachment of Zn to the rest of the enzyme molecule is shown by the concomitant rise of Zn and activity per gram of protein during purification while other elements decrease in concentration. The action of compounds with affinity for Zn in decreasing the activity of the enzyme increases in the order: dithizone; 1, 10-phenanthroline; 8 hydroxyquinoline, and α, α^1-dipyridyl. The oxidation of EtOH and the reduction of AcH are affected equally. Inhibition is prevented when Zn or Cu is added to the enzyme simultaneously with the chelating agent. Thus Zn is an integral functional componen of the enzyme. (C. A., 1957:8850h)

HAR. 07:027

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CYANOGEN-OXYGEN FLAME AS A SPECTROCHEMICAL SOURCE, by M. R. Baker and B. L. Vallee. Sept. 1955 [1]p. incl. diagr. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660]
AD 93617 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 45: 773, Sept. 1955.

A burner system was constructed allowing the combustion in equimolar proportions of the gases $(CN)_2$ and O_2, and the introduction of a sample solution into the burner as a fine fog in the O_2 stream. Spectra were obtained from samples containing various alkaline earths and transition elements. A sample spectrum shown was obtained on a 7-ft grating spectrograph (Jaco Jr. 15, 000 lines/in., Kodak 103-0 film), the exposure time of 4 min corresponding to a total of less than 1 μg of each element introduced into the flame. The $(CN)_2$-O_2 flame permits spectrochemical determination of elements not readily excited by conventional flames. Sensitivities of analyses exceeding those of the dc arc are indicated.

HAR. 07:028

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

LOW-TEMPERATURE ABSORPTION SPECTROSCOPY, by F. L. Hoch. [1955] [4]p. incl. diagr. table, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07660) Unclassified

Published in Jour. Chem. Education, v. 32: 469-472, Sept. 1955.

A review is presented of the development of the field of cryoabsorption spectroscopy (the study of the absorption of electromagnetic radiations by materials which are at low temperatures). The physical basis of this process is discussed. Developments in the design and construction of a suitable apparatus are reviewed. A number of

applications of this process are revealed and future applications are briefly explored. Ranging from 1892-1954, 40 references, domestic and foregin, are cited.

HAR. 07:029

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

GLUTAMIC DEHYDROGENASE OF BEEF LIVER, A ZINC METALLOENZYME, by B. L. Vallee, S. J. Adelstein, and J. A. Olson. [1955] [1]p. incl. table. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under N5ori-07660]) AD 101336 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 5t96, Oct. 5, 1955.

Several crystalline preparations of beef liver glutamic dehydrogenase were examined and it was found that zinc is an integral and functional component of the enzyme molecule. Fractionation of beef liver shows an aggregation of zinc with purification of the enzyme, and as the activity:protein ratio reaches its maximum value. The metal:protein ratio of all other elements studied decreases with progressive enzyme purification. The activity:zinc ratio increases progressively with purification. The rate of conversion of DPN to DPNH at pH 7.7 in the presence of glutamate is inhibited significantly when the enzyme is preincubated with a number of metal binding agents, including sodium sulfide, sodium diethyldithiocarbamate and 1, 10-phenanthroline. These data establish glutamic dehydrogenase as a zinc metalloenzyme. The oxidation of glutamic acid is the second DPN dependent dehydrogenation reaction known to be catalyzed by a zinc metalloenzyme.

HAR. 07:030

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CARBOXYPEPTIDASE, A ZINC METALLOENZYME, by B. L. Vallee and H. Neurath. [1955] [9]p. incl. diagr. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Scientific Research under N5ori-07660) AD 89317 Unclassified

Presented at Third International Congress of Biochemistry, Brussels (Belgium), Aug. 1955.

Also published in Jour. Biol. Chem., v. 217: 253-261, Nov. 1955.

Quantitative emission spectroscopy and chemical analyses established that crystalline pancreatic carboxypeptidase is a Zn metalloenzyme containing 1 atom of Zn/mol of enzyme protein. Metal analyses of the fractions attending the isolation of the enzyme from pancreatic extract showed that Zn is the only metal aggregated in the fractions with increasing enzymic activity. The Zn-activity ratios reached a constant value. Enzymic activity is inhibited by metal-chelating agents such as 8-quinolinol-5-sulfonic acid, 1, 10-phenanthroline, or 2, 2'-bipyridine. Zn is both a structural and functional component of carboxypeptidase and participates in the mechanisms of its catalytic action. (C. A., 1956:3523c)

HAR. 07:031

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

DIRECT READING FLAMESPECTROMETRY PRINCIPLES AND INSTRUMENTATION, by M. Margoshes and B. L. Vallee. [1956] 28p. incl. diagrs. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] PB 111743 Unclassified

A review is given of the development of instruments and techniques of flame spectrometry, as well as of various factors affecting light emission and its accuracie, precise measurement. The design characteristics and operation of a new direct-reading, multichannel flame spectrometer (see U 72411, item no. HAR. 07:008) is described in detail. Results of its use for analytic work and in studies of the nature of the excitation process in the flame are tabulated and discussed. Results of new investigations of interferences are included.

HAR. 07:032

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

FLAME PHOTOMETRY AND SPECTROMETRY. PRINCIPLES AND APPLICATIONS, by M. Margoshes and B. L. Vallee. [1956] [54]p. incl. illus. diagrs. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Methods of Biochemical Analysis, v. 3, D. Glick, ed. N. Y., Interscience Publishers, Inc., 1956, p. 353-407.

A review is presented of the principles and applications of flame photometry and spectrometry. The following items are outlined: (1) the historical background; (2) components of the flame photometer; (3) commercial instruments used; (4) sources of error in flame photometry; (5) handling of samples; (6) the internal standard principle in flame photometry; (7) the direct reading multichannel flame spectrometer with automatic background correction; and (8) current trends in flame photometry. Covering a time period from 1826-1956, 55 foreign and domestic references are cited.

HAR. 07:033 - HAR. 07:036

HAR. 07:033

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

THE SERRE GROUP $E_2^{p,q}$, by A. F. Bartholomay. [1956] [4]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Portugal. Math., v. 15: 31-34, 1956.

Let A be a graded differential group with a filtration. The group $E_2^{p,q}$ of the spectral sequence of A, defined by Serre (Ann. Math., v. 54: 425-505, 1951; MR, v. 13: 574) is shown in this paper to be equivalent to $E_2^{p,q}$ = (image f), where

$$f: H_{p+q}(A^p/A^{p-2}) \longrightarrow H_{p+q}(A^{p+1}/A^{p-1})$$

is the map

$$(ioj)_*: H_{p+q}(A^p/A^{p-2}) \longrightarrow H_{p+q}(A^p/^{p-1}) \longrightarrow$$

$$H_{p+q}(A^{p+1}/A^{p-1})$$

induced on the homology groups by the maps associated with the inclusions among the (A^p). (Math. Rev. abstract)

HAR. 07:034

Harvard U. Medical School. Biophysics [Research] Lab., Boston, Mass.

ANODE TEMPERATURES AND CHARACTERISTICS OF THE DC ARC IN NOBLE GASES, by B. L. Vallee and M. R. Baker. July 22, 1955 [6]p. incl. illus. refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 121537 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 46: 77-82, Feb. 1956.

The construction of a gas-tight arcing chamber and continuously-recording optical pyrometer is described. The system is reproducible. The current and voltage of the dc carbon arc in noble gases show a sensitive and systematic dependence on the atmospheres employed. A small admixture of a foreign gas, such as air, markedly alters the characteristics of the arc. The arc voltage for fixed current decreases in the order He, Ne, A, and Kr; the power input decreases in the same order. The anodic temperature is linearly related to the power input. The behavior of the cross sections of the gases to electrons in the energy range of the Ramsauer-Townsend effect is suggested as a major contributor to the observed behavior of the dc arc in noble gases. (Contractor's abstract)

HAR. 07:035

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

THE EFFECT OF ALKALI AND ALKALINE EARTH CHLORIDES ON THE ANODE TEMPERATURE OF THE DC ARC, by B. L. Vallee and R. E. Thiers. Feb. 1956 [5]p. incl. diagrs. table, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Jour. Opt. Soc. Amer., v. 46: 83-86, Feb. 1956.

Temperatures of graphite anodes have been measured for the dc arc in helium and argon by means of a recording thermistor pyrometer when pure chlorides of the alkali and alkaline earth metals are present as samples. Anode temperatures and gap voltages were depressed by all of the samples. The data for helium indicate a correlation of anode temperature to the boiling point of the sample salt and the lowest excitation potential of the cation. Correlation was also observed between the boiling point of the salt and its rate of volatilization. Temperatures in argon are lower and correlation between anode temperatures and either boiling points or excitation potentials was not observed. However, rates of volatilization were related to the boiling points and excitation potentials of the samples. These effects are large enough to account for the poor precision of the dc arc as a spectrochemical source and show the physical-chemical basis for the use of "spectroscopic buffers." (Contractor's abstract)

HAR. 07:036

Harvard U. Medical School. Biophysics [Research] Lab., Boston, Mass.

INSTRUMENTATION AND PRINCIPLES OF FLAME SPECTROMETRY. 1. MULTICHANNEL FLAME SPECTROMETER, by B. L. Vallee and M. Margoshes. July 19, 1955 [5]p. incl. illus. table, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 89315 Unclassified

Also published in Anal. Chem., v. 28: 175-179, Feb. 1956.

An instrument for the simultaneous photoelectric determination of several elements, using a flame source, is described. The instrument consists of an oxygen-hydrogen burner, a grating monochromator, photomultiplier detectors, and associated power supplies, amplifiers, and meters. Five elements — sodium, potassium, magnesium, calcium, and strontium — are determined simultaneously. The instrument detects as little as 0.002Y of sodium in 1 ml of water. The

calibration curves cover a 1000-fold range of concentrations for each element. The precision of the instrument is within 1 to 2%.

HAR. 07:037

Harvard U. Medical School. [Biophysics Research Lab.] Boston, Mass.

INSTRUMENTATION AND PRINCIPLES OF FLAME SPECTROMETRY. II. EFFECT OF EXTRANEOUS IONS IN SIMULTANEOUS DETERMINATION OF FIVE ELEMENTS, by M. Margoshes and B. L. Vallee. July 19, 1955 [5]p. incl. illus. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 89316 Unclassified

Also published in Anal. Chem., v. 28: 180-184, Feb. 1956.

The effects of extraneous ions on flame spectrometer or photometric analyses have been studied with the multichannel flame spectrometer. Extraneous cations produce heterochromatic background radiation and have no effect on the monochromatic emission intensity measured above background. A method of background correction is described. The precision of the correction depends upon the line-to-background ratio. Certain anions are shown to reduce the emission intensity of the alkaline earths. These anions form compounds with the alkaline earths with high melting and boiling points; their crystals, formed in the spray, do not evaporate during their passage through the flame. Methods of obviating anion interference are discussed briefly. (See also item no. HAR. 07:046) (Contractor's abstract)

HAR. 07:038

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

THE PHYSICAL BASIS OF LINE ENHANCEMENT IN ARGON AND KRYPTON, by M. R. Baker, S. J. Adelstein, and B. L. Vallee. Feb. 1956 [3]p. incl. illus. diagrs. tables. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Published in Jour. Opt. Soc. Amer., v. 46: 138-140, Feb. 1956.

The enhancement of certain metallic ion lines, obtained from the dc arc in atmospheres of argon, krypton, and helium has been examined. The ratios of the intensities of these lines in argon to their intensities in helium and krypton are maximal for those whose excitation potentials (EP) lie in the vicinity of the EP of the lower excited energy levels of argon. This observation is accounted for by the following mechanism. The noble gas is energized to its lowest excited levels by the arc discharge through collisions of the second kind. This energy is transferred to neutral metal atoms volatilized in the arc. The metal atoms are thus ionized and excited; they then fall to the ground state emitting their characteristic radiation. The maximum energy is transferred from argon to metal atoms when the energy of the excited noble gas atom equals the EP of the metal ion line, resulting in the selective enhancement observed. (Contractor's abstract)

HAR. 07:039

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

INHIBITION OF YEAST ALCOHOL DEHYDROGENASE BY METAL BINDING AGENTS (Abstract), by F. L. Hoch and B. L. Vallee. [1956] [2]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at meeting of the Amer. Physiol. Soc., Atlantic City, N. J., Apr. 16-20, 1956.

Published in Fed. Proc., v. 15: 93, Mar. 1956.

Yeast alcohol dehydrogenase (ADH), containing 4 functional atoms of zinc per molecule has previously been shown to be inhibited by certain agents having high affinity for zinc. Yeast ADH is now shown to be inhibited by other metal-binding agents such as BAL, thiosemicarbazide, azide, cupferron and diethyldithiocarbamate. The degree and rate of inhibition are a function of the concentration of inhibitor and the pH, time, and temperature of incubation of the agents with ADH. The effects of DPN, DPNH, ethanol, and acetaldehyde on the inhibition produced by incubation with orthophenanthroline (OP) have been studied in detail. The degree of inhibition is reduced only when DPN is added to ADH at the same time or before OP is added. When DPNH, ethanol or acetaldehyde are added to ADH before OP, inhibition is more rapid and complete than when OP is added alone. DPN competes with OP, but DPNH does not, as shown by kinetic experiments. It thus appears that the zinc of [(ADH)Zn_4] is a site of interaction between DPN and ADH, an interaction which differs from that of DPNH with [(ADH)Zn_4] under these conditions. (Contractor's abstract)

HAR. 07:040

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

INTERACTION OF BEEF LIVER GLUTAMIC DEHYDROGENASE WITH METAL BINDING AGENTS (Abstract), by S. J. Adelstein and B. L. Vallee. [1956] [1]p. (In cooperation with Peter Bent Brigham

Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at annual meeting of the Amer. Soc. for Exper. Pathol., Atlantic City, N. J., Apr. 15-16, 1956.

Published in Fed. Proc., v. 15: 505, Mar. 1956.

Beef liver glutamic dehydrogenase contains 4-5 gm atoms of zinc/mol of protein based on a molecular weight of 10^6. As the activity/zinc ratio reaches a maximum value with progressive purification and crystallization, there is an aggregation of zinc and virtual disappearance of all other metals. Zinc is firmly bound to this relatively heat stable enzyme. The oxidation and reduction of DPNH and DPN is inhibited by incubating the enzyme with a number of metal binding agents: Na_2S, BAL, azide, orthophenanthroline (OP), thiourea, diethyldithiocarbamate (NaDDC), tetraethylthiuram disulfide (Antabuse), 8-hydroxyquinoline and ammonium N-nitrosophenylhydroxylamine (cupferron). In several instances the inhibition has been prevented by the addition of DPN prior to incubation of the enzyme with these reagents. In the presence of a large excess of complexing agent, the initial rate of inhibition is found to be first order with respect to enzyme concentration. This reaction rate has been studied both as a function of temperature and inhibitor concentration. The concentration dependence of the inhibition by various complexing agents has also been investigated at equilibrium. (Contractor's abstract)

HAR. 07:041

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

METAL CONTENT OF SUBCELLULAR RAT LIVER FRACTIONS (Abstract), by R. E. Thiers and B. L. Vallee. [1956] [1]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at annual meeting of the Amer. Soc. of Biol. Chemists, Atlantic City, N. J., Apr. 16-20, 1956.

Published in Fed. Proc., v. 15: 370, Mar. 1956.

The amount and distribution of manganese, zinc, calcium, iron, magnesium, sodium and potassium in rat livers and their subfractions were determined by spark and flame spectroscopy. The livers of 25 normal rats were analyzed in groups of 5. Each liver was perfused with metal-free 0.25 M sucrose; 5 livers were then pooled, the connective tissue was removed and fractionation was performed by differential centrifugation. Connective tissue, nuclei and whole cells, mitochondria, microsomes and all supernatant fluids were obtained in known yield. Each fraction was analyzed by a micro-Kjeldahl method for nitrogen, by flame spectrometry for sodium and potassium, and by spark spectrography for the other elements. The resulting data are presented as amounts and concentrations of the metals in each sample and their absolute and relative distributions between the fractions. The differences in metal content of the various subfractions proved to be statistically significant. Each showed a definite and characteristic pattern both with regard to the concentration of metals and share of the total amount of each metal. (Contractor's abstract)

HAR. 07:042

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

ZINC, A COMPONENT OF ALCOHOL DEHYDROGENASE OF HORSE LIVER (Abstract), by B. L. Vallee and F. L. Hoch. [1956] [2]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at meeting of the Amer. Physiol. Soc., Atlantic City, N. J., Apr. 16-20, 1956.

Published in Fed. Proc., v. 15: 619, Mar. 1956.

The molecular weight of horse liver ADH is 73,000, and it contains 2 mol of zinc. Spectrographic, microchemical, polarographic and enzymatic examination of horse liver ADH demonstrate a concomitant rise of zinc and enzymatic activity with increasing purification. The zinc content approaches 2 mol of zinc/mol of enzyme in highly purified crystalline horse liver ADH. Simultaneously, extraneous metals are removed. The enzyme is inhibited by chelating agents such as orthophenanthroline, 8-hydroxyquinoline, and sodium diethyldithiocarbamate. The inhibition is a function of temperature, time, pH and concentration of inhibitor. The molecular configuration and dentate structure of the chelating agents employed condition the inhibition significantly. The effect of DPN and DPNH on the inhibition of chelating agents will be discussed. Zinc is firmly bound to the apoenzyme, and the active complex has been assigned the empirical formula $[(AD)Zn_2](DPN)_2$. (Contractor's abstract)

HAR. 07:043

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

ZINC, A COMPONENT OF RABBIT MUSCLE LACTIC DEHYDROGENASE, by B. L. Vallee and W. E. C. Wacker. [1956] [2]p. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] AD 121540 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1171-1772, Apr. 20, 1956.

Zinc was the only element conststently present tn high concentration tn crystalltne lactic dehydrogenase; the exact amount was a function of the purtty of the enzyme. Zn ts a functional component of the lactic dehydrogenase of rabbtt muscle. The activity of the enzyme ts markedly inhibited by metal-bindtng agents. (C. A., 1956:9477b)

HAR. 07:044

[Harvard U. Medtcal School. Btophysics Research Lab., Boston, Mass.]

THE RELATION OF COPPER TO CERULOPLASMIN ACTIVITY AND ZINC TO MALIC AND LACTIC DEHYDROGENASE ACTIVITY IN ACUTE MYOCARDIAL INFARCTION (Abstract), by W. E. C. Wacker, S. J. Adelstetn and others. [1956] [2]p. [In cooperation wtth Peter Bent Brtgham Hosptal, Boston, Mass.] [Sponsored jotntly by Offtce of Naval Research and Air Force Office of Scientiftc Research under N5ort-07660] Unclasstfied

Presented at annual meeting of the Amer. Soc. for Clin. Invest., Atlantic Ctty, N. J., Apr. 30, 1956.

Published in Jour. Clin. Invest., v. 35: 741-742, June 1956.

A study of serum metalloenzymes in acute myocardial infarction was conducted. It has been observed that the serum copper concentration rtses and becomes maximal between the fifth and eleventh post-infarction day, and the serum zinc concentration is significantly decreased in this disease. The data indicate an increased rate of paraphenylenedtamine oxidation in the patient's sera tn proportion to the rise in serum copper content. Also the enzymatic activtty of malic and lactic dehydrogenases ts significantly elevated. The increase tn malic and lactic dehydrogenase and the decrease of serum zinc occur within 24 hours followtng the acute injury becoming maximal on the thtrd post-tnfarction day. The apparently paradoxical reciprocal relationship between serum zinc concentratton and zinc dehydrogenase activtty can be explained on the basis of btochemtcal ftndtngs. Lactic dehydrogenase and malic dehydrogenase acttvtties are being employed as routtne atds to diagnose myocardtal tnfarction. These methods are simple and rapid. They represent valuable adjuvants in the management of thts disease providing pertinent information not available by non-enzymatic techniques. (Contractor's abstract)

HAR. 07:045

[Harvard U. Medtcal School. Biophysics Research Lab., Boston, Mass.]

THE SEQUENTIAL PROBABILITY RATIO TEST, A NEW STATISTICAL PROCEDURE FOR CLINICAL INVESTIGATION; ITS VALIDATION IN A STUDY OF SERUM ZINC CONCENTRATION IN LAENNEC'S CIRRHOSIS (Abstract), by A. F. Bartholomay. [1956] [1]p. [In cooperation wtth Peter Bent Brtgham Hosptal, Boston, Mass.] [Sponsored jointly by Offtce of Naval Research and Atr Force Offtce of Sctentific Research under N5ort-07660] Unclassified

Presented at annual meettng of the Amer. Soc. for Clin. Invest., Atlantic Ctty, N. J., Apr. 30, 1956.

Published in Jour. Clin. Invest., v. 35: 688, June 1956.

The Sequential Probabtlity Ratio Test (SPRT) has been used tn a clinical experimental design to detect differences tn serum zinc concentrations in normal and ctrrhottc tndtvtduals. The mean normal zinc concentration was 120 ± 19 μg per 100 cc. After only 9 abservations the SPRT tndtcated that the corresponding concentration tn clrrhosts ts below 82 μg per 100 cc, 2σ less than the normal mean. To validate this conclusion the ztnc concentration was measured tn a total of 28 sera. The mean of this group was 66.7 ± 19.2 μg per 100 cc — a most stgniftcant devtation from the normal value, and corroborated the prediction made by the SPRT. The results of thts study tndtcate the superiortty of the use of the SPRT tn clinical expertmental design as compared wtth the classtcal statistical methods. (Contractor's abstract)

HAR. 07:046

Harvard U. Medtcal School. Btophysics Research Lab., Boston, Mass.

INSTRUMENTATION AND PRINCIPLES OF FLAME SPECTROMETRY. [III] AUTOMATIC BACKGROUND CORRECTION FOR MULTICHANNEL FLAME SPECTROMETER, by M. Margoshes and B. L. Vallee. [1956] [4]p. (In cooperatton wtth Peter Bent Brigham Hosptal, Boston, Mass.) [Sponsored jotntly by Office of Naval Research and Atr Force Office of Sctenttftc Research under N5ort-07660] Unclassified

Published in Anal. Chem., v. 28: 1066-1069, July 1956.

An adaptation of a multtchannel flame spectrometer to automattcally correct for background radiation is descrtbed. Background tntensity is measured to one or both stdes of each line or band and is subtracted automatically from the line-plus-background tntensity measured at the peak of the line or band. The performance of the instrument wtth this modification is discussed. Very high concentrattons — above about 1 g per liter — of some salts cause a depression of emisston intensity in the flame. This depression can be elimtnated by addttton of ethyl alcohol to the solutions. A possible cause of this depression in emtssion tntensity is discussed. (See also ttem nos. HAR. 07:036 and HAR. 07:037.) (Contractor's abstract)

HAR. 07:047 - HAR. 07:050

HAR. 07:047

Harvard U. Medical School. [Biophysics Research Lab.] Boston, Mass.

KINETIC STUDIES ON THE ROLE OF ZINC AND DIPHOSPHOPYRIDINE NUCLEOTIDE IN THE ACTIVITY OF YEAST ALCOHOL DEHYDROGENASE, by F. L. Hoch and B. L. Vallee. Oct. 24, 1955 [10]p. incl. illus. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 121539 Unclassified

Also published in Jour. Biol. Chem., v. 221: 491-500, July 1956.

The kinetics of the interaction between DPN and 1, 10-phenanthroline, a Zn-binding inhibitor of ADH activity, were studied to elucidate the mechanism of action of yeast [$(ADH)Zn_4$]. Inhibition of ADH activity is competitive between OP and DPN. When DPN is added to ADH before OP, inhibition of activity is decreased, indicating protection of the enzyme against the action of OP. When DPN is added to ADH after OP, activity is not changed, indicating that there is no restoration of activity in the OP-inhibited enzymes. Two molecules of OP seem to bind to 1 Zn atom of [$(ADH)Zn_4$] to form the inactive enzyme-inhibitor complex [$(ADH)Zn_4$]-$(2OP)_4$; the apparent dissociation constant, K_{op}, is 6.5×10^{-6} M. The data indicate that 1 molecule of DPN binds to each Zn atom of yeast [$(ADH)Zn_4$] to form the active enzyme-coenzyme complex [$(ADH)Zn_4$]$(DPN)_4$. (Contractor's abstract)

HAR. 07:048

Harvard U. Medical School. [Biophysics Research Lab.] Boston, Mass.

METALLOENZYMES AND MYOCARDIAL INFARCTION. I. THE RELATION BETWEEN SERUM COPPER AND CERULOPLASMIN AND ITS CATALYTIC ACTIVITY, by S. J. Adelstein, T. L. Coombs, and B. L. Vallee. [1956] 5p. incl. illus. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 109669 Unclassified

Also published in New England Jour. Med., v. 255: 105-109, July 19, 1956.

Serum from normal subjects, pregnant women and patients suffering from acute myocardial infarction was analyzed for total serum copper concentration, ceruloplasmin content and paraphenylenediamine and benzidine oxidative capacity. Benzidine oxidase was elevated in patients with acute myocardial infarction to an extent greater than could be accounted for by the copper elevation alone. A linear relation between copper concentration, ceruloplasmin content and paraphenylenediamine oxidation was found for all three groups. (Contractor's abstract)

HAR. 07:049

Harvard U. Medical School. [Biophysics Research Lab.] Boston, Mass.

ZINC METABOLISM IN HEPATIC DYSFUNCTION. I. SERUM ZINC CONCENTRATIONS IN LAENNEC'S CIRRHOSIS AND THEIR VALIDATION BY SEQUENTIAL ANALYSIS, by B. L. Vallee, W. E. C. Wacker and others. [1956] [6]p. incl. illus. table, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660) AD 109670 Unclassified

Also published in New England Jour. Med., v. 255: 403-408, Aug. 30, 1956.

The discovery of several zinc dehydrogenases in liver led to the study of zinc metabolism in cirrhosis. Serum zinc concentrations were lowered significantly in patients with cirrhosis of the liver. The concentrations of zinc found bore a relation to the severity of the disease and its fluctuating course. A group of 28 patients with the stigmas of advanced cirrhosis had a serum zinc concentration of 66 ± 19 μg, as compared to 120 ± 19 μg per 100 ml for a normal group. The sequential probability ratio test was incorporated into the experimental design and was found to be an important innovation in validation of clinical investigative data. (Contractor's summary)

HAR. 07:050

Harvard U. Medical School. [Biophysics Research Lab.] Boston, Mass.

METALLOENZYMES AND MYOCARDIAL INFARCTION. II. MALIC AND LACTIC DEHYDROGENASE ACTIVITIES AND ZINC CONCENTRATIONS IN SERUM, by W. E. C. Wacker, D. D. Ulmer, and B. L. Vallee. [1956] 7p. incl. illus. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07660) AD 109771 Unclassified

Also published in New England Jour. Med., v. 255: 449-456, Sept. 6, 1956.

Serum lactic and malic dehydrogenase are stable in all human serum studied and readily assayed. Activities for both were elevated two or ten times above those normally observed in all cases of clinically proved myocardial infarction. Serum zinc levels are lowered significantly after acute myocardial infarction. Serum lactic dehydrogenase activity is not elevated in angina pectoris, severe coronary insufficiency and myocardial ischemia. Although serum lactic dehydrogenase rises in other

pathologic states, such as renal necrosis and parenchymal liver disease, it is relatively precise and useful to employ this test for the diagnosis of acute myocardial infarction.

HAR. 07:051

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

CYANOGEN-OXYGEN FLAME. NEW SOURCE FOR QUANTITATIVE DETERMINATION OF MICROGRAM AMOUNTS OF METALS, by B. L. Vallee and A. F. Bartholomay. Nov. 1956 [3]p. incl. diagrs. table, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under N5ori-07660]) Unclassified

Published in Anal. Chem., v. 28: 1753-1755, Nov. 1956.

The C_2N_2-O_2 flame was successfully employed as a spectro-chemical source for the quantitative determination of Al, Ba, Ca, Co, Cr, Cu, Fe, Pb, Mg, Mn, Ni, and Sr. Absolute amounts varying from 0.36 to 36.0 γ of metals could be determined. The intensity of radiation emitted is constant with time, and the spectra excited are relatively simple. The toxicity of C_2N_2 occasioned precautions but dit not present any problems. (Contractor's abstract, modified)

HAR. 07:052

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

THE METABOLIC ROLE OF ZINC, by B. L. Vallee. [1956] [5]p. incl. refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07660] Unclassified

Presented at the Symposium on Some Inorganic Elements in Human Nutrition, Nashville, Tenn., Apr. 4, 1955.

Published in Jour. Amer. Med. Assoc., v. 162: 1053-1057, Nov. 10, 1956.

A review is presented of some of the salient facets of the physiological, biochemical, and clinical implications of zinc metabolism with emphasis on recent observations.

HAR. 07:053

Harvard U. Medical School. Biophysics Research Lab., Boston, Mass.

PYRIDINE NUCLEOTIDE DEPENDENT METALLOHYDROGENASE, by B. L. Vallee, F. L. Hoch and others. [1956] [5]p. incl. tables, refs. (In cooperation with Peter Bent Brigham Hospital, Boston, Mass.) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research under N5ori-07660]) Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 5879-5883, Nov. 20, 1956.

The demonstration of zinc as a functional component of four highly purified dehydrogenases had led to the proposition that metals participate in the catalytic activity of other pyridine nucleotide dependent enzymes. This hypothesis was tested by emission spectrochemical analysis for metal content and by inhibition of activity. The following dehydrogenases were examined: the glyceraldehyde 3-phosphate of yeast and of rabbit muscle, the α-glycerophosphate of rabbit muscle, the malic of pig heart and the glucose 6-phosphate of yeast (TPN dependent). All of these enzymes were inhibited significantly by exposure to 1,10-phenanthroline, 8-hydroxyquinoline and sodium diethyldithiocarbamate. They contained zinc, iron and copper as the only elements combining with all three chelating agents employed as inhibitors. The data indicate one of these metals, possibly zinc, to be involved in the mechanisms of action of the dehydrogenases, which are now referred to as pyridine nucleotide dependent metallodehydrogenases (PMD). The determination of the metal, specific to each enzyme, awaits further study. This delineation emphasizes the salient role of metals in oxidative, enzymatic catalysis. (Contractor's abstract)

Haverford Coll., Pa. <u>see under</u> Pennsylvania U., Philadelphia AF 18(600)660, items nos. PEN. 01:001 - PEN. 01:005.

HEI. 01:001

Heidelberg U. Pharmacological Inst. (Germany).

FATE OF ENERGY-RICH PHOSPHATES IN RED BLOOD CELLS AND BRAIN IN ANOXIC STATES, by F. Eichholtz, E. Gerlach, and J. Döring. Technical rept. May 1, 1955-Apr. 30, 1956. July 18, 1956 [12]p. incl. diagrs. table. (AFOSR-TN-56-404) (AF 61(514)823) AD 96212 Unclassified

An effort was made to solve the problem of biochemical changes in brain tissue in states of anoxia and their prevention (or repair) by chemicals inducing increased resistance against anoxia. A method was developed for the estimation of energy-rich phosphates in red corpuscles and brain. The main advantage of the method is reliability, the error seeming to be less than 5%. Experiments were started with human erythrocytes. Results indicated that anoxemia does not lead to any change in the content of energy-rich phosphates. Experiments were also performed to determine the effects of anoxemia on energy-rich phosphates in rat's brain. Results indicated that a stop of brain circulation for 1 min produced a breakdown of CP (creatine phosphate) of about 40%, while the decrease in energy-rich nucleotides, especially ATP

HER. 01:001 - HER. 02:003

(adenosinetriphosphate), is still very small. But after an interruption of brain-circulation for 3 min a considerable fall in the content of all energy-rich phosphates, mainly CP, ATP, and GTP (guanosinetriphosphate), could be observed with a corresponding increase in orthophosphates and AMP (adenosinemonophosphate). Under the same conditions Verbindung X (compound X) remained nearly unchanged.

HER. 01:001

Hermann Föttinger Insl. für Sirömungstechnik, Technische Universität, Berlin-Charlottenburg (Germany).

VORTEX MOTION AND TURBULENCE OF FREE JETS IN STEADY FLOW, by U. Domm and O. Wehrmann. Final repl. Dec. 1, 1953-Nov. 30, 1954, 36p. illus. diagrs. refs. ([AF]OSR-TN-55-118) (AF 61(514)-629-C) AD 76722 Unclassified

Experimental results are reported on the structure of a free air jet, stable in the mean Reynolds number values, near the nozzle; the design and operation of the low-pressure chamber containing the free jet are described. Hot-wire measuring techniques have been applied for determining velocity distributions and vortex-frequencies. The problem of hot-wire calibration at low free stream velocities has been treated using three methods. A comparative study proved that the stable vortex frequency behind cylindrical bodies is the best means for calibrating hot-wires at low velocities. The wiring diagrams of the applied hot-wire techniques are included. Hot-wire measurements indicated that, in the range of the Reynolds number $1830 < Re < 14700$, the free jet in the neighborhood of the nozzle has a periodic structure in time and in space as a function of the velocity. This periodic structure results from a system of annular vortices. The frequency of vortex generation and the group-velocity of the system have been measured. Finally the terms "Anlauflange" (start-length) and "Lauflange" (run-length) have been defined, and examples of measurements are included. These investigations are to be continued. A detailed description is included of a newly developed hot-wire instrument equipped with automatic control of the constant temperature of the hot-wire and having a linearization stage for the signal. (Contractor's abstract)

HER. 02:001

[Hermann Föttinger Insl. für Strömungstechnik, Technische Universität, Berlin-Charlottenburg (Germany).]

THE STABILITY OF VORTEX STREETS WITH CONSIDERATION OF THE SPREAD OF VORTICITY OF THE INDIVIDUAL VORTICES, by U. Domm. Nov. 5, 1954, 5p. [AF 61(514)808) Unclassified

Published in Jour. Aeronaut. Sciences, v. 22: 750-754, Nov. 1955.

The stability of vortex streets consisting of 2 parallel rows of staggered real vortices of identical structure whose vorticity spreads with time into the ambient fluid is considered. It is found that for the case of stability, the ratio of centerline width and pitch of the street is a function of the nondimensional time $\tau = (4\nu/l^2)t$, where ν = kinematic viscosity, l = pitch of the vortex street and t = time. For vanishing viscosity and also for vanishing time, the value calculated by von Kármán, $k = h/l = 0.281$, is obtained. (Contractor's abstract)

HER. 02:002

Hermann Föttinger Insl. für Strömungstechnik, Technische Universität, Berlin-Charlottenburg (Germany).

HOT-WIRE ANEMOMETER FOR MEASUREMENTS IN UNSTEADY FLOW, by O. Wehrmann and R. Wille. [1955] [25]p. incl. illus. diagrs. refs. [AFOSR-TN-56-26] (AF 61(514)808) AD 84466 Unclassified

This hot-wire instrument utilizes carrier-frequency amplification and automatic control of the constant wire temperature. The output is linearized. The following assemblies are provided: (1) an amplifier and demodulator stage for amplification and demodulation of the bridge voltage for obtaining an amplified dc voltage at the output proportional to the bridge voltage; (2) an oscillator, control, and power stage for generating a dc voltage with a constant amplitude and a low harmonic content, using the dc voltage produced by the assembly in the control stage for the modulation of the ac voltage supplied by the generator stage, and for producing an output of 25 w in the power stage to meet measuring conditions; and (3) a linearizing stage for forming the logarithm inherent to the measuring value, multiplying this value with the desired exponent of the linearization function, forming the antilogarithm of this value, and amplifying the linearized function for immediate application to the deflecting plates of an oscillograph. The instrument was designed originally for measuring the periodical velocity changes in the scavenging ports of a model 2-stroke engine. An example of its application is given. Researchers studying the free jet are using the instrument for determining the distribution of the mean velocity. The components of the anemometer are discussed separately. (ASTIA abstract)

HER. 02:003

Hermann Föttinger Inst. für Strömungstechnik, Technische Universität, Berlin-Charlottenburg (Germany).

ON THE STABILITY OF VORTEX STREETS, by U. Domm. [1955] 22p. incl. diagr. refs. [AFOSR-TN-56-27] (AF 61(514)808) AD 84465 Unclassified

A survey is made of the status of research on the stability problem of vortex streets. Analysis shows that the von Kármán vortex street is unstable even in the case of the classical condition $h/l = 0.281$, where h is the width of the vortex street and l is a constant. A

class of vortex streets of lowest tnstabtlity ts shown to exist which contains the von Kármán vortex street as the element of lowest translattonal velocity and largest wtdth under equal assumed ctrculatton and spactng condttions. The tnfluence of tnternal flutd frictton and compresstbtlity are constdered.

HER. 02:004

Hermann Föttinger Inst. für Strömungstechnik, Technische Universttät, Berltn-Charlottenburg (Germany).

CONTRIBUTIONS ON THE MECHANICS OF LAMINAR-TURBULENT TRANSITION OF JET FLOW, by U. Domm, H. Fabian and others. Ftnal rept. Nov. 1955 [52]p. incl. tllus. diagrs. refs. (AFOSR-TR-56-9) (AF 61-(514)808) AD 82004 Unclassified

An analytical and experimental study of free jet flow with emphasts on the phenomena occurrtng tn the ftrst few dtameters downstream from the nozzle has been made. In the analytical treatment, the annular vortex system ts tdealtzed as a plane system in an tdeal flutd. An equation for the trajectories ts derived and tt ts shown that the vortex system ts an unstable equtltbrtum. Expertmental studies were conducted by drawtng atmospherte atr into a cyltndrical chamber, 2-m tn dtameter and 6-m long, through a nozzle. Nozzles of 1.0, 2.5, 5.0, and 10-cm tn dtameter were used. Mean-velocity and velocity-fluctuation measurements were made by a conventtonal hot-wtre technique. It was located on a probe mechanism wtthin the chamber. For mean-velocity measurements a Wheatstone bridge circuit was used, and for velocity fluctuations an osctlloscope was employed in conjunction with constant current operatton of the hot wire. Fluctuation-frequency and frequency-spectrum measurements were also made using a frequency meter and a harmonic wave analyzer. Experimental mean-velocity profiles are shown tn several planes normal to the jet axis at dtstances up to four nozzle dtameters downstream from the nozzle. The results of velocity-fluctuation measurements are correlated with the nozzle efflux Reynolds number in the range from 0 to 25,000. The growth in the amplitude of the fluctuations along the jet ts very clearly shown. Some preliminary results are reported on the measurement of the frequency of fluctuations of various amplitudes.

HOR. 01:001

Horizons Inc., Cleveland, Ohio.

INVESTIGATION OF A NEW METHOD FOR THE DETERMINATION OF THE COEFFICIENTS OF SURFACE DIFFUSION OF METALS, by P. F. Mataich. Ftnal rept. Sept. 10, 1956, 57p. incl. tllus. dtagrs. refs. (AFOSR-TR-56-54) (AF 18(600)644) AD 110344 Unclassifted

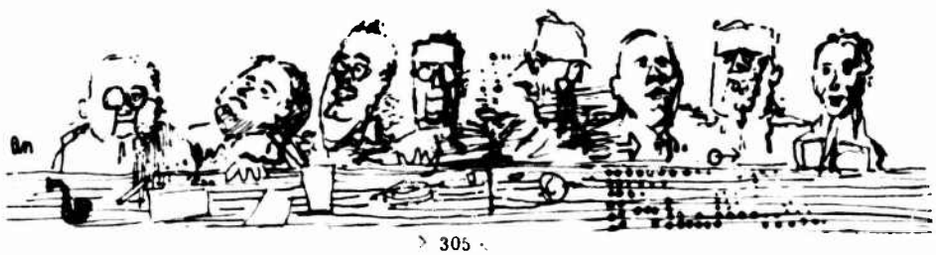
The 3 bastcally dtfferent methods of measurement studted were: (1) an optical method which follows the hetght changes of a dtffustng strtp by ustng interferometrtc measurements; (2) an electrolytic method which utilizes a soltd electrolyte to transform the mass flow of the diffustng atoms into an electrtc current; and (3) an autoradiographic method whtch utilizes photographic processes to trace the progress of the dtffustng atoms. For the tnterferometrtc method, differences tn surface level could be theoretically determtned with accuractes of ±10 Angstrom units under tdeal condittons. This method gave conststent reproducible results when the base surface was made sufftctently flat. For the different electrolytic systems studied, the diffuston rate was so low that tt was masked by background currents inherent tn the system. The autoradiographic measurements varted wtth the film and the small devtations in the processtng techniques. However, the radtoactive technique has an tmportant advantage in cases where the dtffustng layer is very thin. In these cases, the exposure time could be increased to the potnt where the layer becomes vtsible whereas the interferometrtc method would not be sensttive enough to show the layer at all. The autoradtographic and tnterferometrtc methods can supplement each other. (ASTIA abstract)

HOR. 02:001

Hortzons, Inc., Cleveland, Ohio.

RESEARCH IN ELECTRICIAL PROPERTIES OF INTERMETALLIC COMPOUNDS, by T.-S. Ltu and R. Bobone. Final rept. May 1, 1953-June 30, 1954. July 22, 1954, 41p. incl. tllus. diagrs. tables. ([AF]OSR-TR-54-20) (AF 18(600)774) AD 40535 Unclasstfied

Research concerned the preparation and electrical measurements of Nt-Al alloys and Ni-Al-Cu ternary alloys in the cubic β region. The measurements show that the locus of minima of the resistivtty for the Nt-Al-Cu ternartes ts to be found wtthin a strip contatning the transition ltne from nondefect to defect structures. Measurements of resistivtty and thermoelectric power vs temperature are gtven. A qualitative explanatton of the main features in the electrical behavior of the above alloys, based on the Brtlloutn zone theory, is included. (ASTIA abstract)



IIT. 01:001 - IIT. 03:001

IIT. 01:001

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

FUNDAMENTAL STUDIES ON SCINTILLATION PHOSPHORS, by G. M. Burgwald and L. Retffel. (Ftnal rept.) July 9, 1953, 56p. tncl. tllus. dtagrs. tables. (AF 18-(600)352) Unclasstfted

A study is descrtbed of the nature of afterflow in inorgantc sctnttliatton phosphors when bombarded by high energy gamma radiation. The afterflow characteristtcs of several of the more tmportant sctntillatton phosphors were studted, both under standard condttions and under variable temperature and pressure. All of the tmportant tnorganic phosphors studied exhtbtt varytng degrees of afterflow, and tn cases where the level of activtty being measured vartes by orders of magnitude, the effect of restdual ltght from the crystal becomes tmportant. (Contractor's abstract)

IIT. 01:002

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

PRESSURE EFFECTS IN PHOSPHORESCENCE, by L. Retffel. Jan. 25, 1954 [1]p. tncl. dtagr. table. [AFOSR-TR-54-7] [AF 18(600)352] Unclassified

Published in Phys. Rev., v. 94: 856, May 15, 1954.

The influence of hydrostatic stress on the phosphorescence decay of thallium activated sodtum todide ts shown to be very marked. Pressures as low as 100 kg/sq cm produce readily observable effects. Interpretation tn terms of pressure-increased effective trap depth is given. (Contractor's abstract)

IIT. 02:001

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

A STUDY OF A FAMILY OF LAVES-TYPE INTERMEDIATE PHASES, by R. P. Elliott. Aug. 1954, 65p. incl. dtagrs. tables, refs. (Technical rept. no. 1) ([AF]OSR-TN-54-247) (AF 18(600)642) AD 42490 Unclasstfted

Fourteen transition elements were examined for the occurrence of the Laves-type intermediate compounds (Metallwtrtschaft, v. 14: 645, 1935). Laves-type compounds are of the form AB_2, and 3 crystal types characteristic of the phases are $MgCu_2$, $MgZn_2$, and $MgNi_2$. Alloys were prepared by arc-melting or by powder-metallurgical techniques at ccmposttions considered to be of these crystal types. After the identtfication of such compounds by x-ray powder camera techniques, the occurrence of allotropy was tnvesttgated by annealing at 200°C intervals from 600°C to the melting temperature. Lattice parameters and crttical tnteratomtc spactngs are reported. The ftndtngs tndtcated that a crttical d_A/d_B ratio was necessary for the existence of a Laves-type AB_2 phase (where d_A and d_B are the atomtc dtameters of A and B atoms), but tt was not sufftctent to govern tts extstence. A conststent decrease tn the atomtc dtameters compared to the elemental state was evtdenced by the tntersection of the distortton of the A-A and B-B bonds at negative distortion values. The $MgCu_2$ structure seemed to occur at lower electron-atom ratios and the $MgZn_2$ structure at higher electron-atom ratios. (ASTIA abstract)

IIT. 02:002

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

A STUDY OF A FAMILY OF LAVES-TYPE INTERMEDIATE PHASES, by R. P. Elltott. Dec. 20, 1954, 20p. tncl. dtagrs. tables, refs. (Technical rept. no. 2 (Ftnal)) ([AF]OSR-TR-55-4) (AF 18(600)642; conttnued by AF 18(600)1399) AD 54386 Unclassified

Investigations tndtcated on the basts of the study of btnary Laves-type phases that the valenctes of the ftrst transttion sertes tncrease and decrease as the atomtc number tncreases from Tt to Nt. The valenctes of this transttton sertes were calculated. Contrary to the prevtous ftndtngs, the valenctes decreased continuously from Tt to Nt. Calculations were made by ustng the valency of Tt as a parameter. Evidence ts cited to substanttate the best values of the valenctes as calculated for an assumed valency of 4 for Tt.

IIT. 03:001

Illinois Inst. of Tech. Armour Research Foundation, Chtcago.

A STUDY OF A FAMILY OF LAVES-TYPE INTERMEDIATE PHASES, by R. P. Elltott. Apr. 25, 1956, 27p. tncl. dtagrs. tables, refs. (Technical rept. no. 1) (AFOSR-TR-56-22) (AF 18(600)1399; continuatton of AF 18(600)642) AD 88033 Unclasstfted

Effort was initiated to systemattze and complete current knowledge on the extstence of Laves phases tn btnary and selected ternary systems wtth transition elements and attempt to correlate these data wtth a valency assignment to the indivtdual elements and with Brillouin zones for the crystallographtc structures. Ltterature and tesl results showed that the pertodtc vartation of the crystal structure type of the Laves phases of Tt, Zr, Hf, Nb, and Ta may be correlated with electron vartattons; allotropy ts the exceptton rather than the rule and occurs only for those btnary phases that have electron to atom ratios near a crttical value. Constderatton of ternary Laves-type phases tndtcated that there are 2 Brtllouin zone overlaps governing the structure type. On the assumption that the valency of Tt is near 4, tt was possible to calculate the valencies of the

first transition elements as follows: (1) Ti = 3.92; (2) Zr = 3.25; (3) V = 2.19; (4) Cr = 1.69; (5) Mn = 1.35; (6) Fe = 0.92; and (7) Co = 0.72. Valencies of 0.25 and 0.00 for Ni and Cu, respectively, were considered consistent with the foregoing valencies. (ASTIA abstract)

IIT. 04:001

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

CRYSTAL MONOCHROMATIZED X-RADIATION. PART I. A TECHNIQUE FOR THE MEASUREMENT OF INTEGRATED INTENSITIES. PART II. THE POLARIZATION CORRECTION, by L. V. Azaroff. Jan. 1955 [28]p. incl. illus. diagrs. tables. (Technical note no. A052-1) ([AF]OSR-TN-55-38) (AF 18(600)1168) AD 54833 Unclassified

Part I. The use of a bent-crystal monochromator with conventional photographic techniques is described. The reflections, which are recorded on the film, have uniform intensity distributions over the entire area of each spot. This enables the determination of the integrated intensity to be made directly with a microphotometer. The exposure time is approximately the same as for standard film methods. The total time spent to determine the integrated intensities from the photograph is reduced by semiautomation. The sensitivity of the film is increased by decreasing the background. Part II. The polarization correction for diffraction of a crystal monochromatized x-ray beam is derived. Suitable expressions are also given for different experimental methods. The polarization correction is tabulated first in parts so that the appropriate correction for any wavelength and monochromator crystal can be determined. Another table gives the polarization correction, in a final form, for use with Ag $K\alpha$ and a quartz monochromator crystal cut parallel to $(10\bar{1}1)$. (Contractor's abstract, modified)

IIT. 04:002

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

POLARIZATION CORRECTION FOR CRYSTAL-MONOCHROMATIZED X-RADIATION, by L. V. Azaroff. [June 14, 1955], [4]p. incl. tables. [AF 18(600)1168] Unclassified

Published in Acta Crystallographica, v. 8: 701-704, Nov. 1955.

The polarization correction for diffraction of a crystal-monochromatized x-ray beam is derived. Suitable expressions for different experimental methods are also given. The polarization correction is first tabulated in parts so that the appropriate correction for any wavelength and monochromator crystal can be determined. Another table lists selected values of the polarization correction, in a final form, for different wavelength x-radiations reflected from $(10\bar{1}1)$ planes of a quartz monochromator. The maximum correction for Ag $K\alpha$ is a little more than 1%, whereas for Cr $K\alpha$ the maximum correction is 34%. (Contractor's abstract)

IIT. 04:003

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

CRYSTAL STRUCTURE INVESTIGATION OF FAIRFIELDITE, $Ca_2(Fe,Mn)(PO_4)_2 \cdot 2H_2O$ (Abstract), by L. V. Azaroff. [Apr. 16, 1956] 1p. (AFOSR-TN-56-156) (AF 18(600)1168) Unclassified

In this study, fairfieldite, a triclinic crystal having a = 5.820Å, b = 6.544Å, c = 5.512Å, α = 102°40', β = 109°40', γ = 86°42', and ρ = 3.08, is examined. The cell contains one formula weight (x-ray density 3.05) which means that 42 parameters must be determined, excluding H_2. This structure was chosen to test the "direct" methods of structure determination. The results of applying vector shift methods, inequalities, and statistical methods to this structure determination are described. The limitations of these methods, and the possible limitations of determining crystal structures directly from the measured intensities, in general, are also discussed. (Contractor's abstract)

IIT. 04:004

Illinois Inst. of Tech. Armour Research Foundation, Chicago.

SIMPLIFIED UTILIZATION OF THE DAWTON METHOD FOR MEASURING INTEGRATED INTENSITIES, by R. J. Robinson, D. A. Poniarelli, and L. V. Azaroff. July 1956, 5p. incl. diagr. (Technical note no. A052-3) (AFOSR-TN-56-351) (AF 18(600)1168) AD 95437 Unclassified

A procedure is described for calibrating x-ray positive print films prepared as part of a method suggested by Dawton (Proc. Phys. Soc., v. 50: 919, 1938 - for British films) and given by Griffith for American films (Jour. Opt. Soc. Amer., v. 42: 31, 1952). No special treatment of the x-ray negative was required. The positive was prepared by making a contact print onto Eastman Commercial Ortho film. The light source, exposure time, source-to-film distance and developing time in DK-50 developer were selected to satisfy $Tp = -\log Ep$, where Tp is the transmittance and Ep the exposure, respectively, of the positive film. The actual arrangement consisted of a 6 w bulb operated at 60 v and placed 10 ft from the film. It was found necessary to prepare 2 positive films films from each x-ray negative to cover the full useful range of intensities. Advantages of the described modification are the saving of time: the necessity of calibrating only the positive film; the determination of the linear transmittance limit in each case; and the applicability to existing as well as new x-ray negatives.

IIT. 04:005 - IIT. 06:002

IIT. 04:005

Illinois Insi. of Tech. Armour Research Foundatton, Chicago.

A STUDY OF DIRECT METHODS OF CRYSTAL STRUCTURE DETERMINATION, by L. V. Azaroff. Final repi. July 1, 1954-Sepi. 1, 1956. Aug. 31, 1956, iv. incl. illus. diagrs. iable, refs. (Technical note no. A052-4) (AFOSR-TN-56-524) (AF 18(600)1168) AD 110342 Unclassified

The siudy of dtreci meihods of crysial siruciure deiermination has been carried oui with the aid of a single crystal of fairfieldlie. This particular crysial was chosen because iis structural composition was such that ii could not adversely influence this investigation. The firsi method iesied, the Haupiman-Karle statistical meihod, was found to be limited in iis applicabiliiy to siruciures which could alternatively be solved by simpler meihods. Meihods employing inequalities were found to be limiied io siruciures consisting of a small number of similar aioms. The vector shift methods emerged i.om this investigation as the only ones promising universal applicability. There are several difficulties which presently limit their utilization. These limitations, as well as the detailed evaluations of all the methods, are described in this report. Suggestions for extending the usefulness of vector shift methods are also given. In an effort to evaluate the direct methods under the best possible conditions, a new method of measuring diffracilon tniensities was developed. This arrangemeni uses a bent-crystal monochromaior in conjunction with conventional cameras. It has been shown thai ihis photographic arrangement gtves tntensity values wiih an accuracy and senstiiviiy rivaling more elaboraie arrangemenis employing ionizaiion-counter deieciors. (Contracior's abstract)

IIT. 05:001

Illtnots Inst. of Tech. Dept. of Chemtstry, Chicago.

THE CRYOSCOPIC HEAT OF FUSION OF AMMONIUM NITRATE, by A. G. Keenan. Dec. 1955 [13]p. inct. dtagrs. table, refs. (Technical rept. no. 1 (6101)) (AFOSR-TN-56-91) (AF 18(600)1148) (Also bound with iis Fina! rept. Sept. 1, 1954-Sept. 1, 1957; AFOSR-TR-57-48; AD 132478) AD 82005 Unclasstfied

Also published in Jour. Phys. Chem., v. 60: 1356-1361, Oct. 1956.

Freezing-point depresston data have been measured for fused salt systems, wtth Li, Na, K, Rb, Cs, Tl and Ag nitrates as solutes and NH_4NO_3 as solvent, tn the concentratton range 0.5-4.0 mol-% and temperature range 160°-170°C. The reproducibtlity of the data ts within ±0.02°. The results show tnteresting correlation with tonic radii and structure. The data are tnterpreted to tndicate that there ts no solid solution formatton tn the case of the Li, Na and Ag nitrates, without recourse to actual analysis of the solid phase. These solutions are, in fact, very close to ideal, and the data yield a value of 1.53 kcal mol^{-1} for the latent heat of fusion of ammonium nitrate. (Contractor's abstract)

IIT. 06:001

Illinois Inst. of Tech. Lab. of Physical Electronics, Chicago.

ELECTRON DIFFRACTION STUDIES OF FRICTION, by P. L. Copeland and E. J. Scheibner. Feb. 1953-June 1954. June 1954, 58p. incl. illus. diagrs. refs. (Technical rept. no. 1) ([AF]OSR-TR-54-18) (AF 18(600)643) AD 39815 Unclassified

The nature of the frictional wear of single crystal and polycrystalline materials is determined primarily by electron diffraction methods. The current viewpoint of the friction mechanism ts reviewed, as well as methods for studying friction. A theory is developed for the interpretation of single crysial electron diffraction patierns from imperfect crystals based upon the intensity distribution in reciprocal space and the use of the Ewald sphere to determine possible reflections. Studies of frictional behavior for polycrystalline materials sliding on polycrystalline materials and for single crystals sliding on single-crystal and polycrystalline materials are reported. It is concluded that the electron diffraction method is sufficiently sensitive to detect fracturing of the crystal surface and for identifying material transferred during sliding. It is noted that for copper the presence of a thin oxide film tends to reduce the coefficient of friction, but it does not prevent the deformation of the copper crystal. (Contractor's abstract)

IIT. 06:002

Illtnois Inst. of Tech. [Lab. of Physical Electronics] Chicago.

X-RAY AND ELECTRON DIFFRACTION STUDIES OF SINGLE CRYSTAL SURFACES, by E. J. Schetbner. Jan. 1955, 58p. incl. tllus. refs. (AF 18(600)643) Unclassified

A consideration of the nature of crysial surfaces and of x-ray and electron diffraction methods of studytng their structure introduces an tnvesttgation of frtcitonal wear effects on single crystal surfaces. Results are given and dtscussed of experiments using indium sliding on atunitnum, copper on brass, nickel on stainless steel, and rock salt single crystals upon itke crystals to study factors tnvolved in friction and wear. These factors tnctude area of contact, pressure weld, stress concentratton, stick-slip effect, relative flatness of surface, oxidation, and deformatton. The electron dtffractton method ts found to be a sensttive sampling technique of investigating surface conditions due to the low penetratton of electrons tnto the surface region.

IIT. 07:001

Illinois Insl. of Tech. Physiological Psychology Lab., Chicago.

COMPUTATIONAL ANALYSIS OF INTRA AND INTER-WAVE VARIABLES IN HUMAN ALPHA. I. AMONG INTRA-WAVE COMPONENTS AS FUNCTIONS OF INTER-WAVE DISTANCE, by I. G. Sallsbury and P. S. Shurrager. Sepl. 1956 [35]p. incl. diagrs. lables. (AFOSR-TN-56-447) (Sponsored joinlly by Air Force Office of Sclentific Research under AF 18(600)578 and U. S. Public Health Service) AD 96792 Unclassified

Evidence for non-random variation among successive values of four inlra-alpha waveform componenls is reported in this paper. Thal non-random variation occurs ls supporled by lhe following facts. Significanl differences belween oblained sequences of positive and negative values and those expected by chance were found for negative, positive and lolal amplitudes and for negative durations. The serles of correlations oblained in any one sequence showed elther a simple or complex sequentially progressive relationship thal was obviously differenl from a sequence of random values. Interrelationships exisl belween some of lhe sequences whlch, when expressed as correlalion coefficlenls, are significant above lhe 1% level. The correlation belween the interrelationships of the sequences oblained from lwo individuals ls significanlly differenl from zero. (Conlractor's absiract)

ISG. 01:001

Illinois Stale Geological Survey. Div. of Fluorine Chemisiry, Urbana.

AROMATIC FLUORINE COMPOUNDS. VII. REPLACEMENT OF AROMATIC -Cl AND -NO_2 GROUPS BY -F, by G. C. Flnger and C. W. Kruse. Technical rept. Oct. 11, 1956, 15p. lncl. tables, refs. (AFOSR-TN-56-394) (AF 18(600)985) AD 96052 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 6034-6037, Dec. 5, 1956.

Replacemenl of -Cl by -F in aryl chlorides wlth KF has been extended from 2,4-dinitrochlorobenzene lo less activated halides by the use of nonaqueous solvents, especially dimethylformamide (DMF) and dimethylsulfoxlde (DMSO). Also replacement of -NO_2 by -F in substituted nitrobenzenes was studied in DMF. As a direct result of this study, many aromatic fluorine compounds can now be obtalned by a relatively simple synthetic route. (Contractor's abstract)

ILL. 01:001

Illinois U. Control Systems Lab., Urbana.

SIGNAL-TO-NOISE IMPROVEMENT AND THE STATISTICS OF TRACK POPULATIONS, by N. Wax. [Sept. 29, 1954] [10]p. incl. diagr. (Sponsored joinlly by Signal Corps, Ordnance Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-56695]) Unclassified

Published in Jour. Appl. Phys., v. 26: 586-595, May 1955.

A lrealment of the population slatistics of signal and of noise pallerns, or tracks, is given in this paper. Some idealized and absiracl models of lracking procedures are sludied; the models are inlended lo represenl the processes encountered in radar lracking and in scanning nuclear emulsions for lracks. The equilibrium lrack population, lhe age disiribution of the populalion at equilibrium, and a signal-lo-noise lmprovemenl factor are obtained for each of the models considered. Il is shown lhal the equilibrium population can be kept lo reasonably small values, and the signal-lo-noise ratio lmproved, if effective methods are used lo elimlnale deleriorating lracks. (Conlraclor's absiract)

ILL. 02:001

Illinois U. Dept. of Ceramic Engineering, Urbana.

DEVITRIFICATION OF HIGH TEMPERATURE RESISTANT CERAMIC COATING GLASSES, by K. E. Nelson and D. G. Bennell. July 1956, 14p. incl. illus. diagrs. lables, refs. (Repl. no. 76) (AFOSR-TN-56-330) (AF 18(603)28) AD 95206 Unclassified

Prellminary resulls are presenled of a sludy on the chemical and physical mechanisms responsible for the insiability of prolonged elevaled lemperalures of many metal prolective high-lemperaiure resisiant ceramic-coating glasses. Three commercial soda-lime-silica glasses of known composition, very clear and crysial free, devitrified almost compleiely when heated for 17 hr al 871°C on Pl foil. A simple Ba borosilicale glass was prepared and applied lo type 347 slainless steel in the form of a ceramic coating. This glass was essentially crysial free as fired on the metal, bul il devilrified almost compleiely lo Ba disilicale and crisioballe when heated for bul 30 min at 871°C. A more complex glass, formed by adding 5 oxides, CaO, ZnO, CaO_2, Bi_2O_3, TiO_2, to 70% of lhe simple glass, withstood devitrification for upward of 17 hr of heating al 871°C. Interestingly enough, the crysials lhen formed were still those of Ba distilicate and crisioballte.

ILL. 02:002

Illinois U. Dept. of Ceramic Engineering, Urbana.

THE POLYMORPHIC MODIFICATIONS OF SILICA IN CERAMIC COATINGS, by J. H Lauchner. Feb. 1957, 20p. incl. diagrs. lables, refs. (Rept. no. 77) (AFOSR-TN-56-446) (AF 18(603)28) AD 96791; PB 126367 Unclassified

In this study, the polymorphic modifications of silica present in ceramic coatings owing to devitrification or

as a result of direct additions were identified by thermal-strain, x-ray diffraction, and differential-thermal analyses. Comparison of the analytical results indicated thermal strain analysis to be the most sensitive method in identification of all silica modifications studied. Analysis of the tessellated stresses developed in the systems was applied in determining effective linear thermal-expansion characteristics, and interpreting residual stress development. (Contractor's abstract)

ILL. 02:003

Illinois U. Dept. of Ceramic Engineering, Urbana.

AN INVESTIGATION OF THE ALLOTROPIC FORMS OF SILICA IN CERAMIC COATINGS (Abstract), by J. H. Lauchner. Nov. 1956, 1p. (AF 18(603)28)
Unclassified

Presented at meeting of the Amer. Ceramic Soc., Basic Science Div., Clemson Coll., S. C., Nov. 1-2, 1956.

The allotropic forms of silica, present in ceramic coatings due to devitrification or as a result of a direct addition, were identified by thermal strain, x-ray diffraction, and differential thermal analyses of ceramic coated composites. The effective differential coefficients of thermal expansion were determined from thermal strain data and a quantitative estimate of the crystalline content in the coatings was established. (Contractor's abstract)

ILL. 03:001

Illinois U. [Dept. of Chemistry] Urbana.

OBSERVATIONS ON THE RARE EARTHS: ELECTROCHEMICAL STUDIES OF RARE EARTH METAL SALTS IN VARIOUS NON-AQUEOUS SOLVENTS, by T. Moeller and G. W. Cullen. Oct. 1, 1956, 119p. incl. illus. diagrs. tables, refs. (AFOSR-TN-56-437) (AF 18(600)1535)
AD 96520 Unclassified

The solubilities of $La(NO_3)_3$ and $LaBr_3$ in anhydrous ethylenediamine (I) were measured as 3.81 and 0.135 g/l of solution, respectively. $La(NO_3)_3$ and $LaBr_3$ were soluble in dimethylformamide (II), the latter being 251.2 g/l of solution at 30°C. Conductance curves for $La(NO_3)_3$ and $LaBr_3$ in I indicated that the equivalent conductance increased on dilution in low-concentration ranges; the salts behaved as weak electrolytes in both solvents. Limiting conductance values could not be obtained. The presence of H_2O did not appreciably change the shape of the curves in either system and did not affect the strength of either solute as an electrolyte. Light yellow cathode deposits were generally obtained from the electrolysis of $La(NO_3)_3$ in anhydrous I and in I containing small quantities of H_2O. A black deposit was obtained when 2 sintered-glass barriers were placed between the catholyte and the anolyte in the anhydrous I solution. A violent reaction occurred between the anolyte and catholyte during the electrolysis of II solutions of $La(NO_3)_3$. The electrolysis of II solutions of $LaBr_3$ yielded gelatinous appearing cathode deposits. Photomicrographs and chemical reactions of the cathode deposits obtained in the I systems indicated the presence of small quantities of free metal after the deposits were vacuum-heated. Similar analysis of the cathode deposits obtained in the II-bromide system yielded less evidence for the presence of La.

ILL. 04:001

Illinois U. Dept. of Mathematics, Urbana.

A FIXED POINT INDEX, by D. G. Bourgin. Terminal rept. Oct. 27, 1955, 16p. ([AF]OSR-TN-55-410) (AF 18(600)1398; continued by AF 18(603)32)
AD 83019 Unclassified

This mathematical study considers the index of a transformation relative to an open set for an ANR or LC^n space. The spaces occurring are all compact Hausdorff and are denoted by X with points x. Maps are understood to be continuous. The boundary of a set g is written $\dot{g}$. The complement of a set A is indicated by a prime, i.e., A'. Small Greek letters are used for finite open covers with the ordering relation defined by $\alpha < \beta$ if β refines α. The open sets or elements of α are written a_1. The nerve of a cover is a Euclidean complex and is indicated by the corresponding small Roman letter, thus a is the nerve of α. The points of a are written y. The vertex of a corresponding to a_1 is indicated by (a_1). The symbol St for star is utilized in both the point set and the algebraic senses, but the context avoids confusion. The notation $\bar{b}$ is employed both for the algebraic and the topological closure of the simplex b. If β is a cover and L is a subcomplex of the finite complex K containing all the vertices of k, then β is a mesh of the partial realization of L by α if for each simplex of K the map of its faces in L is contained in a single element of β. A homotopy is over α if for each point the orbit under the homotopy lies in an element of α. R is the symbol for a retraction and I or I_A for the unit segment. The parallelotope $P = P^{\{A\}}_{I_A}$, where script set $\{A\}$ is arbitrary and not necessarily denumerable. The space X is usually assumed to be a NR in a parallelotope. The LC^n property is that for every α there is a β such that to every partial realization of a finite complex with a mesh β there is a full realization, or extended realization with a mesh β. The mesh α is termed an extension mesh for β, and is written $\alpha \geq \beta$. Q_a is written for a canonical map from X to a. Throughout, the Čech homology groups $H_n(X)$ are over the rationals. H(X) is used for the direct sum $\sum H_n(X)$. Moreover if P^a_b is the projection transformation on b into a then P^a_b stands not only for the induced chain homomorphism on the chain groups over b into those over a, but also for the homomorphisms of the cycle groups as well as the homology groups. Use is made of I for the identity map $Ix = x$. Q_b is a cocanonical map over α, or more simply, a cocanonical map if $q_b Q_b \cong I$ over α. Lemma O: For arbitrary α there is a β such that every pair of points in an element b_1 of β can be joined by a unique path in some element a_j of α, $j = j(i)$. (Extracted from rept.)

ILL. 05:001

Illinois U. [Dept. of Mathematics] Urbana.

NON LOCALLY CONNECTED SPACES RELATED TO ABSOLUTE NEIGHBORHOOD RETRACTS AND FIXED POINT PROPERTIES, by D. G. Bourgin. Jan. 30, 1957, 10p. (AFOSR-TN-56-578) (AF 18(603)32; continuation of AF 18(600)1398) AD 110400 Unclassified

Spaces which are limits of absolute neighborhood retracts or non-locally connected spaces are considered from the point of view of significant Lefschetz numbers and as natural extensions of absolute neighborhood retracts. Two theorems are discussed. First, if X is a neighborhood retract δ satisfying $t^{\nu} r^{\rho}{}_{\nu} = i^{\rho}$ then $Lf = Lf^{\rho}$ for $\rho_0 < \rho$. If X satisfies Q_1 also, $Lf \neq 0$ implies f has a fixed point. Secondly, suppose X is a neighborhood retract δ satisfying Q_1 or, if X is a NR, and if G is open with fixed point of free boundary G under $f: X \longrightarrow X$ and if the index $\Delta(f^{\rho}, G^{\rho})$ is non-zero for all the values of f for which it is defined, then f has a fixed point in G.

ILL. 05:002

Illinois U. [Dept. of Mathematics] Urbana.

[AN INDEX OF A FIXED POINT, PARTS I AND II] Topologia - Un indice dei punti uniti. I, II, by D. G. Bourgin. [1955 and 1956] [12]p. (AF 18(603)32) Unclassified

Published in Atti Accad. Naz. Lincei. Rend. Cl. Sci. Fis. Mat. Nat., v. 19: 435-440, Dec. 1955; v. 20: 43-48, Jan. 1956.

In these two notes the author lays the foundations for a fixed-point-index theory for transformations $f: X \longrightarrow X$ where X is a compact Hausdorff space, assumed to be an ANR. Using Čech homology theory over rational coefficients, the author exploits the fact that the homology theory of such an X, and its influence under f, can be transferred to a finite approximating polytope where, of course, an index theory is readily available. The principal results are 1) the Lefschetz number of f equals the Lefschetz number of the transformation induced in the nerve of any sufficiently fine covering; 2) if G is an open subset of X whose boundary contains no fixed points, the index of the transformation induced in a sufficiently fine nerve over a certain open subset of the nerve, determined by G, is independent of the nerve chosen. (Math. Rev. abstract)

ILL. 05:003

Illinois U. [Dept. of Mathematics] Urbana.

[AN INDEX OF A FIXED POINT, PART III] Topologia - Un indice die punti uniti. III, by D. G. Bourgin. 1956. 6 p. (AF 18(603)32) Unclassified

Published in Atti Accad. Naz. Lincei. Rend. Cl. Sci. Fis. Mat. Nat., v. 21: 395-400, Dec. 1956.

The author considers spaces which are limits of ANR's and obtains fixed-point theorems for such spaces. A compact subset X of a fixed parallelotope P is called an NR_{δ} if it is the intersection of a family $\{X_{\alpha}\}$ of ANR's, subsets of P, such that X_{α} is a retract of X_{β} whenever $X_{\alpha} \subset X_{\beta}$. Let X be an NR_{δ}. Then X is homologically finite, so that every mapping $f: X \longrightarrow X$ has a Lefschetz number L(f). Assume now that there exists a family of mappings $t_{\alpha}: X_{\alpha} \longrightarrow X$ which are compatible, in a certain homological sense, with the retractions $X_{\beta} \longrightarrow X_{\alpha}$. Assume further that the t_{α} satisfy a uniformity condition which states roughly that t_{α} is near the identity when X_{α} is near X. Under these conditions the nonvanishing of L(f) implies the existence of a fixed point. There are a number of interesting corollaries. (Math. Rev. absiract)

ILL. 06:001

Illinois U. [Dept. of Mathematics] Urbana.

BROWNIAN MOTION ON A GREEN SPACE, by J. L. Doob. Oct. 31, 1957 [31]p. (AFOSR-TN-56-573) [AF 18(603)11] AD 110395 Unclassified

Also published in Teoriia Verofatnostei i EE Primeneniia, v. 2: [3]-33, 1957.

The basic results of Brownian motion theory developed for spaces which are subsets of Euclidean N-space are extended to Green spaces. The study is found to be useful in studying not only harmonic functions, Brownian motion stochastic processes on Green spaces, but also parabolic functions and heat motion stochastic processes on heat spaces. The probabilistic attack is found to be of utility in defining the boundary points of the space in the general problem involving stochastic processes with non-constant lifetimes. The necessary definitions and theorems, relevant to the investigation, are presented.

ILL. 07:001

Illinois U. Dept. of Mining and Metallurgical Engineering, Urbana.

THE MECHANISM OF PHASE TRANSFORMATIONS IN METALS, by D. S. Lieberman. Mar. 19, 1956, 11p. incl. illus. (Rept. no. MEDUI-17-AF) (AFOSR-TN-56-412) (AF 18(600)1311) AD 96221 Unclassified

In this study, the graphical formulation of a crystallographic theory of diffusionless phase transformations is discussed. The theory of Wechsler, Lieberman, and Read (Trans. Amer. Inst. Mining, Metallurgical, and Petroleum Engineers, v. 197: 1953) permits calculations to be made of the following features of martensitic transformations from a knowledge of the lattice parameters and the pattern of inhomogeneity: (a) the orientation of the interface plane separating the parent and product phases; (b) the magnitude and direction of the macroscopic shear accompanying the transformation; (c) and the orientation relationships between the crystal axes in the 2 structures. The graphical method is

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applied to the cubic-to-orthorhombic transformation in a single crystal of AuCd (47.5 at -% Cd).

ILL. 07:002

Illinois U. Dept. of Mining and Metallurgical Engineering, Urbana.

GROWTH BENDS IN IRON WHISKERS, by G. S. Baker. Oct. 15, 1956, 3p. incl. table. (Rept. no. MEDUI-18-AF) (AFOSR-TN-56-413) (AF 18(600)1311) AD 96222 Unclassified

Also published in Jour. Appl. Phys., v. 27: 1561-1562, Dec. 1956.

It has been proposed that the bent part of the whisker is the site of a twin boundary, or of some other type of boundary. The purpose of the present study is to show that this is not the case for Fe whiskers grown from the vapor. Whiskers were grown by the reduction of $FeCl_2$ by H_2. Back reflection Laue x-ray patterns of those whiskers which exhibited bends were taken above, below, and at the position of the bend. The orientation of the crystal lattice is identical at all 3 positions for all specimens x-rayed, 12 in all. This proves that the crystal structure is continuous through the bend, and that no boundary need be postulated in the bend. The bend itself, is caused by the whisker axis shifting from one crystal direction to another, often, but not always, an equivalent crystallographic direction. Tabular data are presented, giving whisker axes, surface planes, and angle of several types of whisker bends. The measured angle always agreed with that calculated within a couple of degrees. In addition to the crystallographic angles, there are occasionally whiskers bent in a smooth arc over long regions. X-ray pictures of 2 of these show the crystal lattice to be uniformly rotated in orientation over these arcs.

ILL. 08:001

Illinois U. Dept. of Physics, Urbana.

PHOTOCONDUCTIVITY IN POTASSIUM IODIDE CONTAINING F CENTERS, by N. Inchauspé and R. J. Maurer. Sept. 1955 [39]p. incl diagrs. tables. (Rept. no 1) ([AF]OSR-TN-55-281) (AF 18(600)662) AD 75287 Unclassified

Photocurrents have been observed when KI crystals containing F centers are irradiated with quanta of energy between 2.0 and 5.6 ev. Under these conditions, photocurrents are not observed in crystals which do not contain F centers. The photocurrents are attributed to the interaction of excitons and F centers. The life-time of the excitons is estimated to be of the order of 5×10^{-9} sec. (Contractor's abstract)

ILL. 08:002

Illinois U. [Dept. of Physics] Urbana.

POLARIZATION IN INSULATING CRYSTALS (Abstract), by C. Inchauspé and N. Inchauspé [1955] [1]p. [AF 18(600)662] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Phys. Rev., v. 98: 1543, June 1, 1955.

An elementary analysis has been made of the problem of the development of space-charge within an illuminated insulating crystal which exhibits photoconductivity. The analysis is applicable to crystals similar to alkali-halides in which the displacement, w, of the photoelectrons by the field is much smaller than the distance, d, between the electrodes. The analysis has been carried out for various types of nonuniform illumination in the form of a plane parallel condenser. The initial slope of the photocurrent time curve is given by $(1/i_0)(di/dt)_0 = (d/a)(i_0/q_0)$, where i_0 is the initial current and q_0 is the charge of the condenser before illumination. The length, a, characterizes the nonuniform illumination and is a measure of the distance within which the radiation is absorbed.

ILL. 08:003

Illinois U. [Dept. of Physics] Urbana.

PHOTOCONDUCTIVITY IN POTASSIUM IODIDE (Abstract), by N. Inchauspé. [1955] [1]p. [AF 18(600)-662] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Phys. Rev., v. 98: 1550, June 1, 1955.

Photoconductivity in potassium iodide at the temperature of liquid nitrogen has been investigated with crystals containing additive F-centers and radiation in the photon energy range from 1.9 ev to 5.8 ev. The maximum of the F-center absorption occurs at the lower limit of this photon energy range and the upper limit marks the maximum of the first (exciton) peak of the fundamental optical absorption. The concentration of F-centers was varied from 10^{14} to 10^{17} cm^{-3}. The number of quanta incident per second upon the crystal was about 10^{11} per second. The observed photocurrents were less than 10^{-15} amperes in crystals which had not been additively colored. When the crystals were prepared in such a low-vapor pressure of K as to contain less than 10^{15} F-centers cm^{-3}, photocurrents became observable at 3 ev and increased to a broad maximum at 5.1 ev. For F-centers concentrations between 10^{15} and 10^{17} cm^{-3}, additional maxima were observed at 1.9 ev and 5.51 ev where the F- and p-bands occur. The photocurrents decreased rapidly as the photon energy was increased beyond 5.51 ev. (Contractor's abstract)

ILL. 08:004

Illinois U. [Dept. of Physics] Urbana.

SELF DIFFUSION OF SODIUM AND IONIC CONDUCTIVITY IN NaCl-$CaCl_2$ CRYSTALS, by J. O. Thomson. Feb. 1956 [20]p. incl. diagrs. tables, refs. (AFOSR-TN-56-59) (AF 18(600)662) AD 81051 Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Abstract published in Phys. Rev., v. 98: 1536, June 1, 1955.

The diffusion of Na^+ in NaCl containing small, known concentrations of $CaCl_2$ was measured as a function of temperature. The diffuston data were compared with the ionic conductivities of the crystals. The degree of association of Ca ions with positive ions to form complexes appeared smaller than theoretically expected. Results showed a small magnitude of discrepancy in the Einstein-Nernst diffusion-conductivity relationship. The small discrepancy appears to substantiate Bean's conclusion (Thesis, Illinois U., 1952) that Ca ions do not readily associate with Na ion vacancies. Effects are discussed which obscure the application of the association theory to the NaCl-$CaCl_2$ system. Anomalous data include (1) similar discrepancies in the Einstein-Nernst relation for crystals with large impurity-content variations and (2) parabolic instead of straight-line conductivity isotherm-vs-concentration curves at lower temperatures. The ratio of free vacancies to impurity atoms apparently increases with increasing impurity concentration and decreasing temperature. A comparison of the NaCl-$CdCl_2$ and NaCl-$CaCl_2$ systems showed a marked difference in the calculated mobility of the free vacancies. A disparity in the calculated mobilities was obtained which was well outside experimental error, and indicated that not all of the Ca introduced into NaCl crystals is effective in creating free or associated vacancies. An irreversible effect may occur with Cd in the NaCl-$CaCl_2$ system. (ASTIA abstract)

ILL. 08:005

Illinois U. [Dept. of Physics] Urbana.

DIELECTRIC LOSS IN SODIUM CHLORIDE, by J. O. Thomson. Dec. 1956 [10]p. incl. diagrs. tables, refs. (AFOSR-TN-56-427) (AF 18(600)662) AD 96509 Unclassified

Dielectric loss measurements were made on crystals of NaCl, which contained small additions of $CaCl_2$, in the frequency range between 0.1 and 100 kc at 50° to 150°C to obtain information on point imperfections in ionic crystals. The crystals were grown by the Kyropoulos method from a melt of NaCl having appropriate amounts of $CdCl_2$. They were cleaved into plates about 0.3 to 0.4 mm thick and 3 to 4 sq cm in area. The faces of the specimens were covered with Ag-conducting paint, and Pt leads were cemented to the electrodes using the same paint. The dielectric loss was measured by means of a General Radio 716C bridge with a bridge voltage of 50 to 100 mv. The concentration of impurity was determined by a nephelometric method (accurate to 25%). Measurements suggested that the number of complexes at low temperatures is substantially less than the number of impurity ions. The data show that in the most highly-doped crystal, the low-temperature defects persist to higher temperatures. The widths of the dielectric-loss peaks (on a log frequency plot) of test crystals were roughly 20 and 60% wider than theoretical values. This may be explained on the basis of the low-temperature defects. (ASTIA abstract)

ILL. 08:006

Illinois U. [Dept. of Physics] Urbana.

SELF-DIFFUSION OF SODIUM AND CONDUCTIVITY IN SODIUM CHLORIDE CRYSTALS (Abstract), by J. O. Thomson. [1956] [1]p. [AF 18(600)662] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Ser. II, v. 1: 214, Apr. 26, 1956.

Na^{24} tracer diffusion measurements and conductivity measurements have been made on single crystals of NaCl containing small amounts of $CaCl_2$ (6 and 20 x 10^{-4} mole fraction). The measurements were made in the temperature range from 240°C to 590°C. The self-diffusion coefficient of the sodium ion was obtained from the tracer diffusion coefficient by application of the Bardeen-Herring correlation factor. The ratio (σ/D) of the conductivity to the self-diffusion coefficient satisfies the Einstein-Nernst relation much better than data obtained from NaCl-$CdCl_2$ crystals. This result may not be due to a small binding energy of the calcium ion-positive ion vacancy complex, because the ratio, (σ/D), and the conductivity, σ, do not depend upon the temperature and concentration of calcium in the manner predicted by association theory. (Contractor's abstract)

ILL. 08:007

Illinois U. [Dept. of Physics] Urbana.

A REPORT TO THE OFFICE OF SCIENTIFIC RESEARCH ON EUROPEAN LABORATORIES AND PERSONNEL (Unclassified title), by R. J. Maurer. Aug. 1956, 16p. (AF 18(600)662) Confidential

ILL. 09:001

Illinois U. [Dept. of Physics] Urbana.

DISLOCATION LINE ENERGY AND SLIP IN NaCl AND

ILL. 09:002 - ILL. 10:001

AgCl CRYSTALS (Abstract), by R. Thomson. [1955] [1]p. [AF 18(600)689] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98: 1171, May 15, 1955.

Calculations of the elastic energy of dislocations in NaCl and AgCl have been made which include the effects due to the elastic anisotropy of the crystals. At low temperatures the calculations give some evidence in NaCl for the choice of (110) slip planes over (100) slip planes. However, the calculations do not predict the large difference in the yield stress experimentally observed. This result suggests that other mechanisms such as a differential pinning of edge dislocations in different slip planes are also important. At high temperatures the preference for (110) slip planes due to crystal anisotropy disappears, in agreement with suggestions by early experimenters that other slip planes become active at high temperatures. The calculations for AgCl do not predict any marked preference for (110) slip planes over (100) slip planes in agreement with the observed pencil glide in AgCl.

ILL. 09:002

Illinois U. [Dept. of Physics; Urbana.

DISLOCATION ENERGIES IN NaCl, by H. B. Huntington, J. E. Dickey, and R. Thomson. May 1956 [12 p. incl. diagrs. tables, refs. (AFOSR-TN-56-181) (In cooperation with Rensselaer Polytechnic Inst., Troy, N. Y.) (AF 18(600)689) AD 87054 Unclassified

Published in Phys. Rev., v. 100: 1117-1128, Nov. 15, 1955.

The energies for both screw and edge dislocations in rock salt have been investigated. The effect of elastic anisotropy has been incorporated into the contribution from the region outside the core. Detailed calculations have been carried out for the energies of the cores themselves as a function of radius, and joined smoothly to the curves of the elastic theory. The core calculations are based on the Born-Mayer model, and employ the formulas of Madelung for the potentials of rows of uniformly spaced charges. For dislocations in the observed plane of slip (110), the constant term associated with the core energy is 1.0×10^{-7} ev/cm more for the edge than for the screw. Approximate calculations show this term to be appreciably larger for the edge dislocation in the (100) plane. Also, there appears to be large lattice potential barrier for dislocation motion in this plane arising from anion closed shell repulsion. This result may explain why these planes, though close-packed, are generally not active in glide for alkali halides. The stability of dislocations with Burger vector longer than the minimum lattice translation is investigated. The possibility of hollow dislocations is also considered. (Contractor's abstract)

ILL. 09:003

Illinois U. Dept. of Physics, Urbana.

ASSOCIATED ENERGY OF VACANCIES AND IMPURITIES WITH EDGE DISLOCATIONS IN NaCl, by F. Bassani and R. Thomson. Sept. 1956 [12]p. incl. diagrs. tables, refs. (AFOSR-TN-56-309) (AF 18-(600)689) AD 96050 Unclassified

Also published in Phys. Rev., v. 102: 1264-1275, June 1, 1956.

Calculations were made of the energies of association of Sr^{++} ions, Cd^{++} ions, and positive-ion vacancies with the core of a (110) edge dislocation in NaCl. It is found that the vacancy has an association energy of 0.4 ev, but that other impurities have smaller association energies. On the basis of this energy of association, the numbers of vacancies and divalent ion-vacancy complexes pinned in the cores of the (110) edge dislocations in a well-annealed crystal were calculated. These numbers are large enough at room temperature to suggest that impurity and vacancy pinning might be the agent determining the critical yield stress in annealed NaCl. The elastic field interaction between point defects and dislocation is tabulated and compared with the interaction obtained within the core. It is shown that the elastic energy of interaction does not necessarily project into the core in a smooth fashion, but that in the case of the vacancy, an elastically "large" inclusion behaves like a "small" inclusion in the core. Several possible suggestions are made which may explain the strong hardening effect of divalent impurity additions to NaCl. (Contractor's abstract)

ILL. 09:004

Illinois U. Dept. of Physics, Urbana.

HALOGEN BAND IN SODIUM CHLORIDE, by R. C. Casella. 1956. 4 p. incl. diagrs. tables, refs. (AF 18(600)689) Unclassified

Published in Phys. Rev. v. 104: 1260-1263, Dec. 1, 1956.

The approximation of tight binding is employed to determine a minimum for the width of the halogen band in NaCl. Approximate curves of the one electron energy E vs wave number k are provided for values of k lying along lines of high symmetry in the first Brillouin zone. A minimum width of about 1.9 ev is obtained. (Contractor's abstract)

ILL. 10:001

Illinois U. Dept. of Physics, Urbana.

TRIP REPORT ON SOLID STATE RESEARCH IN JAPAN (Unclassified title), by F. Seitz. Oct. 15, 1953, 13p. (First interim rept.) (AF 18(600)783) Confidential

ILL. 11:001

Illinois U. [Electrical Engineering Research Lab.] Urbana.

HALL EFFECT AND CONDUCTIVITY OF SYNTHETIC RUTILE CRYSTALS AND SOME ALKALINE EARTH TITANATES, by M. C. Andrews. [1952] 128p. incl. illus. diagrs. tables, refs. (AF 33(038)12644) Unclassified

Determination of the Hall effect and electrical conduction properties are reported of six titanates, $MgTi_2O_5$, $MgTiO_3$, Mg_2TiO_4, $CaTiO_3$, $SrTiO_3$ and $BaTiO_3$, varying in stoichiometric composition from unreduced to a near-maximum reduction, primarily over a temperature range of 25° to -195°C. As these crystalline double oxides have a common component, TiO_2, similar measurements were made of synthetic single crystals of titanium oxide. The physical properties of test materials, measurement methods and semiconductor models are discussed, and experimental results analyzed.

ILL. 11:002

Illinois U. Electrical Engineering Research Lab., Urbana.

A MAGNETIC EFFECT IN MAGNESIUM TITANATE, by E. K. Weise and H. Katz. [1952] [2]p. [AF 33-(038)12644] Unclassified

Published in Phys. Rev. v. 86: 1046-1047, June 15, 1952.

Measurements were made on $MgTiO_3$, Mg_2TiO_4, and $MgTi_2O_5$ of the paramagnetic susceptibility vs percentage of oxygen removed by reduction with H at 850-1450°. The values plotted for $MgTiO_3$ and Mg_2TiO_4 increased smoothly with a decrease of the oxygen. $MgTi_2O_5$, however, showed a remarkable peak between 0.15 and 0.25%. The dependence on magnetic field strength was determined. There was no apparent influence using the laboratory electromagnet, which could be varied from zero to about 2000 gauss field strength. This behavior is typical for paramagnetism and eliminates the possibility of a ferromagnetic effect, which was assumed at first because of the size of the observed forces.

ILL. 11:003

Illinois U. [Electrical Engineering Research Lab.] Urbana.

ON THE ELECTRICAL CONDUCTIVITY OF SOME ALKALINE EARTH TITANATES [Part I], by E. K. Weise and I. A. Lesk. [1953] [6]p. incl. diagrs. [AF 33(038)12644] Unclassified

Published in Jour. Chem. Phys., v. 21: 801-806, May 1953.

The compounds Mg_2TiO_4, $MgTiO_3$, $MgTi_2O_5$, $CaTiO_3$, $SrTiO_3$, and $BaTiO_3$ were prepared in crystalline form by reaction in the solid state between TiO_2 and the carbonate or oxide of the appropriate alkaline earth. Samples in the form of rods were sintered in O at 1450° and were reduced in H at temperatures from 560° to 1400°, n-type semiconductors being produced. The most highly reduced Mg titanates lost 3% in weight during this treatment, but the largest reduction in weight with $CaTiO_3$, $SrTiO_3$, and $BaTiO_3$ was 0.25%. Resistivity values from 10^{-1} to 10^8 ohm-cm were obtained. The plot of log resistivity vs reciprocal absolute temperature was linear in most cases over a wide range of temperature and resistivity. The curves for $BaTiO_3$ changed slope abruptly at approximately 115°; this is probably attributable to the crystal structure change at the Curie temperature of approximately 120°. The dependences of impurity activation energy and Fermi level on percentage reduction were determined for the case of Mg_2TiO_4. The Bilitz-Meyer rule, stating a linear relation of impurity activation energy with resistivity at a reference temperature, was not obeyed over the large range of reductions obtained.

ILL. 11:004

Illinois U. Electrical Engineering Research Lab., Urbana.

VACUUM TUBE ELECTROMETER WITH HIGH INPUT IMPEDANCE, by M. C. Andrews and E. K. Weise. July 31, 1955, 12p. incl. diagrs. table. (Technical note no. 1) ([AF]OSR-TN-55-259) (AF 33(038)12644) AD 72937 Unclassified

For the measurement of small dc voltages across very high resistances, a vacuum-tube electrometer was built with the use of feedback (1) to make the input resistance match the resistors across which the voltage is to be measured, and (2) to increase the range, linearity, and stability. Variable cathode emission, which resulted in drift effects, was reduced by a new type of circuit. (ASTIA abstract)

ILL. 11:005

Illinois U. Electrical Engineering Research Lab., Urbana.

TEMPERATURE CONTROL WITH VARIABLE PULSE TIME DELAY THYRATRON CIRCUIT, by M. C. Andrews and E. K. Weise. Aug. 1, 1955, 3p. incl. diagr. (Technical note no. 2) ([AF]OSR-TN-55-260) (AF 33(038)12644) AD 75286 Unclassified

A description is given of a modified thyratron for the control of temperatures (within 0.1°C) in furnaces. The amplified signal from an unbalanced Wheatstone bridge controls a variable pulse time delay circuit which influences the firing angle of a thyratron. A circuit diagram, without the Wheatstone bridge circuit, is included.

ILL. 11:006 - ILL. 11:010

ILL. 11:006

Illinois U. Electrical Engineering Research Lab., Urbana.

MEASUREMENT OF THE MELTING POINT OF STRONTIUM TITANATE, $SrTiO_3$, by E. K. Weise and A. S. Chodakowski. Aug. 15, 1955, 7p. incl. diagrs. (Technical note no. 3) ([AF]OSR-TN-55-294) (AF 33(038)-12644) AD 75734 Unclassified

Specially shaped samples of $SrTiO_3$ were heated by a surrounding W coil in a vacuum metal evaporator. The sample was mounted horizontally, and the loop of Mo wire, which prevented direct contact of the sample with the supporting structure, was held in a vertical plane by the support. With this arrangement, viewing conditions of almost perfect quality were possible. The melting point of $SrTiO_3$ was found to be higher than 1750°C.

ILL. 11:007

Illinois U. Electrical Engineering Research Lab., Urbana.

SIMPLE THERMOCOUPLE NEEDLE THERMOMETER WITH HIGH SENSITIVITY, by E. K. Weise and A. C. Hershberger. Oct. 25, 1955, 7p. incl. diagrs. (Technical note no. 4) ([AF]OSR-TN-55-423) (AF 33(038)-12644) AD 80106 Unclassified

A simple thermocouple needle thermometer was used directly with a sensitive galvanometer and a salt bath as a reference for temperature measurements in living animal tissues. The thermocouple was constructed of a 0.20-in.-od, 0.014-in.-id, 2.5-in.-long nickel tube with a copper wire soldered at one end and a nickel wire soldered at the other end. The reference bath was a melt of ordinary Glauber salt (sodium sulfate decahydrate), which has a conversion point at 32.38°C. Dropping a small crystal of the salt into the melt is recommended to remedy the frequent occurrence of supercooling. Any galvanometer with a high sensitivity and a low impedance can be used. With a Rubicon galvanometer, a sensitivity of 6.7 mm/0.1°C from 36° to 39°C was obtained.

ILL. 11:008

Illinois U. Electrical Engineering Research Lab., Urbana.

ON THE ELECTRICAL CONDUCTIVITY OF SOME ALKALINE EARTH TITANATES, PART II, by E. K. Weise and M. C. Andrews. Mar. 15, 1956, 23p. incl. diagrs. tables, refs. (Technical note no. 8) (AFOSR-TN-56-125) (AF 33(038)12644) AD 86001 Unclassified

Measurements are described of the electrical conductivity of the following reduced heavy metal titanates from room temperature down to about -190°C: Mg_2TiO_4, $MgTiO_3$, $MgTi_2O_5$, $CaTiO_3$, $SrTiO_3$, and $BaTiO_3$. Samples 1 x 3 x 12 mm were prepared with Pt strips, 5 mm apart, and fired on one of the wide surfaces to serve as voltage probe contacts. Before reduction, all samples were sintered in O for about ½ hr at 1360° to 1415°C. Reduction times and temperatures were varied, and a combination of H and H-He atmospheres were used. Voltages and currents were measured with a vacuum-tube electrometer capable of measuring voltages as low as about 0.01 v and currents as low as 10^{-16} amp. The degree of reduction was determined by cleaning and weighing the samples after all electrical measurements had been taken and then weighing again after heating the samples in O. The change in weight was assumed to be equal to the weight of the O removed from the sample by reduction. The densities of the oxygen vacancies were computed from the change in weight data. Plots were made of the log of the resistivity vs the reciprocal of the absolute temperature. The removal of O from the lattice brings about n-type semiconductivity. A 1- or 2-donor-level model was used for the interpretation of the results. Gap width, density, and activation energy of donors, and concentration and mobility of electrons in the conduction band were determined. (ASTIA abstract, modified)

ILL. 11:009

Illinois U. Electrical Engineering Research Lab., Urbana.

VARIABLE TEMPERATURE CHAMBERS, by M. C. Andrews, A. S. Chodakowski, and E. K. Weise. May 10, 1956, 7p. incl. diagrs. (Technical note no. 5) (AFOSR-TN-56-206) (AF 33(038)12644) AD 87520 Unclassified

The construction of 2 different temperature chambers which were built for measurements of Hall effects and magnetic susceptibilities on semiconducting materials is described. The temperature range covered was from lower than -190° up to about 200°C. For measurements below room temperature, a cryostat was built. A second chamber was built for temperature ranges above room temperature. The cryostat has a built-in heating element which enables the temperature of the sample chamber to be raised from its lowest value (-175°C) to some value above 200°C. Temperatures between -60°C and room temperature required frequent heater-current adjustments and additions of liquid N to prevent temperature variations during measurement. Temperature equilibria were maintained easily from room temperature to 200°C. (ASTIA abstract, modified)

ILL. 11:010

Illinois U. Electrical Engineering Research Lab., Urbana.

THE AC RESISTANCE OF SINTERED TITANATES, by M. C. Andrews and E. K. Weise. May 15, 1956, 5p. incl. diagrs. table. (Technical note no. 6) (AFOSR-

TN-56-207) (AF 33(038)12644) AD 87521 Unclassified

The ac resistance of sintered reduced titanate samples was measured as a function of frequency from 0 to 30 mc. The samples consisted of the following materials: TiO_2, Mg_2TiO_4, $MgTi_2O_5$, $CaTiO_3$, $SrTiO_3$, and $BaTiO_3$. (ASTIA abstract)

ILL. 12:001

Illinois U. [Electrical Engineering Research Lab.] Urbana.

COMPLEX IMPEDANCE OF CONDUCTING THIN FILMS (Abstract), by C. E. Drumheller. [1952] [1]p (AF 33(038)21255) Unclassified

Presented at meeting of the Opt. Soc. of Amer., Boston, Mass., Oct. 9-11, 1952.

Published in Jour. Opt. Soc. Amer., v. 42: 877, Nov. 1952.

A new point of view is proposed to account for the observed optical characteristics of conducting thin films without the necessity of postulating any unusual or anomalous frequency dependence of resistivity. By considering the complex impedances associated with the structure of such films it is possible not only to account theoretically for their observed optical behavior, but important new information concerning the structure can be derived from simple electrical and optical measurements. Measurements on evaporated bismuth films indicate that those in the resistance range of 10,000 to 50,000 ohms per square have a parallel capacitance of about 2.5×10^{-6} micromicrofarad per square. Those evaporated to a resistance of 90 ohms per square have both parallel and series capacitances of about 3.8×10^{-5} micromicrofarad per square. These results can be explained satisfactorily if one assumes that the resistance is contributed primarily by the grain boundaries between adjacent bismuth crystals and that a wide variation exists in the grain-to-grain resistances. This conclusion is also consistent with electron micrograph observations of the oxidation process of bismuth films. (Contractor's abstract)

ILL. 12:002

Illinois U. [Electrical Engineering Research Lab.] Urbana.

SUDDEN CHANGE IN THE ARRANGEMENT OF CRYSTALLITES IN THIN EVAPORATED BISMUTH FILMS, by L. L. Howard. [1954] [3]p. incl. diagrs. [AF 33(038)21255] Unclassified

Published in Jour. Appl. Phys., v. 25: 125-127, Jan. 1954.

Changes obtained in the appearance of thin Bi films during the first few seconds of exposure to the electron beam of an electron microscope are ascribed to tilting of various crystallites under the direct or indirect action of the beam.

ILL. 12:003

Illinois U. [Electrical Engineering Research Lab.] Urbana.

ANOMALOUS THERMAL TRANSITION IN THE INFRARED OPTICAL PROPERTIES OF EVAPORATED BISMUTH FILMS (Abstract), by C. E. Drumheller. [1954] [1]p. (AF 33(038)21255) Unclassified

Presented at meeting of the Opt. Soc. of Amer., New York, Mar. 25-27, 1954.

Published in Jour. Opt. Soc. Amer., v. 44: 345, Apr. 1954.

Studies of the effect of temperature variations on the infrared optical properties of evaporated bismuth films have led to the discovery of an anomalous transition in the infrared transmission. Heating of a bismuth film (on cellulose nitrate substrate) by any of several means caused a slight increase in transmission at wavelengths less than 1.7 micron and a decrease at longer wavelengths. The transition wavelength is essentially constant for films of various thicknesses. Careful examination of this transition revealed a sharp crossover resembling the familiar anomalous dispersion curves in optics. The mid-point corresponds to an energy of 0.68 electron volt. The results can be explained by taking into account three different effects on transmission, i.e., (1) film structure, (2) variations of conductivity with temperature, and (3) variations in index of refraction with temperature. The nature of these effects are discussed in relation to possible inferences concerning the electronic structure of bismuth in thin-film form. (Contractor's abstract)

ILL. 12:004

Illinois U. Electrical Engineering Research Lab., Urbana.

MOTION PICTURE STUDIES OF ELECTRON BOMBARDMENT OF EVAPORATED BISMUTH FILMS (Abstract), by L. L. Howard. [1954] [1]p. [AF 33-(038)21255] Unclassified

Presented at meeting of the Electron Microscope Soc. of Amer., Highland Park, Ill., Oct. 14-16, 1954.

Published in Jour. Appl. Phys., v. 25: 1457, Nov. 1954.

The orientation of crystallites in evaporated bismuth films under study in the electron microscope often undergoes changes. It is possible to record this activity on motion pictures without modification of the RCA model EMU electron microscope and with film recently

ILL. 13:001 - ILL. 14:002

made commercially available, Eastman Tri-X Negative Panchromatic. Motion ptctures were made of these changes tn a bismuth film approximately 1000Å thick and having an initial resistance per square of 100 ohms. (Contractor's abstract)

ILL. 13:001

Illinois U. Electrical Engineering Research Lab., Urbana.

THE KERR CELL AS AN ULTRAHIGH FREQUENCY OPTICAL SHUTTER. 1. THEORETICAL ANALYSIS, by G. L. Clark, D. F. Holshouser, and H. M. Von Foerster. Mar. 1955, 120p. incl. illus. dtagrs. tables, refs. (Technical note no. 1-1) ([AF]OSR-TN-55-88) (AF 18(600)1018) AD 59191 Unclassified

A broad survey is presented of the vartous posstbilities tn whtch a Kerr cell ltght shutter may be operaled tn the microwave region. It is shown thal owing lo the strong nonlinear character of the Kerr effect, light pulses of $\mu\mu$ sec duration, correspondtng to about 100th harmonics of the fundamental of the driving field may be wtthin the scope of experimental realization. The new element which enters is the transtt time lhe light requires to pass through a cell of ftnite length. Al ultra high frequenctes, this time element ts no longer negligible for the rapidly changing electric fields may alter considerably durtng the time the ltght ts travers-ing the cell. For this reason, the "drtfl length", Φ, of the cell (a familiar quantity in UHF tube technology) is an all-important quantity. In this survey, the photon, not the electron, is the focal potnt of tnterest.

ILL. 13:002

Illtnots U. [Electrtcal Engineering Research Lab.] Urbana.

DIELECTRIC PROPERTIES OF NITROBENZENE IN THE REGION OF ANOMALOUS DISPERSION, by G. L. Clark. Aug. 23, 1955 [5]p. tncl. diagrs. tables, refs. [AFOSR-TN-55-295] [AF 18(600)1013] Unclassifted

Published in Jour. Chem. Phys., v. 25: 125-129, July 1956.

This study was carried oul to delermine the highest frequency at which nitrobenzene can be used as a Kerr medium, and to obtain design data for microwave Kerr cells. A determination was made of the complex dte-lectric constant of htghly purified nitrobenzene tn the region of anomalous dispersion by measuring the input impedance of a variable length of a coaxial transmission ltne filled with the liquid. Measurements were obtained at frequencies ranging from 0.65 kmc/sec to 3.00 kmc/sec in the temperature range from 15°C to 50°C. They indicated that at low frequencies, the effect of increasing temperatures is to decrease the real part of the dielec-trtc constant owing to the shift in the staltstical equtlib-rium between the aligning force of the field and the ran-domizing effect of thermal motion. In the region of anomalous dispersion, however, the dielectric conslant may rise with increasing temperalure as a result of the effect of temperature on the relaxation time. It is observed that there is a frequency region in which the 2 effects tend lo neutralize each other, causing the dielectric constanl lo be insensitive to temperature changes. Concerning lhe frequency limitation on nitro-benzene as a Kerr medtum, the behavior of the dielec-trtc constant reveals lhal above 1000 mc/sec, the di-pole polartzation falls away rapidly as the frequency increases.

ILL.14:001

Illinois U. Electrical Engineering Research Lab., Urbana.

THERMAL ACCEPTORS IN GERMANIUM, by H. Letaw, Jr. Aug. 20, 1955, 38p. incl. dtagrs. tables, refs. [AFOSR-TN-55-298] (Sponsored jointly by Office of Naval Research as Technical rept. no. 7 under N6ort-07140 and Office of Sctentific Research as Technical note no. 1 under AF 18(600)1310) AD 72718 Unclassified

Thermal acceptors are identified as vacancies with an energy of formation of 2 ev. The annealing of thermally tnlroduced acceptors in germanium ts described by a mechanism involving lhe formation of divacancies as the first step. The activation energy for the formation of a divacancy is 1.7 ev, consisting of a contribution of 0.97 ev from the activation energy for the diffusion of a vacancy and 0.7 ev from the laltice strain repulsion of 2 vacancies. The energy of formation and the bindtng energy of a dtvacancy are 1.1 and 2.9 ev, respectively. The diffuston coeffictent of a divacancy may probably be represented by $D_{VV} = 0.1 \exp(51,000/RT)\ cm^2\ sec^{-1}$. At dry tce temperatures, a vacancy accepts 1 electron and a divacancy, 4, while at room temperature these are 1 and 2, respectively. The second step of the an-nealing process involves the formation of clusters of 4, the acttvation energy of formation of which is 2.8 ev, a contribution of 2.2 ev from the acttvaiion energy for the diffusion of a dtvacancy and 0.6 ev from the lattice strain repulsion of 2 divacancies. Further annealtng takes place through the formation of clusters of higher order. The behavtor of the mathemattcal model is com-pared to experiments reported by others. The model is shown to account for the slow rate of annealing, as well as the lnittal increase in acceptor density often observed during annealing. (Contractor's absiract)

ILL. 14:002

Illinois U. Electrical Engineering Research Lab., Urbana.

MELTING AND GROWTH PATTERNS APPEARING ON SINGLE CRYSTALS OF InSb, by M. F. Millea and C. T. Tomizuka. [Oct. 1955] 8p (AF 18(600)1310) Unclasstfted

Published in Jour. Appl. Phys., v. 27: 96-97, Jan. 1956.

It has been found that melting originates on a surface of InSb at discrete nucleation sites and proceeds from those in a definite pattern. The melting patterns are intersections of (111) planes with the surface of the specimen. Facets and striations occuring on the surface of single crystals pulled from the melt are characteristic of the growth process and not due to external influences. A surface of InSb which was the interface between the liquid and a growing crystal quickly removed from the melt was examined. In order to account for the observed structure, it was postulated that growth proceeds by a layer mechanism. The similarities between InSb, Ge, and Si crystals are discussed. (Contractor's abstract)

ILL. 14:003

Illinots U. Electrical Engineering Research Lab., Urbana.

SELF DIFFUSION IN GERMANIUM, by H. Letaw, Jr., W. M. Portnoy, and L. Slifkin. May 15, 1956, 11p. tncl. diagrs. table, refs. (AFOSR-TN-56-129) (Sponsored joindy by Offtce of Naval Research as Technical rept. no. 8 under N6ori-07140 and Air Force Offtce of Scientiftc Research as Technical note no. 2 under AF 18(600)1310) AD 86006 Unclassified

Also published in Phys. Rev. v. 102: 636-639, May 1, 1956.

An accurate determination of the self-diffusion coefficienl tn Ge was obtained and ts represented by D = 7.8 exp(-68, 500/RT) sq cm/sec tn the 766° to 928°C range. After preparation and electroplating, ihe specimens were placed on quariz flats and sealed in Vycor tubes which contained about a 10^{-5}-mm air atm. Annealing was conducted tn furnaces which were maintained within ±2°C of the desired temperature. Nineteen successful determinaiions of the self-dtffusion coefficient were obtained. The probable errors in the frequency faclor and activation energy were ±3.4 sq cm/sec and ±0.96 kcal/mol, respectively. The defect responsible for thermal converston was apparently associated with self diffusion in Ge.

ILL. 14:004

Illinois U. [Electrical Engineering Research Lab.] Urbana.

THE EFFECT OF DOPING ON THE SELF-DIFFUSION OF GERMANIUM (Abstract), by M. W. Valenta and C. Ramasatry. Feb. 1956, 1p. (Sponsored jotnily by Motorola, Inc. and Atr Force Office of Scientiftc Research under AF 18(600)1310) Unclassified

Presented at meeting of the Amer. Inst. of Metallurgical Engineers, New York, Feb. 1956.

If vacancies in germantum act as acceptors, ihe equilibrtum concentration ts expected to be higher tn the n-type than in p-type germanium. To delermine whether or not self-diffusion in germanium occurs by a vacancy mechanism, measurements were made in (1) As-doped, (2) intrinsic and (3) Ga-doped specimens in the temperature range of 750° to 900°C. Self-diffusion coefficients obtained for the intrtnsic specimens were in good agreement with earlier work, those for the As-doped (about 1×10^{19} atoms/cm^3) ranged from 1.1 to 2 times the corresponding ones for the intrtnsic samples, and those of the p-type (about 6×10^{19} atoms/cm^3) ranged from 0.5 to 0.25 times those of the intrinsic samples. The observed changes are in the direction predicted by the vacancy mechanism, although those tn the case of Ga-doping are not as large as expecled from the shifts in the Fermi level with doptng. The doped specimens were prepared by W. W. Tyler of the G. E. Research Laboratory. X-ray measurements made there tndicale only small changes tn the lattice parameter (about a 0.02% decrease) and in the same dtrection for both As- and Ga-doped germanium. The data indicate that self-diffusion probably takes place vta vacanctes. (Contractor's absiract)

ILL. 15:001

Illinois U. Engineering Experiment Station, Urbana.

COMPRESSIBLE TWO-DIMENSIONAL JET MIXING AT CONSTANT PRESSURE, by H. H. Korst, R. H. Page, and M. E. Childs. Apr. 22, 1954, 22p. incl. diagrs. (ME Technical note no. 392-1) ([AF]OSR-TN-54-82) (AF 18(600)392) AD 32990 Unclassified

This analysis of turbulent conslant-pressure mixing takes into consideration the effects of the initial boundary layer. Velocity profiles in the mixing region are represented tn a transformed plane by 1-parameter families of curves, wtth no specification for the mtxing mechanism beyond that of an exchange coefficient concept being made. The exchange coefficient is represented by the kernel function of an integral transform for the x coordinate of an tnirtnstc system of coordtnates. The intrtnsic system and the physical coordinate system are related by means of a momentum integral. Satisfactory correlation of theory and experimental low-speed data ts obtained with a simple form of kernel function. An asymptotic solution, corresponding to a fully developed velocity profile in the jet boundary, allows the calculation of the mechanical energy level along the separating streamline in the jet boundary without the use of empirical information. (ASTIA abstract)

ILL. 15:002

Illinois U. Engineering Experiment Station, Urbana.

A THEORY FOR BASE PRESSURES IN TRANSONIC AND SUPERSONIC FLOW, by H. H. Korst, R. H. Page, and M. E. Childs. Mar. 1955, 73p. incl. diagrs. refs.

ILL. 15:003 - INN. 01:002

(ME Technical note no. 392-2) ([AF]OSR-TN-55-89) (AF 18(600)392) AD 61544 Unclassified

A theory for base pressures in transonic and supersonic flow is developed using a physical model composed of simplified flow components. The model is based on the concepts of interaction between dissipative flow regions with the adjacent freestream, and the conservation of mass in the dead-air region. While the pressures in the dissipative flow regions are impressed by the adjacent freestream, which is, e.g., subject to a Prandtl-Meyer expansion at the trailing edge and to recompression by the trailing shock, a unique and stable solution is determined by the formulation of an escape concept applied to a particular streamline in the jet-mixing component of the flow in order to satisfy the continuity equation. The theory, which employs the mixing mechanism described in University of Illinois Mechanical Engineering Dept. Technical Note 392-1, is capable of dealing with the effects of various established parameters of the base-pressure problem, e.g., Mach number, Reynolds number, and initial boundary-layer configuration, if certain empirical information on the jet-mixing component is available. For thin approaching boundary layers, the theory predicts, for any given Mach number and geometrical configuration, lowest base-pressure values, asymptotically reached as Reynolds number increases. These values, obtained without the use of empirical information, by what is termed the restricted theory, are in good agreement with experimental data. Applications of both the restricted and unrestricted theory to various base-pressure problems are included. (Contractor's abstract)

ILL. 15:003

Illinois U. Engineering Experiment Station, Urbana.

COMPRESSIBLE TWO-DIMENSIONAL JET MIXING AT CONSTANT PRESSURE. TABLES OF AUXILIARY FUNCTIONS FOR FULLY DEVELOPED MIXING PROFILES, by H. H. Korst, R. H. Page, and M. E. Childs. Apr. 1955, 69p. incl. diagrs. tables. (ME Technical note no. 392-3) ([AF]OSR-TN-55-99) (AF 18(600)392) AD 61678 Unclassified

A tabulation of auxiliary functions applicable to the 2-dimensional jet-mixing problem and to the mixing component of the base pressure model is presented in which numerical values of the integrals

$$I_1(C_{2_a};\eta) = \int_{\omega}^{\eta} \frac{\varphi}{1 - C_{2_a}^2 \varphi^2}\, d\eta$$

and

$$I_2(C_{2_a};\eta) = \int_{\omega}^{\eta} \frac{\varphi^2}{1 - C_{2_a}^2 \varphi^2}\, d\eta,$$

and the function $\omega(\eta) = \frac{1}{2}[1 + \operatorname{erf}\eta]$ are listed as functions of the variable η for 21 values of parameter, C_{2_a}. The value of the location, η_j, and the velocity ratio, φ_j, of the jet boundary streamline, j, and the coordinate shift (rotation), η_m, is also listed for each C_{2_a} value.

Industrial Scientific Co., New York. see Warner and Swasey Research Corp., New York.

INN. 01:001

Innsbruck U. [Inst.] of Theoretical Physics (Austria).

A NEW SPINOR THEORY OF ELEMENTARY PARTICLES, by F. Cap. [1954] [1]p. incl. refs. [AF 61(514)633-C] Unclassified

Published in Phys. Rev., v. 93: 907, Feb. 15. 1954.

Sufficient description of an elementary particle by only $2(2S + 1)$ spinor components is considered possible since measurements on such a particle distinguish $2(2S + 1)$ different states of a quantized spinor wave field of spin. Multiple application of formulas of the type

$$\partial_{\mu M \nu N + 1}\, a_{\nu 1 \ldots \nu N - 1 \nu N} = t\,\frac{mc}{\hbar}\, a_{\dot\mu 1 \ldots \dot\mu M - 1 \dot\mu M \nu 1 \ldots \nu N - 1 \nu N \nu N + 1} - \partial_{\dot\mu t \ldots \dot\mu M - 1 \dot\mu M}\, a_{\nu 1 \ldots \nu N - 1 \nu N}$$

yield spinors $a_{\dot\mu 1 \ldots \dot\mu 2s_{2s}}$ which contain only indices of one kind and exactly $2(2S + 1)$ components. These new spinors obey second-order differential equations: $(\Box - m^2c^2/\hbar^2)\, a_{\dot\mu 1 \ldots \dot\mu 2s} = 0$, $(\Box - m^2c^2/\hbar^2)\, a_{\nu 1 \ldots \nu 2s} = 0$, which describe the propagation of the unquantized spinor wave field. First-order differential equations, considered as unnecessary by Pauli are eliminated. A relativistically — and gauge — invariant theory can be built up which is also invariant against inversions $X_k \longrightarrow -X_k (k = 1, 2, 3)$, $X_4 \longrightarrow X_4$. After quantization the new theory reproduces the well-known results of the usual theory for the free particle in a generalized manner. Besides the possibility of giving other results for interacting particles, the new theory is a consistent general theory without superfluous components or accessory conditions, basic to a proposed unified nonlinear spinor theory of all elementary particles.

INN. 01:002

Innsbruck U. Inst. of Theoretical Physics (Austria).

NONLINEAR MESON THEORY OF NUCLEAR FORCES, by F. Cap. [1954] [2]p. incl. refs. [AF 61(514)-633-C] Unclassified

Published in Phys. Rev., v. 95: 287-288, July 1, 1954.

The author presents in part mathematical formulations supporting the theory that pseudoscalar π mesons are responsible for nuclear forces. The proposed theory can be made unitary or non-unitary. In this note only the unitary form is treated.

INN. 01:003

Innsbruck U. Inst. of Theoretical Physics (Austrta).

INVESTIGATION ON THE NONLINEAR PSEUDOSCALAR RELATIVISTICALLY INVARIANT MESON THEORY OF NUCLEAR FORCES, PART I, by F. Cap. Ftnal technical rept., vol. 1. Mar. 1-Dec. 31, 1954, 504p. (Rept. no. EOARDC-TR-1954) (AF 61(514)633-C) AD 69669 Unclassified

A detatled survey of the ltterature (2258 refs.) introduces an evaluation of the linear pseudoscalar meson theory. Known modtftcations of the usual theory are presented, and the static potential according to the 1_0 theory ts discussed. Reasons for the nonlinear meson theortes, justiftcation of a static semiphenomenological approximation, and behavtor of the potential for small dtstances are constdered. Also included are a short survey of Born's nonlinear electrodynamics, ε-formalism of nonlinear theories, Lagrangian formaltsm, nonunitary nonltnear theortes, relations between nonlinear and linear theories, effectlve source density for the 1_0 theory and nonlinear form, calculation of potentials from extended sources, classtcal approxtmation of nuclear forces, dtscussion of special Lagrangians, gage invariance, differential equations, nucleon interaction from unitary nonlinear theories, nucleon interaction from nonunitary nonlinear theories, integration of the nonhomogeneous D'Alemberitan, Lagrangian with complex A, electric charge, as well as the nucleon spin and partial differential equations.

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Innsbruck U. Inst. of Theoretical Physics (Austrta).

INVESTIGATION ON THE NONLINEAR PSEUDOSCALAR RELATIVISTICALLY INVARIANT MESON THEORY OF NUCLEAR FORCES, PART II, by F. Cap. Ftnal technical repl., vol. 2. Mar. 1-Dec. 31, 195[illegible] [360]p. incl. diagrs. tables. (Rept. no. EOARDC-TR-1954) (AF 61(514)633-C) AD 69670 Unclassified

The equation of motion of the sources of the meson field is treated, as also are quantization of nonlinear theories, and numerical data. A consideration of the binding energy of the deuteron includes wrong formulas, analytical approximation for the interaction and Ritz's method; right formulas, analytical approximation of the interaction energy and Ritz's method; right formula, March's interaction and Ritz's method; right formulas numerically given interaction, and Ritz's method. Also treated are different trials of numerical integrations, Groebner's numerical integration with R(x), quadrupole and magnetic moment of the deuteron, and experimental scattering data. A consideration of neutron-proton scattering gives references on methods for cross-section computations, and includes treatment of interaction energies and their exchange character, results of the usual linear theory, experimental data, Born's approximation with tensor force, and calculation of phases. The text also covers proton-proton scattering, as well as velocity dependent terms and relativistic corrections.

INN. 01:005

Innsbruck U. Inst. of Theoretical Physics (Austria).

DERIVATION OF THE VALUE OF THE COUPLING CONSTANT g FROM THE REST ENERGY OF THE NUCLEON, by F. Cap. [Jan. 1955] [7]p. incl. diagrs. refs. (AF 61(514)633-C) Unclassified

Published in Progress of Theoretical Phys., v. 13: 62-68, Jan. 1955.

The static interaction energy between two nucleons and the value of the coupltng constant g are derived from a unitary nonltnear charge symmetrical pseudoscalar meson theory that contains no free parameters. (Contractor's abstract)

INN. 01:006

Innsbruck U. Inst. of Theoretical Physics (Austrta).

NEW METHOD FOR THE SOLUTION OF THE DEUTERON PROBLEM, AND ITS APPLICATION TO A REGULAR POTENTIAL, by F. Cap and W. Gröbner. [1955] [12]p. incl. dtagrs. refs. [AF 61(514)633-C] Unclassified

Published in Nuovo Ctmento, Series X, v. 1: 1211-1222, 1955.

Ftrst, success and failure of the usual ltnear charged PS meson theory of nuclear forces are discussed and reasons given for nonlinear terms, yielding finite potential. Second, a new method of solution of the deuteron problem is gtven and applied to a regular PS potential. It ts shown that the discussed nonlinear PS theory ytelds far better results for the deuteron than the linear theory. (Contractor's abstract)

INN.02:001

Innsbruck U. Inst. of Expertmental Psychology (Austria).

AUDITORY GUIDANCE STUDIES, by I. Kohler. Summary progress repl. Oct. 1, 1955-July 31, 1956 [62]p. incl. illus. diagrs. table, refs. (AFOSR-TR-56-43) (AF 61(514)889) AD 97077 Unclassified

An investigation was made of obstacle sense which ts the faculty of blind persons to orient themselves correctly with respect to near objects by the aid of sound. Obstacle sense was measured by making use of a standard obstacle (a round carboard disk with a diameter of 50 cm) which could be quickly and noiselessly brought within range of the test person at any desired distance. The greatest distance from which it was still possible to detect this obstacle with exactitude was used as a measure for the obstacle-sense performance of the respective person. A sonic guidance device to be carried on the person was also developed which consisted of a microphone, an amplifier connected to the latter,

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and measurtng devtces. Measurements were carrted out on 267 persons between the ages of 4 and 85 yr who were blind or normal but blindfold. Results tndtcated that everyone appeared to possess the faculty of blind ortentation tmmedtately wtth the atd of sonic devices when approaching obstacles. Optimum results were obtained tf short tmpulses wtth a broad frequency band are used which are radtated at an angle of the greatest posstble wtdth by a sonic device attached to the person. By tratning, obstacle sense performance ts further tmproved. The tlmtts of efftctency dtffered constderably tn each tndtvtdual case and appeared connected wtth the ftneness of the dtscrtminatory limtts for the modiftcations of sound tntenstties. The quaitty of a person's absolute heartng capactty ts of mtnor tmportance. Expertments showed that skin sensations accompanytng the detection of near obstactes are cortical projections. The sensations are descrtbed as factal vtston. (ASTIA abstract)

IAS. 01:001

Instttute for Advanced Study, Prtnceton, N. J.

[ARITHMETIC REPRESENTATIONS IN FINITE FIELDS AND POLYNOMIAL DOMAINS] by E. Cohen. [Ftnal rept.] [Nov. t952] 1p. [AF t8(600)134] Unclasstfted

The following problem ts constdered: Let r be an arbtrary odd number > 1, and let $a_1, \ldots, a_s$ be tntegers prtme to r. Then we destre the number of solutions $N = N_s(n, r)$ of

$$n \equiv a_1x_1^2 + \ldots + a_sx_s^2 \pmod r.$$

Thts problem ts deftned as a ftnite "stngular sertes" $S = S_s(n, r)$, analogous to the Hardy-Ramanujan sertes tn the non-modular case. The function S ts a dtvtsor sum tnvolvtng the Ramanujan sum tn case s ts even and a Gauss character sum tn case s ts odd. Ustng orthogonallty properties of these stmple exponenttal sums, tt ts shown on the basis of tnductton, that $N = S$. A dtrect proof of this fact ts also gtven. The functton S ts evaluated completely to gtve the followtng result for $s = 2m$,

$$N_{2m}(n, r) = r^{2m-1} \sum_{d/r} \sum_{\substack{d'(n,d) \\ d'e=d}} \left(\frac{a}{d}\right) \frac{d'p(e)}{d^m}$$

$$(a = (-1)^m a_1 \ldots a_{2m})$$

where $(\frac{a}{d})$ ts the Jacobi symbol and μ ts the Möbius functton. The case $s = 2m + 1$ ts more complicated; stmplifications artse under the hypothests that n has no square factor > 1 tn common wtth r. In this case, tt ts shown that

$$N_{2m+1}(n, r) = r^{2m} \sum_{\substack{D^2/r \\ D/n}} \frac{\mu(d)}{D^{2m}} \sum_{\substack{e/r \\ (e,D)=1}}$$

$$(-\frac{an}{e}) \frac{\mu^*(e)}{e^m}, \quad (a = (-1)^{m+1} a_1 \cdots a_{2m+1})$$

where $\mu^*(e) = 1$ or 0 according as e ts or ts not square-free. Correspondtng results for $GF[p^n, x]$, p odd, are also obtained. (Contractor's abstract)

IAS. 02:001

Instttute for Advanced Study, Prtnceton, N. J.

A CLASS OF TRANSFORMATIONS OF THE PLANE, by G. A. Hedlund. June 1954, 20p. ([AF]OSR-TN-54-135) (AF 18(600)667) AD 34546 Unclassifted

Also published in Proc. Cambridge Philos. Soc., v. 5t: 554-564, 1955.

This report constitutes an analysts of the class of transformations ϕ of the complex plane Z onto ttself defined by

$$\phi(re^{t\theta}) = re^{f(\theta)}e^{t(\theta+\beta)},$$

where f ts a real-valued conttnuous functton of pertod 2π and β/π ts trrattonal. It ts shown that any such transformation is either (t) equtvalent to a rotatton; or (2) transtttve tn the sense that the orbtt of some potnt ts everywhere dense tn Z; or (3) equivalent to a dtlatton. Stmple crtterta for the vartous cases are dertved and models of all posstbtlttes are exhibtted. (Contractor's abstract)

IAS. 02:002

Instttute for Advanced Study, Prtnceton, N. J.

[INVESTIGATION OF PROBLEMS IN GLOBAL GEOMETRY], by G. A. Hedlund. Ftnal rept. Sept. 1, t953-Sept. t, t954, 1p. ([AF]OSR-TR-54-29) (AF 18(600)-667; continued under AF t8(600)11t6) Unclasstfted

A ftnal report on the progress of a book on the subject of topological dynamtcs. Thts book was publtshed tn t955 under the tttle Toplogtcal Dynamtcs under Pennsylvanta Univ. contract AF 18(600)1116 and AF 18(600)-667 (see item no. PEN.03:002).

IAS. 03:001

Institute for Advanced Study, Prtnceton, N. J.

THE SPLITTING OF CERTAIN SOLVABLE GROUPS, by E. Schenkman. July 1954, 8p. (In cooperation wtth Louistana State U., Baton Rouge) ([AF]OSR-TN-54-t90) (AF 18(600)790) AD 47333 Unclassifted

Also published in Proc. Amer. Math. Soc., v. 6: 286-290, Apr. 1955.

Proofs are presented that if Hts Abeltan, where H is

the least member of the descending central series so that G/H is nilpotent and [G, H] = H, and if G is a finite group, then (1) there is a complement X of H in G so that G = HX, and $x \cap H = E$, the subgroup consisting of the identity element; (2) if X and Y are 2 complements of H in G then $X = hYh^{-1}$ for some h in H; and (3) if G has no center, then G and A, the group of automorphisms of G, are contained in the holomorph of H. (ASTIA abstract)

IAS. 03:002

Institute for Advanced Study, Princeton, N. J.

ON THE TOWER THEOREM FOR FINITE GROUPS, by Schenkman. July 1954, 4p. [In cooperation with Louisiana State U., Baton Rouge] ([AF]OSR-TN-54-205) (AF 18(600)790) AD 47334 Unclassified

A proof is presented that if the group G is a member of a composition series of the finite group A, and if the centralizer of G in A is the identity, then the centralizer of G* in A is contained in G*, where G* denotes the intersection of the members of the descending central series of G. An example is given to show that G* need not be normal in A, and in this case, methods previously used by Schenkman (Amer. Jour. Math., v. 73: 453-474, 1951) cannot be used to improve the lower theorem of Wielandt (Math. Zeitschr., v. 45: 209-244, 1939). (ASTIA abstract)

IAS. 03:003

Institute for Advanced Study, Princeton, N. J.

ON THE DERIVATION ALGEBRA AND THE HOLOMORPH OF A NILPOTENT LIE ALGEBRA, by E. Schenkman. July 1954, 11p. (In cooperation with Louisiana State U., Baton Rouge) ([AF]OSR-TN-54-236) (AF 18(600)790) AD 47332 Unclassified

Also published in Mem. Amer. Math. Soc., No. 14: 15-22, 1955.

Derivations of nilpotent Lie algebras are studied in an attempt to determine whether the holomorph of a Lie algebra determines the algebra up to an isomorphism. Proofs are presented of the following theorems: (1) if L is a finite Abelian Lie algebra with holomorph H, then H is the holomorph of no other Lie algebra; (2) if K is an arbitrary Lie algebra and if L is the free Lie algebra with the smallest possible number of generators such that K = L/M (where M is the characteristic ideal of L), then the algebra of derivations of K is isomorphic to $\hat{D}_M/\hat{D}_{LM}$, where $\hat{D}_M$ and $\hat{D}_{LM}$ are maps which send M and L into M, respectively; (3) if L is a free nilpotent Lie algebra of class n generated by q elements, then D_1, a nilpotent ideal of the derivation algebra $\hat{D}$, is the nil radical of D; $L + D_1$ is the nil radical of H, the holomorph of L; and the center of L is the center of $L + D_1$; and (4) if H is the holomorph of L, a free nilpotent Lie algebra of class n generated by $q \geq 2$ elements, the H cannot also be the holomorph of another Lie algebra K, unless K is isomorphic to L.

IAS. 03:004

Institute for Advanced Study, Princeton, N. J.

THE EXISTENCE OF OUTER AUTOMORPHISMS OF SOME NILPOTENT GROUPS OF CLASS 2, by E. Schenkman. Oct. 1954, 10p. (In cooperation with Louisiana State U., Baton Rouge) ([AF]OSR-TN-54-282) (AF 18(600)790) AD 47331 Unclassified

Also published in Proc. Amer. Math. Soc., v. 6: 6-11, Feb. 1955.

A proof is presented which states that if G is a p-group whose commutator subgroup is in the center and if for some fixed number p^k the p^kth powers of all the elements of G are in the commutator subgroup, then: (1) G has an outer automorphism (except when G is order 2); and (2) the order of G divides the order of the automorphism group of G provided G is not Abelian. (ASTIA abstract)

IAS. 03:005

Institute for Advanced Study, Princeton, N. J.

ON THE STRUCTURE OF THE AUTOMORPHISM GROUP OF A NILPOTENT GROUP, by E. Schenkman. Nov. 1954, 9p. ([AF]OSR-TN-54-311) (AF 18(600)-790) AD 47335 Unclassified

Also published in Portugal. Math., v. 13: 129-135, 1954.

The terminology is as follows: G is a nilpotent group so that $G^* = E$, the identity, where $G^* = \bigcap_{k=1} G^k$, $G^k = [G^{k-1}, G]$ and $G^1 = G$. A is the group of automorphisms of G, and A_k is the subgroup of automorphisms of A which induce the identity transformation in G/G^k. Proofs are presented for the following theorems: (1) A_2 is a normal nilpotent subgroup of A of class at most one less than that of G. (2) If H is the holomorph of the nilpotent group G, then the subgroup of H generated by G and A_2 is normal in H and nilpotent of the same class as G. (3) If G is a nilpotent group, then the elements of finite order generate a characteristic subgroup which is the direct product of (p,∞) groups, where (p,∞) groups are those generated by elements whose orders are powers of the same prime p and which contain no elements of finite order other than those of that prime power. (4) If a $(p-\infty)$ Sylow subgroup P of a group G is normal in G, then P contains all the elements of G whose orders are powers of the given prime p, and so is the only $(p-\infty)$ Sylow subgroup of G. (4) Let G be a nilpotent group of class n generated by elements whose orders divide a certain prime power p^k. If A is the complete group of automorphisms

IAS. 04:001 - IAS. 05:004

of G and if B_1 is the subgroup of A such that the elements of B_1 leave G/G(p) fixed, then B_1 is a normal subgroup of A which is nilpotent of class at most kn. If H is the holomorph of G, then GB_1 is a normal subgroup of H which is nilpotent of class at most kn. (ASTIA abstract)

IAS. 04:001

Institute for Advanced Study, Princeton, N. J.

A GENERALIZED FUNCTION-THEORY AND THE RELATED DIRICHLET PROBLEM. PART 1, by J. Sanders. [1956] [21]p. (AF 18(600)791) Unclassified

Published in Ann. Math., v. 64: 523-543, Nov. 1956.

This paper is concerned with the partial differential equation $N(N(u)) = 0$, where $N(u) \equiv (\sigma(x))^{-1}(\sigma(x)u_x)_x + (\tau(y)((\tau(y))^{-1}u_y)_y$, which includes the biharmonic partial differential equation $\Delta\Delta u = 0$ as the special case $\sigma = \tau \equiv 1$. A function theory, bearing roughly the same relation to the equation $N(u) = 0$ as the classical theory of analytic functions of one complex variable bears to Laplace's equation $\Delta u = 0$, was constructed by L. Bers and A. Gelbart (Trans. Amer. Math. Soc., v. 56: 67-93, 1944). A method for attaching a function theory to the biharmonic equation was given by L. Sobrero [Theorie der ebenen Elastizität ..., Teubner, Leipzig-Berlin, 1934], using hypercomplex numbers. This last approach, together with the procedure of Bers and Gelbart, was used by J. B. Diaz (Amer. Jour. Math., v. 68:611-6[illegible] 1946) to obtain a function theory associated with the n times iterated equation $N^n(u) = 0$. The author proceeds directly to the construction of a function theory for the equation $N^2(u) = 0$, as follows. A function $u(x, y) - iv(x, y)$ is said to be Δ_2-monogenic in a domain D of the $z = x + iy$ plane provided that u and v are four times continuously differentiable in D (i.e., $u, v \in C^4$) and satisfy the system of equations $\sigma(x)u_y - \tau(y)v_x = 0$, $\sigma(x)u_x + \tau(y)v_y = 0$, $N'(w) = 0$, where $\sigma, \tau \in C^3$, $\sigma > 0$, $\tau > 0$, $w \in C^2$, and the operator N' is given by $N'(w) \equiv (\sigma^{-1}w_x)_x + (\tau^{-1}w_y)_y$ for any function w. For such functions, differentiation and integration processes are defined and are shown to be inverses of each other. By repeated integration of some simple functions, a series of functions are defined which are generalizations of the usual powers $a(z - z_0)^n$, and a generalization of Taylor's theorem is proved. Next, a fundamental solution $\Phi(x, y; \xi, \eta)$ of $N^2(u) = 0$ is obtained, and an analogue of Cauchy's integral formula $f(t) = (2\pi i)^{-1}\int_C f(z)(z - t)^{-1}dz$ is derived. The paper concludes with indications as to how the theory can be extended to $N^n(u) = 0$ and to certain non-iterated equations. (Math. Rev. abstract)

IAS. 05:001

Institute for Advanced Study, Princeton, N. J.

ON A GAME WITHOUT A VALUE, by M. Sion and P. Wolfe. [1952] 8 p. incl. diagrs. (AF 18(600)1109) Unclassified

Published in Ann. Math. Studies, "Contribution to the Theory of Games", Rand Corp., Santa Monica, v. 3: 299-396, 1951-1952.

The object of this paper is to show that one of the main results in the theory of infinite games, the theorem of Glicksberg on semi-continuous payoffs, cannot be extended in certain directions. A game is presented on the square (a form of continuous Blotto) which does not have a value, but whose payoff function is topologically even simpler than that of the classical example due to J. Ville. Scarf and Shapley have applied Glicksberg's theorem to a number of infinite games in extensive form. The question of whether the condition of semi-continuity of the payoff is equally important for the determinacy of such games is shown by the fact that any game on the square may be transcribed into a game in extensive form with its value, or lack of value, preserved. It is found that the transcription of the example of the game on the square to extensive form yields a type of "game of pursuit" without a value.

IAS. 05:002

Institute for Advanced Study, Princeton, N. J.

AN ELEMENTARY INEQUALITY FOR THE TRAVELING SALESMAN PROBLEM, by S. P. Diliberto. June 1955, 4p. ([AF]OSR-TN-55-170) (AF 18(600)1109) AD 71236 Unclassified

The problem is that of determining a path, P, of minimal length, D, which joins all N points of a set, $P_1, \ldots, \ldots, P_n$, $P_i = (x_i, y_i)$, lying in a plane. It is shown that if the points lie in a rectangle R of sides L and W, D is the order of $N^{1/2}$ times the length of the diagonal. (ASTIA abstract)

IAS. 05:003

Institute for Advanced Study, Princeton, N. J.

A NOTE ON LINEAR ORDINARY DIFFERENTIAL EQUATIONS, by S. P. Diliberto. June 1955, 3p. ([AF]OSR-TN-55-171) (AF 18(600)1109) AD 71235 Unclassified

A sharp version of Diliberto's triangulization theorem (Contributions to the Theory of Nonlinear Oscillations, Ann. Math. Stud., p. 1-48, Princeton, 1950) is established for systems of first order linear ordinary differential equations. (Contractor's abstract, modified).

IAS. 05:004

Institute for Advanced Study, Princeton, N. J.

A SINGULAR FUNCTIONAL, by A. D. Martin. May 1955, 15p. ([AF]OSR-TN-55-239[A].) (In cooperation with Washington U., St. Louis, Mo.) (AF 18(600)1109) AD 74651 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 1031-1035, Dec. 1956.

A functional J of the type

$J(y) \Big|_x^b = \int_x^b [\, ry'^2 + 2qyy' + py^2]\, dx$ $(0 < x < b)$, is considered in which the functions r, p, and q are continuous on $(0, \infty)$ while r is positive. The point x = 0 is singular for the functional in the sense that the conditions on r, p, and q may not hold for an interval of the form [0, b]. All of the integrals which appear are Lebesgue integrals. The functional J has an X-minimum limit on [0, b] when the lim inf $J(y) \Big|_x^b \geq 0$ for all functions of y in a subclass X[0, b] of F[0, b]. The class F[0, b] consists of all functions y which are absolutely continuous with $y' \in L_2$ on every closed subinterval of (0, b]. The subclasses are: F'[0, b], the set of all $y \in F[0, b]$ for which y is bounded on [0, b]; $F_0[0, b]$, the set of all $y \in F[0, b]$ such that $x \subset 0$ is a limit point of zeros of y; A[0, b], the set of all $y \in F[0, b]$ which are continuous on [0, b] and for which y(0) = 0; and $A_0[0, b]$, the set of all $y \in A[0, b]$ for which x = 0 is a limit point of zeros of y. Necessary and sufficient conditions are given for the existence of F-, F_0-, and A_0-minimum limits. Some sufficient conditions for the A-minimum limit are given for the case q = 0. The results supplement those in which a quadratic functional with a singular endpoint was studied by Leighton and Martin (Trans. Amer. Math. Soc., v. 78: 98-128, 1955). (Contractor's abstract, modified)

IAS. 05:005

Institute for Advanced Study, Princeton, N. J.

AN APPLICATION OF THE MORSE THEORY TO THE TOPOLOGY OF LIE-GROUPS, by R. Bott. Dec. 1955, 36p. refs. ([AF]OSR-TN-55-464) (AF 18(600)1109) AD 81507 Unclassified

Also published in Bull. Soc. Math. France, v. 84: 251-218, 1956.

A compact group G, acts on itself by inner automorphisms. This action decomposes G into orbits. In this study the space of paths, Ω, on G, which start at a fixed point and end on a fixed orbit, is investigated. By applying the Morse theory, it is shown that: (a) Ω is always free of torsion; (b) Ω has vanishing Betti numbers in odd dimensions; and (c) the Poincaré series of Ω is determined by the infinitesimal structure of G. A similar result concerning the orbits of the adjoint representation of G on its Lie-algebra leads to formulas for the Betti numbers of certain homogeneous spaces. (Contractor's abstract)

IAS. 05:006

Institute for Advanced Study, Princeton, N. J.

HOLOMORPHIC FUNCTIONALS AND COMPLEX CONVEXITY IN BANACH SPACES, by H. J. Bremermann. Feb. 1956, 32p. refs. (AFOSR-TN-56-42) (AF 18(600)1109) AD 80554 Unclassified

Also published in Pacific Jour. Math., v. 7: 811-831, 1957.

A complex valued function f(z) is "Gaieaux holomorphic" in a domain D of a complex Banach space B_c if it is single-valued and if $f(z_0 + \lambda a)$ is a holomorphic function of the complex parameter λ at $\lambda = 0$ for every $z_0 \in D$ and $a \in B_c$. It is shown that in general, as in the case of finitely many variables, all functions that are holomorphic in a domain D can be continued into a larger domain. If this is not the case D is a domain of holomorphy. The domains of holomorphy have the property to be pseudo-convex. This notion is defined by requiring $-\log d_D^{(N)}(z)$, where $d_D^{(N)}(z)$ is the distance of the point z from the boundary of D measured in the norm N, to be plurisubharmonic. It is shown that this property is independent of the norm N. The relationship of the pseudo-convexity to the ordinary convexity is studied and an application to tube domains is made. (Contractor's abstract)

IAS. 05:007

Institute for Advanced Study, Princeton, N. J.

A METHOD OF PARAMETRIX IN THE THEORY OF HARMONIC FORMS IN A COMPLEX LINE BUNDLE, by S. Nakano. Jan. 1956, 12p. refs. (AFOSR-TN-56-52) (AF 18(600)1109) AD 81044 Unclassified

The theory of harmonic forms in a complex line bundle or in a complex vector bundle is reduced to the usual theory. Vectorial forms on the base space are transformed into usual differential forms on the bundle space, and a spectal metric is introduced into the latter space; thus the method of parametrix can be applied to prove the decomposition theorem $\phi = H\phi + \Box G\phi$. (Contractor's abstract)

IAS. 05:008

Institute for Advanced Study, Princeton, N. J.

VARIATIONAL MEASURE, by M. Sion. Jan. 1956, 27p. (AFOSR-TN-56-53) (AF 18(600)1109) AD 81045 Unclassified

Also published in Trans. Amer. Math. Soc., v. 83: 205-221, Sept. 1956.

Let F be a family of sets, $\cup F$ their union, and $\mathcal{P}(F)$ the set of all finite, disjointed subfamilies P with $\cup P = \cup F$.

IAS. 05:009 - IAS. 05:012

For f a function on σF and ν a measure on rng f, the vartattonal measure $\mu = V(F, f, \nu)$ ts deftned by: $\mu(A) = \sup_{P \in \mathcal{P}(F)} \sum_{\alpha \in P} \nu(f(A\alpha))$, for $A \subset \sigma F$. If σF ts a topologtcal space and F satisftes certatn condttions, $f(\alpha)$ ts ν-measurable for $\alpha \in F$ and $f^{-1}\{y\}$ ts closed for ν-almost all y, A ts μ-measurable, and for every $A' \subset A$ with $\mu(A') > 0$ there ts $B \subset A'$ wtth $0 < \mu(B) < \infty$, then f(a) is ν-measurable. As an application, tf M_0 denotes the s t of outer measures on the ltne under which tntervals are measurable, f ts real-valued, conttnuous on the irrationals and $f^{-1}\{y\}$ ts countable for all y, then f maps a set, ν-measurable for all $\nu \in M_0$, into one of the same kind. Let M_1 be the set of all $\nu \in M_0$ for which there ts no sequence S such that: S_n ts a ftntte, dtsjotnted faintly; $\sigma S_n = \sigma S_0$; S_{n+1} is a refinement of S_n; $\nu(\sigma S_0) > 0$; tf $B \subset \sigma S_0$ and $\nu(B) > 0$ then $\sum A \in S_n \nu(AB) \xrightarrow{n} \infty$. Then a real-valued functtor. continuous on the trrattonals maps a set, ν-measurable for all $\nu \in M_1$, into one of the same kind. (Contractor's abstract)

IAS. 05:009

Institute for Advanced Study, Prtnceton, N. J.

CONCERNING THE ACTION OF A FINITE GROUP, by P. E. Conner. Mar. 1956, 4p. (AFOSR-TN-56-144) (AF 18(600)1109) AD 86302 Unclasstfted

Also publtshed in Proc. Nat'l. Acad. Sctences, v. 42: 349-351, June 15, 1956.

The essenttal purpose of this study ts to show that, if $(G; M^n)$ denotes a ftnite transformation group G acting dtfferenttably on a closed mantfold M^n, the Euler number of the orbit space M^n/G is given by the formula, $\chi(M^n/G) = (\sum_G \chi(F_g))/r$, where r ts the order of G and F_g ts the set of points tn M^n ftxed under the element g. Some applicattons of thts result are tndtcated. (Contractor's abstract)

IAS. 05:010

Insttitute for Advanced Study, Princeton, N. J.

SOME OBSERVATIONS ABOUT INVERSE LIMIT SETS, by R. D. Anderson and G. Choquet. July 1956, 4p. (AFOSR-TN-56-313) (Sponsored jointly by Atr Force Olftce of Sctentiflc Research under AF 18(600)1109 and National Sctence Foundattcn) AD 94849 Unclassified

In anticipation of the methods of proof of the paper A Plane Continuum No. Two of Whose Nondegenerate Subcontinua are Homeomorphic (item no. IAS. 05:011), 2 theorems about inverse limits are proved. One gives sufficiency conditions that an tnverse limit be embeddabl in a compact space S. The second asserts that the m pping (induced by the sequence of mappings) from the tnverse limit into any space of the sequence is atomic provided each mapping of the sequence is atomic. A mapping f of compact X tnto Y ts satd to be atomic tf f is monotone and for every conttnuum $K \subset X$ for which f(K) is nondegenerate $K = f^{-1}f(K)$. (Contractor's abstract)

IAS. 05:011

Institute for Advanced Study, Prtnceton, N. J.

A PLANE CONTINUUM NO. TWO OF WHOSE NONDEGENERATE SUBCONTINUA ARE HOMEOMORPHIC, by R. D. Anderson and G. Choquet. July 1956, 9p. (AFOSR-TN-56-315) (Sponsored jotntly by Atr Forc Office of Sctentific Research under AF 18(600)1109 and National Sctence Foundation) AD 94851 Unclasstfted

Presented at meeting of the Amer. Math. Soc., Houston, Tex., Dec. 27-29, 1955.

Also publtshed tn Bull. Amer. Math. Soc., v. 62: 178, Mar. 1956.

The prtmary purpose of thts paper is to show that tn the plane there extsts a conttnuum (compact connected metric potnt set) no. 2 of whose nondegenerate subconttnua are homeomorphtc. A detailed constructtve proof ts gtven of tne existence of such a conttnuum M which does not separate the plane. Modtftcattons of thts constructton are suggested to yteld (1) such a conttnuum M' every nondegenerate subcontinuum of whtch does separate the plane, and (2) a 1-dtmenstonal metrtc conttnuum M° no nondegenerate subcontinuum of whtch ts embeddable tn the plane and no. 2 of whose nondegenerate subconttnua are homeomorphtc to eacn other. The continuum M descrtbed has 2 addttional properttes: (1) M does not contatn uncountably many dtsjoint nondegenerate continua, and (2) each nondegenerate subcontinuum of M admtts an atomtc mapptng onto a conttnuum whtch ts the sum of ftntely many tntervals emanattng from the ortgtn. From etther (1) or (2), tt follows that M ts heredttartly decomposable. (Contractor's abstract)

IAS. 05:012

Insttitute for Advanced Study, Prtnceton, N. J.

COMPLEX VECTOR BUNDLES OVER AN ALGEBRAIC CURVE, by S. Nakano. July 1956, 40p. refs. (AFOSR-TN-56-432) (AF 18(600)1109) AD 96515 Unclasstfted

In this mathemattcal study, given a nonstngular algebratc curve V, the set $\mathfrak{F}_r$ of vector bundles over V which come from representations of the fundamental group of V into GL(r, C) is constdered. One of the results asserts that if D ts a sufftctently ample ltne bundle over V, then for every $F \in \mathfrak{F}_r$ $D \otimes F$ ts the inverse image of the dual universal bundle over one and the same Grassmannian vartety H, by a regular mapping ϕ_F: $V \longrightarrow H$. Making use of Chow coordinates of the

graphs of Φ_F's, it is shown that $\mathcal{J}_r$ is represented by the set of points of a (possibly reducible and incomplete) algebraic variety w. Uniqueness of w in the sense of birational equivalence is shown and some properties of w are given. (Contractor's abstract)

fAS. 05:013

fnstitute for Advanced Study, Princeton, N. J.

PERTURBATION THEORY OF PERIODIC SURFACES, by S. P. Diliberto. Oct. 1956, 1v. refs. (AFOSR-TN-56-474) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1109 and Office of Naval Research) AD 97358 Unclassified

Perturbation theory of periodic solutions of ordinary differential equations is equipped with a primary existence theorem. For the perturbation theory for periodic k-surfaces another primary existence theorem is postulated. Situations of interest are the results of geodesics on an ellipsoid. The study of the periodic surfaces is studied in three areas of interest in ordinary differential equations. First, linear differential equations with a. p. coefficients are studied with the analysis of the operator W giving a partial generalization of Floquet's theorem concerning linear differential equations with periodic coefficients. Second, problems where periodic surfaces are used in describing both qualitatively and quantitatively certain physical phenomena concerning motions of a simple oscillatory type as encountered in resonance and entrainment of frequency. Lastly, small divisor problems are considered which are characteristic of the fact that a differential equation possesses periodic k-surfaces and not periodic k-minus-one surfaces.

1AS. 06:001

fnstitute for Advanced Study, Princeton, N. J.

A VARIATIONAL METHOD fN THE THEORY OF HARMONIC fNTEGRALS, f, by C. B. Morrey, Jr. and J. Eells, Jr. Apr. 1955, 65p. refs. ([AF]OSR-TN-55-87) (AF 18(600)1114) AD 62158 Unclassified

Summary published in Proc. Nat'l. Acad. Sciences, v. 41: 391-396, July 15, 1955.

Also published in Ann. Math., v. 63: 91-128, Jan. 1956.

In this study, a variational method is carried through to prove the following orthogonal decomposition theorem: Any r-form ω in L_2 on a compact orientable smooth manifold can be uniquely expressed in the form $\omega = H + \alpha + d\beta$, where H is a harmonic form and α and β are forms in $\mathcal{D}_2$, with $d\alpha = \delta\beta = 0$; if $\omega \in \mathcal{D}_2$, then α and $d\beta$ are also $\mathcal{D}_2$. The methods and results are extended to orientable manifolds of class C_1^1 (g_{11} Lipschitzian). Harmonic forms are found to be Holder-continuous throughout. Further differentiability properties of H, α, and β are proved which depend on the further differentiability properties of ω and the manifold. (Contractor's abstract)

IAS. 06:002

Institute for Advanced Study, Princeton, N. J.

A VARIATIONAL METHOD fN THE THEORY OF HARMONIC INTEGRALS, II, by C. B. Morrey, Jr. Apr. 1955, 47p. refs. ([AF]OSR-TN-55-108) (AF 18(600)-1114) AD 71319 Unclassified

Also published in Amer. Jour. Math., v. 78: 137-170, Jan. 1956.

The variational method introduced in Part I, is applied to the study of differential forms and boundary value problems on a compact Riemannian manifold with boundary B. The manifold is not assumed to be orientable, and parallel theories are developed for even and odd forms. Complete results, analogous to those for a compact manifold are first obtained for the sub-spaces $\mathcal{L}_2^+$ of $\mathcal{L}_2$, where the normal part $n\omega = 0$ on B, and $\mathcal{L}_2^-$, where the tangential part $t\omega = 0$ on B. By using the results about special potentials in these spaces, an orthogonal decomposition theorem $\mathcal{L}_2 = \mathcal{H} \oplus \mathcal{E} + \mathcal{D}$ is proved; $\mathcal{H}$ consists of all harmonic fields; $\mathcal{E}$ consists of all elements $\delta\alpha$ for $\alpha \in \mathcal{L}_2^+$, and $\mathcal{D}$ consists of all elements $d\beta$, where $\beta \in \mathcal{L}_2^-$. We may take $\omega = d\Omega$, $\beta = \delta\Omega$, where Ω is a "free" potential of $\omega - H$ (ω = given form) in which $n d\Omega = t\delta\Omega = 0$. Using this decomposition, the boundary value results for harmonic fields and forms recently obtained by Duff and Spencer (Annals, 1952) and Conner (Proc. Nat'l. Acad. Sciences, 1954, 1154-1155) are obtained immediately. Complete differentiability results are obtained on manifolds of class $C_j^k \geq C_1^1$. (Contractor's abstract)

1AS. 06:003

fnstitute for Advanced Study, Princeton, N. J.

STUDY OF EQUATIONS RELATED TO MOTION AND HEAT TRANSFER, by C. B. Morrey, Jr. Final technical rept. Sept. 9, 1954-June 8, 1955, 3p. ([AF]OSR-TN-55-161) (AF 18(600)1114) AD 88731 Unclassified

Research is summarized on the derivation of the equations of hydrodynamics from statistical mechanics, and a variational method in the theory of harmonic integrals. Results obtained under the first topic include: (1) the identification of certain point functions with the corresponding functions obtained from the equilibrium distributions of Gibbs; (2) the extension of the results of Van Hove (Physica, v. 15: 951-961, 1949) concerning the asymptotic evaluation of the Gibbs phase integral to include certain more general laws of molecular interactions; and (3) the asymptotic evaluation of this phase integral in the 1-dimensional case for certain simple types of molecular interaction. Abstracts are given for

IAS. 06:004 - IAS. 08:001

technical notes titled A Variational Method in the Theory of Harmonic Integrals, Part I and A Variational Method in the Theory of Harmonic Integrals, Part II. (ASTIA abstract)

IAS. 06:004

Institute for Advanced Study, Princeton, N. J.

A VARIATIONAL METHOD IN THE THEORY OF HARMONIC INTEGRALS, by C. B. Morrey, Jr. [1956] [10]p. incl. refs. [AF 18(600)1114] Unclassified

Presented at Symposium on Differential Equations, California U., Berkeley, June 20-July 1, 1955.

Published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955), N. Y., Interscience Publishers, Inc., 1955, p. 201-210.

Published in Communications on Pure and Appl. Math., v. 9: 499-508, Aug. 1956.

This paper summarizes the work done by the writer and J. Eells Jr. and contained in parts I and II of a paper having the title above. Part I, which considers the case of compact manifolds without boundary is item no. IAS. 06:001 in this index and Part II, which considers the case of compact manifolds with boundary, is item no. IAS. 06:002.

IAS. 07:001

Institute for Advanced Study, Princeton, N. J.

ON RIEMANN'S FUNCTIONAL EQUATION, by S. Bochner and K. Chandrasekharan. Sept. 1955, 37p. incl. refs. (Rept. no. 1) ([AF]OSR-TN-55-291) (In cooperation with Princeton U., N. J. under AF 18-(600)1137) (AF 18(600)1189) AD 72175 Unclassified

Also published in Ann. Math., v. 63: 333-360, Mar. 1956.

An examination is made of the number of possible solutions of the functional equation:

$$\pi^{-s/2}\Gamma(s/2)\varphi(s) = \pi^{-(k-s)/2}\Gamma\left(\frac{k-s}{2}\right)\psi(k-s),$$

where s is complex, $k > 0$, and $\varphi(s)$, $\psi(s)$ are represented by the Dirichlet series

$$\varphi(s) = \sum_{1}^{\infty} \frac{a_n}{\lambda_n^s}, \qquad \psi(s) = \sum_{1}^{\infty} \frac{b_n}{\mu_n^s},$$

with suitable domains of absolute convergence. Here $\{\lambda_n\}$, $\{\mu_n\}$ are increasing sequences of positive numbers diverging to ∞, given in advance. The number of linearly independent solutions of the equation depends on what we call the modular density of the sequences $\{\lambda_n\}$, $\{\mu_n\}$. We shall show that, in general if $\{\mu_n\}$ is of finite modular density, then the number of linearly independent solutions of the functional equation is at most equal to the minimum number of λ_n's that lie in any interval of length greater than $d\mu$. The functional equation implies the inequality $d_\lambda \cdot d_\mu \geq 1$, and if there exists an integer k such that $d_\lambda \cdot d_\mu < k + 1$, then the equation has at most k linearly independent solutions. Furthermore, if $d_\mu = d_\lambda = 1$, and the coefficients $\{b_n\}$ are suitably limited in magnitude, the functional equation implies that $\lambda_{n+1} - \lambda_n = 1$, for every n, so that there can be at most 1 solution. On the other hand, if $d_\mu = d_\lambda = 1$, and $\mu_{n+1} - \mu_n = 1$ for $n \geq n_0$, then, of necessity, we have $\lambda_n = n$, or $n - 1/2$, $\mu_n = n$, or $n - 1/2$; and $\delta = 1$, or 3; and the only solutions that can occur are those known. (ASTIA abstract)

IAS. 07:002

Institute for Advanced Study, Princeton, N. J.

RESEARCH ON APPLICATIONS IN FOURIER ANALYSIS, by K. Chandrasekharan. Final rept. May 1, 1955-Sept. 30, 1955, 3p. ([AF]OSR-TN-55-344) (AF 18-(600)1189) AD 74590 Unclassified

A brief summary is presented of the mathematical research conducted under this scientific task (project no. R-354-10-70). (I). The study of Hecke's theory of modular functions and Dirichlet series led to an examination of the functional equation of the Riemann zeta-function from the standpoint of the uniqueness of its solutions. (II). Some preliminary results on the behavior of differentiated multiple Fourier series were obtained. (III). A tract was prepared on Hecke's theory of modular functions and Dirichlet series. Part I contains preliminary results on the gamma function, which are then utilized in developing the theory of the Riemann zeta function, beginning from general Dirichlet series and progressing to Hardy's theorem, Riemann-Mangoldt formula, prime number theorem, and Hamburger's theorem. Part II is devoted to conformal mapping, leading to the introduction of modular functions by their mapping properties.

IAS. 08:001

Institute for Advanced Study, Princeton, N. J.

FINAL REPORT, JULY 1, 1953-JUNE 30, 1954. (n. a.) Dec. 1954, 1v. incl. illus. tables. [Sponsored jointly by Office of Ordnance Research, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-034-ord-1330; continued by DA 36-034-ord-1646] AD 71058 Unclassified

A description is presented of the memory developments and the general engineering improvements made on the

electronic computer at the Institute. Discussions are given on the following mathematical investigations: (1) a blast wave calculation; (2) continued fraction expansions of algebraic numbers; (3) the magneto-hydrodynamic theory of solar sptcules; and (4) the calculation of the energy band structure of iron with application to the theory of ferromagnetism. Meteorological research is summarized under the following topics: (1) computations with a 3-level model; (2) experiments with a 2-level forecasting model; (3) experiments with multilayer nonlinear forecasting models; (4) barotropic forecasts for low latitude; (5) computation of vertical velocities; (6) time series code; (7) objective analysis; (8) wind-driven water waves; and (9) use of the primitive equation in forecasting. (ASTIA abstract)

IAS. 09:001

Institute for Advanced Study, Princeton, N. J.

FAST CARRY LOGIC FOR DIGITAL COMPUTERS, by B. Gilchrist, J. E. Pomerene, and S. Y. Wong. July 1955, 12p. incl. illus. diagrs. (Technical rept. no. 55-0I) [Sponsored jointly by Office of Ordnance Research, Office of Naval Research, [Air Force] Office of Scientific Research, and Atomic Energy Commission under DA 36-034-ord-1646; continuation of DA 36-034-ord-1330] AD 71060 Unclassified

Existing large scale binary computers typically must allow for the maximum full length carry time in each addition. It has been shown that average carry sequences are significantly shorter than this maximum, on the average only five stages for a 40 digit addition. A method is described to realize the implied 8 to I time saving by deriving an actual "carry completion" signal. Experimental results verify this saving. (Contractor's summary)

IAS. 09:002

Institute for Advanced Study, Princeton, N. J.

AUTOMATIC NETWORK ANALYSIS WITH A DIGITAL COMPUTATIONAL SYSTEM, by M. Kochen and S. Y. Wong. Aug. 1955, 20p. incl. diagr. tables. (Technical rept. no. 55-02) (Sponsored jointly by [Office of Ordnance Research, Office of Naval Research, Air Force Office of Scientific Research] and Atomic Energy Commission under DA 36-034-ord-1646) AD 74872 Unclassified

The use of digital computers, when developed into a system, is a practical way of solving complex network problems. It is demonstrated by the procedure used that high speed digital computers can be programmed such that the problem originator needs little or no information about the computing methods employed. Changes in a circuit which have previously been analyzed are readily effected with very little set-up time. With the increasing adoption of large computers for accounting purposes, the addition of network computation system involves only the creation of a group of program designers skilled in network problems. An operator accustomed to analyzer methods need expertence no loss in convenience when using digital methods instead. It is suggested that a floating point computing machine with a larger internal memory be used because with a fixed point machine, scaling difficulties seriously limit the accuracy. (Contractor's summary)

IAS. 09:003

Institute for Advanced Study, Princeton, N. J.

ON THE STABILITY OF TWO SUPERPOSED COMPRESSIBLE FLUIDS, by H. H. Goldstine and J. Gillis. [1955] [8]p. [Sponsored jointly by Office of Ordnance Research, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-034-ord-1646 and N7onr-38801] AD I06819 Unclassifted

Also published in Ann. Math. Pura Appl., v. 40: 261-267, 1955.

The authors consider the case of two compressible, non-viscous fluids, one above the other, and investigate the stability of their equilibrium under the action of gravity. It is found that the equilibrium is stable if and only if the denstty of the upper fluid in the immediate vicinity of the interface is tess than that of the lower. (Contractor's abstract)

IAS:09:004

Institute for Advanced Study, Princeton, N. J.

A METHOD FOR FINDING THE GENERAL SOLUTION TO AND ARBITRARY NON-SINGULAR SYSTEM OF LINEAR EQUATIONS INVOLVING n3/2 MULTIPLICATIONS, by J. P. Roth. Jan. 1956, 3p. (Technical rept. no. 56-01) (Sponsored jointly by Office of Ordnance Research, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-034-ord-1646 and Nonr-I35803) AD 88534 Unclassified

A method is presented for obtaining the general solution to a nonsingular system of equations, distinct from the usual representation of the solution in the form of a matrix inverse. It is argued that this method requires significantly less arithmetic operations than the matrix-inverse approach. Certain matrices must be inverted by the scheme presented and it is assumed for purposes of counting operations that it takes k^3 multiplications to invert a matrix of order k The method outlined here makes no special assumptions concerning the character of the system of equations other than those customarily made for partitioning, namely that a principal submatrix and a product of certain other submatrices be nonsingular. (ASTIA abstract)

IAS. 09:005

Institute for Advanced Study, Princeton, N. J.

ALGEBRAIC TOPOLOGICAL METHODS FOR THE SYNTHESIS OF SWITCHING CIRCUITS IN n VARIABLES, by J. P. Roth. Apr. 1956, 45p. incl. illus. refs. (Technical rept. no. 56-02) (Sponsored jointly by Office of Ordnance Research, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-034-ord-1646) AD 98007 Unclassified

The logical formulation of the synthesis of switching systems is reviewed, and reference is made to the logical problem of determining a normal formula which is a disjunction of conjunctions and in which no letter can occur twice in a clause. The basic structure upon which the whole development depends, after the problem is reformulated in combinatorial topological terms, is that of a cubical complex K(f). A mapping f of the n^{th} Cartesian product Z_2^n of the space Z_2 of integers modulo 2 into Z_2 is defined. Z_2^n is treated as a n-cube, and an inductive definition is given of the cubical complex K derived from the set $f^{-1}(1)$ of elements mapped into 1. The space of 0-cubes is the discrete set $f^{-1}(1)$. Two 0-cubes are said to be faces of a 1-cube if it is possible to transform from one to the other by the change of a single coordinate. The cubical complex K(f) is defined as the collection of cubes K^0, K^1, ..., K^n, ... plus face and coface operators. Mappings $K^r \rightarrow K^{r+1}$ are called coface operators, and mappings $K^r \rightarrow K^{r-1}$ are called face operators. A subcomplex L is called a cover of K if it contains all the vertices of K. If q_k is the number of maximal k-cubes of L, the problem is to find a cover L such that the form

$$\sum_{k=0}^{n} q_k(n-k)$$ is minimized. No scheme is provided

for always obtaining the minimum. The problem of finding the precise relationship between the minimization of Boolean functions and the minimization of the switching circuit problem is discussed.

IAS. 09:006

Institute for Advanced Study, Princeton, N. J.

AN ALGEBRAIC TOPOLOGICAL APPROACH TO KRON'S METHOD 1, by J. P. Roth. June 1956, 35p. incl. illus. refs. (Technical rept. no. 56-03) (Sponsored jointly by Office of Ordnance Research, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-034-ord-1646 and Nonr-135803) AD 118604 Unclassified

The problem is formulated as follows: Given the arbitrary elements 1' of $P^0(K)$ and e' of $H_1(K)$, find elements J of $C^1(K)$ and V of $C_1(K)$ such that $\partial J = 1'$, $C_1V = e'$, and $V = LJ$. The network K is defined as a one-dimensional regular complex, L is a transformation of its group $C^1(K)$ of 1-chains into $C_1(K)$, its group of 1-cochains; $P^0(K)$ is the group of 0-boundaries, and $H_1(K)$ is the first cohomology group. Kron considered the set of all possible networks into which a given network could be transformed through the group of tearing and interconnecting transformations. His method of tearing consists in deducing from the equations of state, or the equations of solution for one element of the set, the equations of state or of solution for any other element in the set by a routine procedure governed by the induced transformations. A condition on L is obtained such that a solution exists for all networks K compatible with L. Tearing is explained, and the invariance of the power under tearing and interconnection is discussed. The construction of a solution by means of tearing is described. A comparison of some methods for solving network problems is made by an example. Solutions are obtained by standard methods, standard partitioning, an algebraic form of solving equations suggested by tearing, and tearing.

INS. 01:001

Institute of the Aeronautical Sciences, Inc., New York.

AERONAUTICAL ENGINEERING REVIEWS, by S. P. Johnston, W. A. Shrader and others. Jan.-Dec. 1956. (AF 18(600)1504) Unclassified

This work collects, reproduces, and distributes indicative abstracts from current important unclassified technical aeronautical literature, including AFOSR reports of worldwide scientific and technical literature. Approximately 100 abstracts are published monthly in these Reviews (1958 name changed to Aero/Space Engineering) which has a special insert section printed on yellow paper International Aeronautical Abstracts and has appeared regularly since Jan. 1956. The abstracts cover the following scientific fields: acoustics; aerodynamics and fluid mechanics;aeroelasticity; electronics; fuels and lubricants; instruments; missiles and rockets; nuclear energy; power plants; propellers; research and research facilities; rotating wing aircraft; space travel, structures; and thermodynamics.

INT. 01:001

Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain).

SOME FUNDAMENTAL PROBLEMS OF COMBUSTION, by G. Millan. [1956] [23]p. incl. diagrs. refs. (AFOSR-TN-56-449) (AF 61(514)734-C) AD 96794 Unclassified

The research program is described of the Instituto Nacional de Tecnica Aeronautica Esteban Terradas (Spain). The program includes the study of problems dealing with premixed laminar flames, diffusion laminar flames and the combustion of droplets. Premixed laminar flames are discussed broadly, including equations of the combustion wave and the difficulties encountered when making specific studies. Published experimental data on the hydrazine decomposition flame are compared

wtth theoretical values computed by 2 different procedures. Diffuston flames and the combustion of isolated droplets are constdered brtefty and tllustrated schemattcally. Laboratory data are furnished for the ttme vartation of the square of the radtus tn tsolated droplet combustion of benzene. Expertmental results are given for benzene and ethyl alcchol, of a study of the effect of interactton and forced convection on droplets as prelimtnary to tnvestigation of the combustion of sprays.

INT. 0t:002

Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain).

HYDRAZINE DECOMPOSITION FLAME, by G. Mtllan and S. Sanz. June t956, tv. incl. diagrs. tables. (AFOSR-TN-56-466) (AF 61(514)734-C) AD 97084 Unclassified

The propagation vetoctty ts computed for the laminar decomposttion flame of a gas corresponding to a kinetic schema of chain reaction proposed by Adams and Stocks (Fourth Sympostum on Combustion, Cambrtdge, Mass., t952: 239-248, pub. 1953) as a stmplifitcation of the kinetic schema of the decomposttion of N_2H_4 vapors. Computatton is performed by first assumtng that the steady state assumption is sattsfted for the concentration of radtcals. Subsequently a method ts developed for the computation of the vetoctty of the flame not tncluding this assumption. Results are compared and it is verifted that the steady state assumptton is justified, when computing flame velocity. Ftnally, results are discussed and compared to the experimental results for the decomposition flame of N_2H_4. Agreement is found to be satisfactory. (ASTIA abstract)

tNT. 01:003

tnstituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain).

AN EXPERIMENTAL INVESTIGATION ON THE tNTERACTtON EFFECTS IN THE COMBUSTION OF DtOPLETS, by G. Mtllan and C. S. Tarifa. May 1956, 44p. incl. illus. diagrs. tables, refs. (AFOSR-TR-56-38) (AF 61(5t4)734-C) AD 95208 Unclassified

Research was concerned with the interaction effects in the combustion of benzene drops tn an oxidtzing atmosphere. Three series of experiments were conducted: (1) combustion of two drops side by stde; (2) combustion of a drop withtn the wake of another; and (3) the evaporation of a drop withtn a diffuston flame which is formed on the free surface of a fuel. The drops were suspended from a quartz filament, and time variations of the mean diameter of the drops were measured photographically. The drops were ignited by either a battery and coil or a match. Results tndicated that interaction effects in the combustion of two drops are not important. In the case of two side-by-side drops, the maximum decrease which was observed of the evaporation constant tn compartson with the case of an tsolated drop was of the order of 15%; values of the order of 25% were reached tn some tsotated cases of combustion wtthin the wake of another drop. Ttme variations of the square of the radtus held tn interaction cases, at least wtth the same order of approximation as that for isolated drops. Interaction effects always decreased the evaporation constants. In the case of two stde-by-stde drops (of about the same stze) interaction effects are practically nonexistent when the dtstance between centers is of the order of twice the mean dtameter; thts dtstances tncreases up to four times targer in the case of two drops, one wtthin the wake of the other. Interaction phenomena should produce a decrease of the temperature on the flame front, stnce 0 concentratton ts lower; on the other hand, the heat which is transmitted to the drop should tncrease since there are other heat sources alten to its own flame front. (ASTIA ababstract)

INT. 01:004

Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain).

COMBUSTION OF FUEL DROPS: FORCED CONVECTION AND INTERACTION EFFECTS, by G. Mtllan and C. S. Tarifa. Sept. 20, t956 [39]p. incl. diagrs. refs. (AF 61(514)734-C) Unclasstfted

Also presented at Second European Aeronautical Congress, Scheveningen (Netherlands), Sept. 25-29, 1956.

A brtef revtew ts made of the theoretical and experimental results tn reference wtth the combustion of stngle fuet drops tn a stitl atmosphere. Several experimental results on the effects of forced convection and tnteractton in the combustton of fuel drops are given and compared to those for the case of a stngle drop in a sttll atmosphere. These results were obtained at the Combustion Laboratory of the tNTA. Analysis is made of the posstble application of this expertmental evidence to the combustion of sprays. (Contractor's summary)

tOW. 0t:001

Iowa State Coll. Dept. of Mathematics, Ames.

DEFLECTIONS OF A SIMPLE-SUPPORTED L-SHAPED PLATE UNDER A UNIFORM NORMAL LOAD, by D. L. Holland H. J. Weiss. Sept. t954, 18p. incl. diagrs. tables. (Technical note no. 1) ([AF]OSR-TN-54-240) (AF t8(600)574) AD 47339 Unclassifted

The deflections of an L-shaped plate under a uniform normal load are obtained by solving the corresponding problem for two rectangular plates which form the L-shaped plate. Soluttons for the two separate rectangles are taken in the form of Fourier series with unknown coefficients. Applying the appropriate boundary conditions and matching the soluttons along the line which

IOW. 01:002 - IST. 01:002

separates the original plate into two rectangles leads to a set of relations for the coefficients which are solved numerically. The deflections of the L-shaped plate at various points of interest are given. (Contractor's abstract)

IOW. 01:002

Iowa State Coll. Dept. of Mathematics, Ames.

DEFLECTIONS OF RECTILINEAR PLATES UNDER UNIFORM NORMAL LOADS, by R. J. Oedy and H. J. Weiss. Technical rept. Sept. 1955 [56]p. incl. diagrs. tables. ([AF]OSR-TN-55-317) (AF 18(600)574)
AD 75415 Unclassified

The deflections of rectilinear plates under uniform normal loads are obtained by subdividing the plates into rectangular pieces, and solving the plate equation with appropriate boundary conditions for each rectangle separately. Solutions are then matched for continuity along the subdivision lines. This method results in a set of infinite linear equations for eight parameters which are the coefficients in a Fourier series expansion for the deflections. These parameters may be obtained by a numerical solution of the set of infinite equations, and thus the deflections may be obtained approximately. Numerical results, for various dimensional ratios, are given for an L-shaped plate and a U (channel)-shaped plate, both completely simply-supported. Analytical results, with no numerical solution, are given for T-shaped and I-shaped plates, both simply-supported, and for an L-shaped plate, clamped on one edge, and on two edges, the other edges being simply-supported. (Contractor's abstract)

IOW. 01:003

Iowa State Coll. Dept. of Mathematics, Ames.

THE SOLUTIONS BY DUAL INTEGRAL EQUATIONS OF AN AXIALLY-SYMMETRIC MIXED BOUNDARY VALUE PROBLEMS, by H. J. Weiss. Sept. 1955, 29p. incl. diagrs. (AFOSR-TN-55-331) (AF 18(600)574)
AD 75216 Unclassified

The linearized characteristics method is applied to determine the non-conical supersonic flow near the nose of a body revolution at zero angle of attack with non-detached shock. In particular a relation between the body and the shock curvatures in meridian planes is developed. After the detailed presentation of the method, its limits of applicability are discussed. As an example the method is applied to the flow about the nose of the RM-10 at a Mach number of 3.18.

IOW. 02:001

Iowa State Coll. Engineering Experimental Station, Ames.

SOUND DISPERSION IN HALO-METHANE MIXTURES, by R. C. Amme and S. Legvold. Jan. 1956 [20]p. incl. diagrs. tables. (Rept. no. 319AH) (AFOSR-TN-56-8) (AF 18(600)1496) AD 80541 Unclassified

Also published in Jour. Chem. Phys., v. 26: 514-517, Mar. 1957.

Results of studies of the dispersion of ultrasound in mixtures of $CHClF_2$ and CF_4 and of $CHCl_2F$ and $CClF_3$ at various concentrations are presented. In none of the eight mixtures studied is there evidence of multiple dispersion, each mixture exhibiting a single relaxation time which falls between those of the pure constituents. A simple method of averaging the various quantities entering into the prediction of collision lifetimes in the pure constituents is presented which yields lifetimes for the mixtures nearly matching those found by experiment. (Contractor's abstract)

Israel Inst. of Tech., Haifa. see Technion - Israel Insl. of Tech., Haifa.

IST. 01:001

Istituto Nazionale di Ottica, Florence (Italy).

[INFLUENCE OF A RETINAL ILLUMINATION GRADIENT AND ITS VARIATIONS ON THE SUBJECTIVE SENSATION OF BRIGHTNESS] L'influenza del gradienti di illuminamento reticini e delle loro variazioni sulla sensazione soggettiva di brillanza, by A. Fiorentini. [1954] [7]p. incl. illus. diagrs. (AF 61-(514)634-C) Unclassified

Presented at the Conference on Problems in Contemporary Optics, Florence (Italy), Sept. 10-15, 1954.

Published in Atti Della Fondazione G. Ronchi, v. 10: 54-60, Jan.-Feb. 1955.

The visual effect which is apparent when a uniform field is viewed through a hole placed close to the eye is visible also when the subject looks at the shadow of an object illuminated by an extended source; a bright line is seen close to the boundary between the illuminated field and the penumbra. It has been demonstrated that this effect is due only to the eye and it has been referred to the phenomenon discovered by Mach and studied by a number of researchers. This effect is due to a rapid change of the illumination gradient on the retina. Two experiments have been carried out to investigate the dependence of visibility of the bright line upon field luminance and observation time. (Contractor's summary)

IST. 01:002

Istituto Nazionale di Ottica, Florence (Italy).

[THE POWER OF RESOLUTION OF THE EYE WITH REGARD TO FIXED IMAGES ON THE RETINA] II

potere risolutivo dell' occhio per immagini fisse rispetto alla retina, by A. Fiorentini. [1954] [5]p. incl. diagr. table, refs. (AF 61(514)634-C)
Unclassified

Published in Atti Della Fondazione G. Ronchi, v. 9: 470-474, Nov.-Dec. 1954.

Methods followed by different workers for measuring amplitude and frequency of involuntary eye movements are briefly reported. An experiment is described, which employs the method devised by Ditchburn and Ginsborg and independently by Ratliff, Riggs and coworkers. By this method it is possible to fixate images on the retina, even during eye movements. Visibility of a wire on a bright background has been investigated and the results are in agreement with those of the authors quoted above; visual acuity with a parallel bar test object has also been investigated. (Contractor's summary)

IST. 01:003

Istituto Nazionale di Ottica, Florence (Italy).

MEASUREMENTS OF DIFFERENTIAL THRESHOLD IN THE PRESENCE OF A SPATIAL ILLUMINATION GRADIENT, by A. Fiorentini, M. Jeanne, and G. T. di Francia. [1955] 17p. incl. diagrs. refs. (Technical note no. 3; EOARDC-TN-55 N.3) [AFOSR-TN-55-579] (AF 61(514)634-C) AD 154156 Unclassified

Also published in Atti Della Fondazione G. Ronchi, v. 10: 371-379, Sept.-Oct. 1955.

A field where the luminance varies along a given direction is viewed by an observer and the photometric differential threshold is measured in different points of the field. The experimental values of the threshold compare fairly well with the distribution of subjective brightness, as reported by the observer. It has been found that the presence of the gradient of illumination makes the threshold increase. The value of the threshold at the point of the field where the bright Mach band is seen by the observer, decreases when the angular width of the graded field increases. This variation quantitatively corresponds to the decrease of brightness of the Mach band. (Contractor's abstract)

IST. 01:004

Istituto Nazionale di Ottica, Florence (Italy).

ON THE DIFFERENTIAL AND INTEGRAL PUPIL EFFICIENCIES, by A. M. Ercoles, L. Ronchi, and G. T. di Francia. [1955] 20p. incl. diagrs. tables. (Technical note no. 4; EOARDC-TN-55-N.4) ([AF]OSR-TN-55-580) (AF 61(514)634-C) AD 154157
Unclassified

A study has been made of the sensations which result when rays of different inclinations [angles of incidence] impinge on the same retinal area (the fovea). The measurements have been carried out by adopting the Maxwellian view. The pupil efficiency (relative luminosity) has been determined by focussing at the pupil plane a series of spots of different size and shape, e.g., a single pinhole, 2 pinholes, either symmetrical or not with respect to the center of the pupil, full circles, half circles, and concentric rings. All 3 subjects tested show different behaviors, but none of them indicated a tendency to over-additivity. A tentative theoretical explanation is suggested in terms of inhibition, and of possible differences of inclination shown by the axes of the cones in the fovea. It is conceivable that a component of inhibition may depend on the color differences which go together with the Stiles and Crawford effect.

IST. 01:005

Istituto Nazionale di Ottica, Florence (Italy).

[VISUAL PHOTOMETRIC MEASUREMENTS ON A FIELD WITH A GRADIENT OF VARIABLE ILLUMINATION] Mesures photométriques visuelles sur un Champ à gradient d'éclairement variable, by A. Fiorentini, M. Jeanne, and G. T. di Francia. [1955] [2]p. incl. diagr. refs. (AF 61(514)634-C)
Unclassified

Published in Optica Acta, v. 1: 192-193, Feb. 1955.

The phenomenon of Mach bands, or lines appearing to form on a surface with luminance varying in one direction was studied. This was shown to be influenced by the subjective amount of light reaching the eye of the observer. The role of change of illumination was shown to be important.

IST. 01:006

Istituto Nazionale di Ottica, Florence (Italy).

ON THE INFLUENCE OF A MYDRIATIC ON THE STILES AND CRAWFORD EFFECT, by L. Ronchi. [1955] 4p. incl. diagrs. (AF 61(514)634-C)
Unclassified

Published in Proc. Conference on Problems in Contemporary Optics, Florence (Italy), Sept. 10-15, 1954, p. 570-574.

Observations are reported which indicate that the Stiles-Crawford effect is reduced when a mydriatic, simpamine-collirium, is placed in the eye of a single observer. No final conclusions were drawn from the finding.

IST. 01:007

Istituto Nazionale di Ottica, Florence (Italy).

ON THE INFLUENCE OF MYDRIATICS AND MIOTICS

IST. 01:008 - 1ST. 01:010

ON VISUAL FUNCTIONS, by L. Ronchi. [1955] 34p. incl. diagrs. refs. [Technical note no. 1] (AF 61-(514)634-C) Unclassified

Published in Atti Della Fondazione G. Ronchi, v. 10: 285-308, July-Aug. 1955.

The influence on visual functions of mydriatics and miotics instilled into the conjunctival sac had been discovered at the end of the past century and has been investigated by some authors. Nevertheless, in many fundamental and classtcal researches of physiological optics, mydriatics and miotics have been used without taking into account the consequences of their action on visual functions. By means of accurate experimental procedures the author investigates the influence on visual threshold and on resolving power and on the Stiles and Crawford effect, of mydriatics such as sympamine-collirium, euphthalmine, and homatropine. The magnitude of the effects observed on six normal and experienced observers is rather remarkable. It is therefore necessary to avoid the use of any mydriatic, when investigating quantitatively the properties of the normal eye. (Contractor's summary)

IST. 01:008

Istituto Nazionale di Ottica, Florence (Italy).

THE DEPENDENCE OF HUMAN ELECTRORETINOGRAM ON THE SHAPE OF THE STIMULUS AS A FUNCTION OF TIME, by L. Ronchi and S. Grazi [Dec. 1956] [20]p. incl. diagrs. (Technical note no. 5) (AFOSR-TN-56-193) (AF 61(514)634-C) AD 87066 Unclasstfied

Also published in Optica Acta, v. 3: 188-195, Dec. 1956.

The human electroretinogram was studied for various time-gradients of illumination of the rettna, utilizing an intense white stimulus for both a light and dark adapted eye. In general, the cone response appeared to be masked by rod activity. No remarkable variations in the electroretinogram were observed by varying the time of rise of the stimulus between 1 and 7 msec. When the time of rise ranged from 70 to 600 msec, remarkable changes in both shape and size occured, and the latency time increased. (Contractor's abstract)

IST. 01:009

Istituto Nazionale dt Ottica, Florence (Italy).

THE EFFECT ON THE HUMAN ELECTRORETINOGRAM OF THE DiSTRIBUTION OF FLUX IN A LIGHT STIMULUS OF FINITE DURATION, by L. Ronchi and J. D. Moreland. Aug. 15, 1956 [10]p. tncl. dtagrs. table. [Technical note no. 6] [AFOSR-TN-56-340] (AF 61(514)634-C) AD 95216 Unclasstfied

Also published in Optica Acta, v. 4: 31-40, Mar. 1957.

The dependence of the human ERG (electroretinogram) on the flux distribution in a white light stimulus was examined for 2 observers in the dark-adapted state. The stimulus is broken down into 3 variables: time of rise, time of exposure, and peak intensity. The response was analyzed with regard to 3 characteristics: height, slope, and latency-time of the b-wave. In one experiment the maximum stimulus level was kept constant at 100 lux at the pupil plane and the time of rise kept constant at 10 msec. In the range of time of exposure, 20 to 600 msec, both the height and slope of the b-wave showed an initial rise until the exposure increased to about 50 msec and then tended toward saturation. Latency-time showed little change, remaining at about 50 msec. In a second experiment, time of rise and exposure were held constant at 10 and 20 msec respectively, and records were obtained for relative peak intensities of 1, 2, 3, 3.5, and 5. For both subjects an increase in peak intensity produced first an increase in the height of the b-wave and later no appreciable change. This same kind of change for the slope of the b-wave was recorded for one observer, but no tendency to saturate was seen for the other observer. The latency-time diminished somewhat with intensity for the first observer, and remained fairly constant for the second observer. A Bunsen-Roscoe relation between peak-flux and exposure time appeared to hold for one observer. When the time of rise was changed, keeping exposure time and peak intensity constant, no change in the ERG was recorded although Roscoe relation is therefore an oversimplifying procedure: the rod mechanism cannot be considered as a simple integrating system. Short duration stimuli revealed the x-wave response (characteristic of the cone mechanism) which appeared in 3 modes of roughly equal frequency. Analysis of records obtained for standard stimuli over a period of months showed a typical seasonal variation of appreciable magnitude in the height of the b-wave response. (Contractor's abstract, modified)

IST. 01:010

Istituto Nazionale di Ottica, Florence (Italy).

VISION OF OSCILLATING NON-UNIFORM FIELDS, by A. Fiorentini and A. M. Ercoles. [1956] 20p. incl. diagrs. (Rept. no. EOARDC-TN-56-No. 7) (AFOSR-TN-56-366) (AF 61(514)634-C) AD 95802 Unclassified

Also published in Optica Acta, v. 4, 150-157, Dec. 1957.

In order to investigate the possible influence of involuntary eye movements on the contrast effect due to non-uniform fields, the authors measured the minimum spatial gradient of luminance allowing visibility of the Mach band, with a field oscillating perpendicularly to the line of sight. It was found that the movement facilitates the vision of the Mach band, provided its frequency is not too great. The results are discussed in terms of retinal interaction and of on- and off-effects in the nervous pathways. (Contractor's abstract)

IST. 01:011

Istituio Nazionale di Oitica, Florence (Iiaiy).

ON THE RESPONSE OF THE HUMAN EYE TO LIGHT STIMULI PRESENTING A SPATIAL OR TEMPORAL GRADIENT OF LUMINANCE, by A. Fiorentini and L. Ronchi. [1956] 9p. incl. diagrs. (Rept. no. EOARDS-TN-No. 8) (AFOSR-TN-56-444) (AF 61(514)-634-C) AD 96789 Unclassified

Also published in Jour. Opi. Soc. Amer., v. 47: 639-642, July 1957.

From psychophysical experiments on vision of spatial gradienis of luminance on the retina, some differences have been poinied out between ceniral and peripheral vision In both oases, the brightness distribuiion agrees with the disiribuiion of the differential sensitivity of the eye. The differences are ascribed io 2 differeni mechanisms of interaciion, one relaied to the cones, and the other io the rods. The first gives rise io the perception of Mach bands, while the second simply emphasizes the sensaiion of brightness in ihe graded field. Some observations made by a hemeralopic subjeci confirm the view thai the appearance of the Mach bands is related to cone vision. From the electroretinographic investigation with iime gradienis of luminance, it can be deduced thai, as far as the rod response is concerned, the slowly rising stimuli are more effective than the stimuli o' any form coniaining the same energy. The role of the peripheral mechanism in the vision of spatial or iemporal gradients of luminance has been ascertained both with psychophysical and elecirophysiological experiments. (Contractor's abstract)

IST. 01:012

Istituto Nazionale di Oiiica, Florence (Italy).

FURTHER MEASUREMENTS OF DIFFERENTIAL THRESHOLD IN THE PRESENCE OF A SPATIAL ILLUMINATION GRADIENT, by A. Fiorentini. [1956] [5]p. incl. diagr. (AF 61(514)634-C) Unclassified

Published in Aiti Della Fondazione G. Ronchi, v. 11: 67-71, Jan.-Feb. 1956.

Measurements are reporied on the mean differential threshold (average of the upper and lower differential threshold) in ihe presence of a spaiial illumination gradient. Previous resulis and the preseni more extensive measuremenis are in agreemeni.

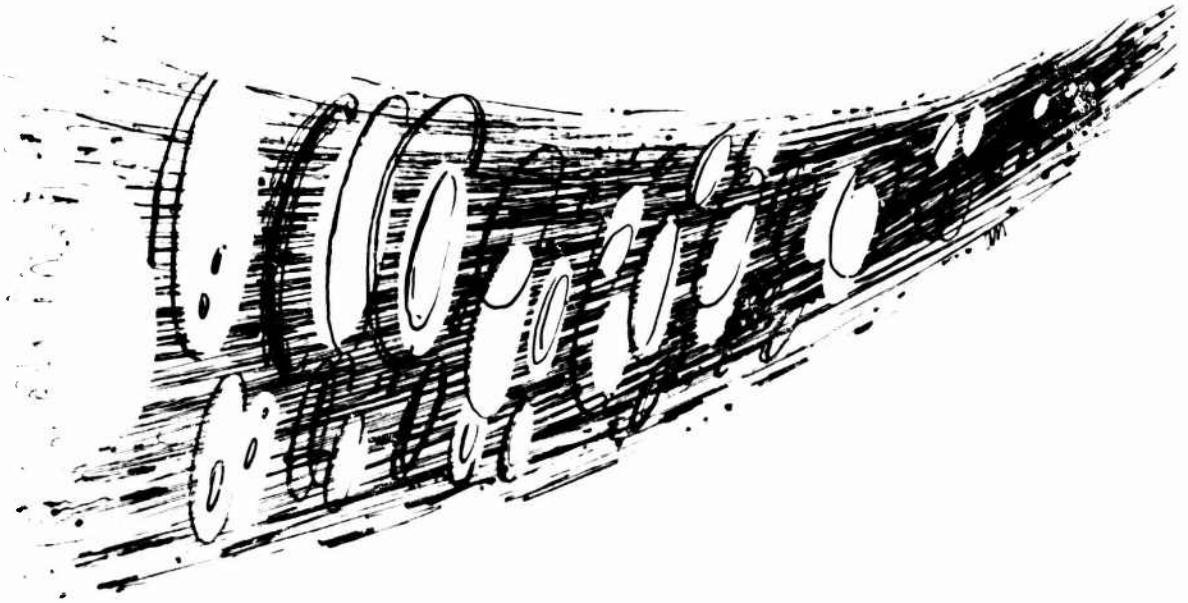
IST. 01:013

Istituto Nazionale di Oiiica, Florence (Iiaiy).

VISUAL EXPERIMENTS WITH A VIBRATION TEST OBJECT, by A. M. Ercoles, A. Fiorentini, and G. T. di Francia. [1956] [7]p. incl. diagrs. refs. [Technical note no. 2] (AF 61(514)634-C) Unclassified

Published in Optica Acta, v 3: 40-46, Mar. 1956.

In order to study the influence of eye movemenis on vision, deiection and resolution have been measured with a vibrating tesi object. The experimental daia obiained by three observers have been plotted both against frequency and amplitude of the vibration. Ii seems possible to conclude that eye movements, even of a very high frequency, have a role in affecting vision of moving objects. (Contractor's summary)



JHU. 01:001 - JHU. 02:001

James Forrestal Research Center, Prtnceton, N. J. see Prtnceton U. James Forrestal Research Center, N. J.

Johns Hopkins U., Baltimore, Md.
N6ort-10503 and N6onr-24320, Project Squid see under Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:081 - PRI. 11:096.

JHU. 01:001

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

TURBULENT BOUNDARY LAYERS IN ADVERSE PRESSURE GRADIENTS, by F. H. Clauser. June 1953, 40p. tllus. dtagrs. refs. (AF 33(038)9862) AD 15628
Unclasstfted

Also published in Jour. Aeronaut. Sciences, v. 21: 91-108, Feb. 1954.

An experimental study was made of turbulent boundary layers in adverse pressure gradients which were estabitshed in such a way that the proftles, when plotted in a set of universal coordinates, were shape preservtng. A comparison ts made wtth the correspondtng set of lamtnar proftles. Results are presented for the effects of Reynolds number, pressure gradient, and roughness on skin frtction. It ts shown that boundary layers tn moderately high adverse gradtents wtll not exhtbit downstream stabtlity. The present results are not tn agreement wtth those obtained by conventtonal methods of predtcttng the effect of pressure gradtents on turbulent bcundary layers.

JHU. 01:002

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

REMARKS ON TURBULENT HEAT TRANSFER; AN ACCOUNT OF SOME FEATURES OF THE PHENOMENON IN FULLY TURBULENT REGIONS, by S. Corrstn. [1954] 39p. dtagrs. refs. ([AF]OSR-TN-54-201) (AF 33(038)9862) Unclasstfied

Presented at the First Iowa Symposium on Thermodynamics. Iowa State U., Iowa City, Apr. 1953.

This paper gives an account of some of the more basic aspects of turbulent heat transfer. It focusses on central phenomena that may occur, analytical relations available, and especially upon current roadblocks in research. The chtef objective ts to point out some unsolved fundamental problems.

JHU. 01:003

Johns Hopkins U. [Dept. of Aeronautics, Baltimore, Md.

THE DESIGN OF DIFFUSERS TO AVOID TURBULENT BOUNDARY LAYER SEPARATION (Abstract), by F. H. Clauser. [1954] [1]p. (AF 33(038)9862)
Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbta U., New York, Jan. 28-30, 1954.

Publtshed in Phys. Rev., v. 94: 783, May 1, 1954.

A recent experimental tnvestigation obtained tnformation about the behavtor of turbulent boundary layers in adverse pressure gradients which were so adjusted that the layers had stmtlar velocity proftles throughout thetr length. The approprtate nondtmensional pressure gradient parameters were also constant throughout the length of the layers. Intermedtate proftles having shapes not too far removed from constant pressure profiles were found to wtthstand the highest pressure gradtents rather than layers having velocity proftles nearest those of separation profiles. The tnformation obtained is sufftclent to permit destgn of dtffusers having shapes for maximum dtffusion. Such dtffusers can give unltmtted amounts of diffuston without separation. The diffuser shapes are particularly easy to calculate if the free-stream velocity ts considered to be constant across the channel. The resulttng shapes are not straight stded, but expand most raptdly at ftrst where the boundary layers are thin and then less rapidly as the boundary layers grow. The expansion rates are greatly affected by the thickness of the boundary layer at the begtnning of the expanston, a fact not usually taken tnto account in the design of diffusers for wind tunnels and the like. (Contractor's abstract)

JHU. 02:001

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

THE GENERAL THEORY OF LINEARIZED ROTATIONAL COMPRESSIBLE FLOW AND APPLICATIONS, by C.-C. Chang and B.-T. Chu. Feb. 2, 1951 [24]p. incl. dtagrs. refs. [AF 33(038)12919)
Unclassifted

Presented at annual meeting of the Amer. Phys. Soc., New York, Feb. 2, 1951.

The fundamental equations governtng the motion of a steady nonviscous compressible flow can be linearized for a parallel but not necessarily uniform main stream as long as the dtsturbances are small. For two-dimenstonal or axially-symmetric flow, these equations can be reduced to the generalized Cauchy-Rtemann equations considered by Bers and Gelbart. For general three-dtmenstonal flow, a single second order partial differential equation is obtatned. The procedure of determining the boundary conditions for these equations is presented. It is shown that the linearized equation for the shear flow in general can be applied in the transonic range. For certain main stream velocity distributions, simple solutions can be found. In one case, the pressure distribution on an arbitrary airfoil in supersonic flight is given, and the result can be readily compared with Ackert's thin airfoil theory; the latter

gives only a first approximation for pressure distributions provided that the main stream velocity gradients in the neighborhood of the airfoil are small. The mathematical and physical aspects of the problems are briefly reviewed.

JHU. 02:002

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

A PRELIMINARY STUDY OF THE AERODYNAMIC THEORY OF TURBOMACHINERY AND OF THREE-DIMENSIONAL SHEAR FLOW OF NONVISCOUS COMPRESSIBLE FLUIDS, by C.-C. Chang, H. Yeh, and B.-T. Chu. Apr. 1-June 30, 1951, 1v. incl. diagrs. refs. (AF 33(038)12919) ATI-158011 Unclassified

Some preliminary investigations on the aerodynamical aspects of turbomachinery and on three-dimensional shear flows are discussed. Study was concentrated on the fundamental equations of nonviscous, non-heat-conductive flow, summing up some of the early theoretical accomplishments in this field from a unified point of view. The thermoaerodynamic relations and the cascade theory are also discussed.

JHU. 02:003

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

AERODYNAMIC CHARACTERISTICS OF AN OSCILLATING CASCADE, by C.-C. Chang and W.-H. Chu. Sept. 1, 1952 [42]p. incl. diagrs. (AF 33(038)12919) AD 4878 Unclassified

A study is presented of the simplified mechanism of aeroelastic instability or flutter in high-speed aircraft having turbomachinery. The rotor blades are considered approximately as a 2-dimensional cascade of an infinite number of identical airfoils spaced evenly in the lateral direction. The cascade is in an uniform flow of a perfect incompressible fluid and is subject to a quasi-steady harmonic oscillation. The pitching and flopping modes of small oscillations are considered. By assuming all the blades of the cascade to oscillate in synchronization, the conformal mapping technique may be applied in the analysis. The whole cascade is mapped onto a unit circle, and vice versa, by means of a combination of Joukowski's transformation and an exponential function. The flow is decomposed into steady mean flow, noncirculatory oscillating flow, and circulating oscillating flow. The second type of flow is considered as an oscillating doublet sheet replacing each blade; the third type is contributed by the oscillatory circulations in the cascade and the vorticity in the infinitely long wakes shed from the cascade. The lift and moment are not expressed in closed forms. The final expressions are given in integrals and series, and in the expression of the moment two new integrals occur. One of them may be reduced to the Theodorsen function (NACA Technical rept. no. 496, 1934) in the single-airfoil flutter if the gap/chord ratio goes to infinity.

JHU. 02:004

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

PROPAGATION OF DISTURBANCES THROUGH SHEAR LAYERS OF COMPRESSIBLE FLOW, PART I, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 34p. diagrs. (AF 33(038)12919) ATI-170700 Unclassified

Analytical solutions are given for the propagation of steady two-dimensional disturbances in shear layers bounded by a uniform supersonic stream on one side and by another uniform supersonic or subsonic stream on the other side. There is no restriction on the variation of Mach number inside the shear layers except that it is piecewise differentiable. (Contractor's summary)

JHU. 02:005

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

THIN AIRFOIL THEORY IN TWO-DIMENSIONAL COMPRESSIBLE SHEAR FLOW, PART II, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952 [34]p. incl. diagr. (Bound with its Propagation of Disturbances Through Shear Layers of Compressible Flow, Part I, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 34p.; ATI-170700) (AF 33(038)12919) Unclassified

This theory contains Ackeret's thin airfoil theory for uniform supersonic flow and the thin airfoil theory of Munk and Glauert for uniform incompressible as special cases; it, therefore, unifies the formerly entirely different analyses. (Contractor's summary)

JHU. 02:006

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

LIFTING-LINE THEORY FOR A WING IN COMPRESSIBLE SHEAR FLOW, PART III, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 31p. incl. diagr. (Bound with its Propagation Disturbances Through Shear Layers of Compressible Flow, Part I, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 34p.; ATI-170700) (AF 33(038)12919) Unclassified

The purpose of this paper is to show how the analysis, by von Kármán and Tsien, of Prandtl's lifting line theory may be extended to the case of compressible shear flow.

JHU. 02:007

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

POINTED BODY IN A SUPERSONIC SHEAR FLOW,

JHU. 02:008 - JHU. 03:003

PART IV, by C.-C. Chang and J. Werner. Final rept. Sept. 26, 1951-Sept. 25, 1952, 31p. (Bound with its Propagation of Disturbances Through Shear Layers of Compressible Flow, Part I, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 34p.; ATI-170700) (AF 33(038)12919) Unclassified

This paper investigates the aerodynamics of a pointed nose body in a supersonic shear flow with the Mach number varying only in the vertical direction. It is done in such a way that the fundamental equation of shear flow developed by Chang can be reduced to the damped wave equation by means of a change of variables and normalization.

JHU. 02:008

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

THE PRESSURE ON A SLENDER BODY OF REVOLUTION IN SUPERSONIC SHEAR FLOW, PART V, by C.-C. Chang and J. Werner. Final rept. Sept. 26, 1951-Sept. 25, 1952, 7p. (Bound with its Propagation of Disturbances Through Shear Layers of Compressible Flow, Part I, by C.-C. Chang and B.-T. Chu. Final rept. Sept. 26, 1951-Sept. 25, 1952, 34p.; ATI-170700) (AF 33(038)12919) Unclassified

This part is a further simplification of Part IV, considering the body to be much thinner. This will give the asymptotic solution for the disturbance pressure.

JHU. 03:001

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

THE BEHAVIOR OF TURBULENT BOUNDARY LAYERS, by F. H. Clauser. Feb. 25, 1054 [35]p. incl. diagrs. [AFOSR-TN-54-328] (AF 18(600)671) AD 48122 Unclassified

Presented at the Second Canadian Symposium on Aerodynamics, Toronto U., Feb. 25, 1954.

A review is presented of established work on turbulent boundary layers. The concept of the equilibrium layer is introduced, and a discussion is given of a number of ways in which a boundary layer can be disturbed. Experiments showed that (1) when the boundary layer passes through a changing environment, the layer is in a disturbed condition; and (2) when the environment of the boundary layer is held constant, the layer approaches a natural state appropriate to that environment. An experiment is described in which the skin friction in a conventional constant-pressure layer on a smooth plate was abruptly increased by roughening the wall with corrugated paper. The experiment showed that the region next to the wall is affected first, and that the change propagates outward until the entire profile is shifted over to a new curve. No rescaling of the variables is possible which can cause the profile to have the same shape as in the equilibrium zones ahead of or behind the transition zone. Experiments are described for the measurement of the time required for a boundary layer to return to equilibrium after it has been disturbed (the response time of the boundary layer). The problem of the nonequilibrium behavior of the outer portion of the layer is discussed.

JHU. 03:002

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

TURBULENT HEAT TRANSFER IN A BOUNDARY LAYER WITH DISCONTINUOUS WALL TEMPERATURE, by D. S. Johnson. Aug. 1955 [133]p. incl. diagrs. refs. ([AF]OSR-TN-55-289) (AF 18(600)671) AD 71773 Unclassified

Results are presented of an experimental investigation of the concomitant thermal and velocity fields occurring when there is a small stepwise discontinuity in the temperature of the wall on which a zero-pressure-gradient turbulent boundary layer has formed. The mean velocity and temperature fields have been measured, and the statistical behaviors of several relevant fluctuating quantities have been obtained at a typical cross-section in the region where the thermal boundary layer has not yet reached the free stream. No over-all similarity between the thermal and velocity fields was found. The instantaneous surface of demarcation between heated and unheated fluid was found to be sharp and distinct at all points, resulting in intermittent temperature fluctuation signals well within the fully turbulent region of the momentum boundary layer. Values have been obtained for the variation of local heat transfer coefficient in the streamwise direction, and of the distribution of the local turbulent Prandtl number through the boundary layer at 1 section. (Contractor's abstract)

JHU. 03:003

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

VELOCITY, TEMPERATURE, AND HEAT-TRANSFER MEASUREMENTS IN A TURBULENT BOUNDARY LAYER DOWNSTREAM OF A STEPWISE DISCONTINUITY IN WALL TEMPERATURE, by D. S. Johnson. [1956] [7]p. incl. diagrs. refs. (AF 18(600)671) Unclassified

Published in Jour. Appl. Mech., v. 24: 2-8, Mar. 1957.

Results are presented of an experimental investigation of the concomitant thermal and velocity fields occurring when there is a small stepwise discontinuity in the temperature of the wall on which a zero-pressure-gradient, low-speed, turbulent boundary layer has formed. The mean velocity and temperature fields have been measured and local heat-transfer-coefficient values in the streamwise direction have been obtained in the region where the thermal boundary layer has not yet reached the free stream. No over-all similarity between the thermal and velocity fields was found. (Contractor's abstract)

JHU. 04:001

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

PROBE INTERFERENCE IN MEASUREMENTS IN SUPERSONIC LAMINAR BOUNDARY LAYERS, by M. V. Morkovin and W. S. Bradfield. June 15, 1954, 2p. illus. refs. (Sponsored jointly by [Air Force] Office of Scientific Research and Office of Naval Research under [AF 18(600)1121]) Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 785-786, Nov. 1954.

Investigations have been made on the effects of the total-pressure probe used for measuring velocity and other profiles of supersonic laminar boundary layers. The existence and partial evaluation of these effects were based on comparison of results obtained from different size probes and on comparison of results with boundary-layer theory, which cannot account for the complicating leading-edge effects. The current study presents direct visual evidence of strong interference near the wall and discusses its implications. Observations were made of local, 3-dimensional separation under various probes (hot-wire and total-pressure) in the Johns Hopkins U. tunnel over a flat plate at M = 1.72 using the light-oil, lamp-black technique. In addition, these observations were rerun at the University of Minnesota (Minneapolis) at M = 3.05 using a short focus schlieren system and the china-film technique (J. S. Murphy and R. E. Phinney, Visualization of Boundary Layer Flow, Jour. Aeronaut. Sciences, v. 18: 771, Nov. 1951).

JHU. 04:002

Johns Hopkins U. Dept. of Aeronautics, Baltimore Md.

EFFECTS OF HIGH ACCELERATION ON A TURBULENT SUPERSONIC SHEAR LAYER, by M. V. Morkovin. [1955] 10p. illus. diagrs. tables, refs. [AFOSR-TN-55-126] [AF 18(600)1121] Unclassified

This paper describes, without detail interpretation, some recent measurements in the supersonic turbulent boundary layer under conditions of high acceleration. The information touches on the questions of mean and fluctuating reflection of a realizable Prandtl-Meyer wave from a turbulent boundary layer, of detailed structure of the fluctuations in that boundary layer, and of interactions between entropy and vorticity fluctuations with mean expansion flows. (Contractor's abstract)

JHU. 04:003

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

FLUCTUATIONS AND HOT-WIRE ANEMOMETRY IN COMPRESSIBLE FLOWS, by M. V. Morkovin. Nov. 1956, 102p. incl. diagrs. tables, refs. (AFOSR-TN-56-295) (NATO AGARDograph rept. no. 24) (AF 18(600)1121) AD 90007 Unclassified

Treatment of the problem of extracting information from a heated thin wire cooled by an unsteady compressible flow is based on the concept of local linearization around each operating point of an otherwise nonlinear system. This leads to a general formula for the direct voltage sensitivities with respect to the fluctuation modes of vorticity, entropy, and sound. Empirical evidence on heat transfer to thin wires at high speeds is analyzed in relation to the parameters entering the sensitivities. The potentialities and actual performance of the hot wire as a turbulence indicator, thermometer or microphone were evaluated on the basis of sensitivity expressions derived for different speed ranges. The direct mode sensitivities allow a generalization of Kovasznay's fluctuation diagrams so that decomposition of electrical signals into the separate mode contributions is not limited to supersonic speeds. In the range of Re no corresponding to hot-wire operation, families of straight lines in the Nu vs $\sqrt{Re}$ planes fit the empirical data well (except at very low Re's). Sensitivity expressions indicate that individual calibrations of wires are not required for most fluctuation measurements at supersonic speed. Procedures leading to spectral analysis of the mode fluctuations are given.

JHU. 04:004

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

ON THE ENERGY TRANSFER TO SMALL DISTURBANCES IN A VISCOUS COMPRESSIBLE HEAT CONDUCTIVE MEDIUM, by B.-T. Chu. July 25, 1956, 38p. [AFOSR-TN-56-377] (AF 18(600)1121) AD 95813 Unclassified

The energy in a small disturbance in a viscous, compressible, heat-conductive medium is defined as a positive, definite quantity characterizing the mean level of fluctuation in the disturbance which, in the absence of heat transfer at the boundaries and of work done by them or by body forces, and in the absence of heat and material sources, is a monotone nondecreasing function of time. A quantity satisfying these requirements is found for small disturbances in a viscous, compressible heat-conductive medium. When viscosity and heat conductivity are neglected, the quantity reduces to the familiar acoustic energy in the theory of sound. Stability in the mean of such a fluid system can then be discussed with reference to the growth and decay of the energy in the disturbance. The effects of body forces, heat, and material sources are discussed. Rayleigh's criterion for the stability of systems involving heat sources is derived, and its limitations are shown. The transfer of energy from a steady main stream to a disturbance is examined, and the particular case of a parallel main stream is considered. A mathematical application of the energy relation is appended which demonstrates the uniqueness of solution of an initial- and boundary-value problem in the linearized theory of a viscous, heat-conductive medium. (ASTIA abstract)

JHU. 04:005 - JHU. 06:001

JHU. 04:005

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

THOUGHTS ON SUPERSONIC WIND TUNNELS WITH LOW FREE-STREAM DISTURBANCES, by M. V. Morkovin. Nov. 1956 [20]p. tncl. diagrs. refs. (AFOSR-TN-56-540) (AF 18(600)1121) AD 110359 Unclasstfted

Mean-flow nonuniformities tn supersonic tunnels apparentty can be made sufficiently small by standard techniques. Large ratio of the settling chamber area to sonic throat area decreases effectively those mean Mach-number nonuniformtties which come from upstream of the throat. Great care in keeping nozzle contours continuously curvtng wtthout bumps or wavtness minimizes both the mean-disturbance wave pattern seen in many schlteren photographs and the unsteady sound level from "shivering Mach waves." Supersonic turbulence ts effectively suppressed by a large contraction ratio. Entropy (temperature) fluctuations can be reduced by matching mean temperatures at duct junctures and by provtdtng "long passage time" from such junctures to the test section. In particular a low-velocttty settling chamber with graduated screens to decrease the scale of the temperature nonuniformities ts thought effective. In constdertng the effect of free-stream disturbances thetr spectral dtstrtbution may be relevant. Vorticity and entropy fluctuations wtll not be important in the frequency range above 8 kc. The sound generated in the supersonic section, however, wtll have frequencies charactertstic of thtn high-speed layers, i.e., up to 60 kc and higher. The offendtng sound in the supersonic section is generated in the watl boundary layer. This sound is very difficult to measure experimentally or to predict theoreitcally and apparently little can be done to reduce tts ievel apprectably (except tn tunnels with contour nonuniformtties). The restdual sound level, however, ts probably unimportant except in transttion studies and very careful drag measurement.

JHU. 04:006

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

ON TRANSITION EXPERIMENTS AT MODERATE SUPERSONIC SPEEDS, by M. V. Morkovin. Oct. 22, 1956 [7]p. incl. diagrs. refs. [AFOSR-TN-56-541] (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1121 and Office of Naval Research) AD 1t0360 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 24: 480-486, July 1957.

Studies of transition over a flat plate at Mach number 1.76 were carried out using a hot-wire anemometer as one of the principal tools. The nature and measurements of free-stream disturbances at supersonic speeds are analyzed. The experimentat results are tnterpreted in the light of present over-all information on transition at supersonic speeds and conclusions as to further fruitful experiments are drawn. (Contractor's abstract)

JHU. 04:007

Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.

CONDENSATION EFFECTS AND AIR DRYING SYSTEM FOR SUPERSONIC WIND TUNNELS, by J. J. Smolderen. July 1956, 79p. tncl. refs. (NATO AGARDograph rept. no. 17) (AF 18(600)t12t) Unclassifted

Anatysts of vartous aspects of the condensation problem is discussed. The phenomenon of condensation effects and the resulting flow disturbances are studted, and an investigation ts made of the posstbility of complete removal of the effects. A presentatton of a crtterton based on expertmental results ts tncluded. Condttions under whtch flow dtsturbances are sufficientty small are also indicated. A survey ts made of vartous drytng by cooltng, compression, and adsorption. A review is presented of different measurtng devtces for the determination of humidtty.

JHU. 05:001

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

AN AUTOMATIC POTENTIOMETER WITH DIGITAL RECORDING AND COMPUTING (Abstract), by L. J. Todd and D. H. Andrews. [t953] [1]p. [AF 18-(600)765] Unclassifted

Presented at meeting of the Amer. Chem. Soc., Chicago, Ill., Sept. 6-t1, t953.

Published in 124th meettng of Amer. Chem. Soc. Abstracts of Papers, 1953, p. 46-R.

A Wenner-type potentiometer has been constructed wtth magnetically operated stepptng switches substituted for the usual hand knobs, so that the changtng potentials from a reststance thermometer can be automatically observed and recorded on punch cards. The assembly ts designed espectally for heat capactty measurements and has auxiliary equtpment, so that all other necessary data are likewise card-punched. Used wtth master cards containing caltbration constants and converston factors, the data cards can be fed to an IBM 604 digital calculator which will compute and print tables of heat capacity against temperature for any desired intervals. Relative temperature is measured to 0.001° and relative temperature increments to 0.0001° Ttme ts recorded to the nearest 0.t sec and may be read vtsually to the nearest 0.01 sec. While constructed to cover only a 1000-mv range, the destgn permtts adtttonal banks of contacts to be added, scanned, and recorded on the punch cards. Automatic resetting in less than t sec permtts rapid hunting for zero balance and quick recordtng. (Contractor's abstract)

JHU. 06:00t

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

tSOTOPIC ANALYSIS OF GASEOUS BORON HYDRIDES

BY NEUTRON ABSORPTION, by R. P. Hamlen and W. S. Koski. Jan. 1956, 6p. incl. table. (Technical note no. 1) [AFOSR-TN-56-6] (AF 18(600)1526) AD 88583 Unclassified

An isotopic boron analysis of diborane and pentaborane containing varying amounts of B^{10} has been made using a neutron-absorption technique. The gas was placed in a cell, the inside of which was coated with a ZnS silver-activated phosphor, and exposed to a neutron flux. The number of events from the $B^{10}(n, \alpha)Li^7$ reaction was a measure of the B^{10} content. The accuracy and reproducibility of the results agreed to within 1%. Preliminary results indicate the method is applicable to other gaseous boron hydrides such as dihydropentaborane and tetraborane. (Contractor's abstract)

JHU. 06:002

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

Cl^{35} NUCLEAR QUADRUPOLE RESONANCES IN $TiCl_4$ AND WCl_6, by R. P. Hamlen and W. S. Koski. Apr. 1956 [6]p. incl. diagrs. table. (Technical note no. 2) (AFOSR-TN-56-171) (AF 18(600)1526) AD 86593 Unclassified

Also published in Jour. Chem. Phys., v. 25: 360, Aug. 1956.

The temperature dependence of the Cl^{35} resonances has been measured in $TiCl_4$ and WCl_6. These resonances fall near 6 and 10 mc/sec, respectively. Interpretation of the nuclear quadrupole coupling constants on the basis of existing theories indicates that both s-hybridization and double bond character should be considered. (Contractor's abstract)

JHU. 06:003

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

INFRARED STUDY OF THE EXCHANGE OF DEUTERIUM BETWEEN DECARBORANE AND DIBORANE, by J. J. Kaufman and W. S. Koski. May 1956 [8]p. incl. diagr. table. (Technical note no. 3) (AFOSR-TN-56-247) (AF 18(600)1526) AD 88367 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 5774-5775, Nov. 20, 1956.

An infrared speciroscopic study has been made of partially deuterated $B_{10}H_{14}$ samples prepared by exchanging deuterium between B_2H_6 and $B_{10}H_{14}$ at 100°C. These spectra have been compared with those of partially deuterated $B_{10}H_{14}$ in which the deuteriums are randomly distributed. This comparison shows that the exchange proceeds on the terminal hydrogens in $B_{10}H_{14}$ and that the bridge hydrogens are not involved at all in the reaction under the experimental conditions. (Contractor's abstract)

JHU. 06:004

Johns Hopkins U. Dept. of Chemistry, Baltimore, Md.

NUCLEAR MAGNETIC RESONANCE STUDY OF THE B_2D_6-B_5H_9 EXCHANGE REACTION, by W. S. Koski, J. J. Kaufman, and P. C. Lauterbur. Oct. 1956 [12]p. incl. diagrs. refs. (Technical note no. 4) (AFOSR-TN-56-494) (AF 18(600)1526) AD 110308 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 2382-2385, May 20, 1957.

The exchange of deuterium between diborane and pentaborance was investigated by nuclear magnetic resonance. It was found that the exchange proceeded preferentially in the terminal hydrogen positions in pentaborane. The rate of exchange of the apex hydrogen was to within ±10% the same as the exchange rate of the base terminal hydrogen. Under the experimental conditions the bridge hydrogens in pentaborane did not participate in the exchange. (Contractor's abstract)

JHU. 06:005

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

APPLICATION OF VAPOR PHASE CHROMATOGRAPHY TO THE BORON HYDRIDES, by J. J. Kaufman, J. E. Todd, and W. S. Koski. Nov. 1956 [10]p. incl. diagrs. (Technical note no. 5) (AFOSR-TN-56-534) (AF 18-(600)1526) AD 110353 Unclassified

Also published in Anal. Chem., v. 29: 1032-1035, July 1957.

Application was made using Celite as a packing coated with paraffin oil, Octoil S or tricresyl phosphate. Complete separation of diborane, tetraborane, and pentaborane was realized without decomposition. Extensive decomposition was observed in the case of dihydropentaborane. Small amounts of ethane, which were present in our diborane samples as an impurity, could be readily separated from the diborane. (Contractor's abstract)

JHU. 06:006

Johns Hopkins U. [Dept. of Chemistry] Baltimore, Md.

CHLORINE NUCLEAR QUADRUPOLE RESONANCE IN TUNGSTEN HEXACHLORIDE (Abstract), by W. S. Koski and R. P. Hamlen. [1956] [1]p. [AF 18(600)-1526) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 215, Apr. 26, 1956.

JHU. 07:001 - JHU. 08:001

The pure nuctear quadrupole resonance frequency has been measured for Cl^{35} and Cl^{37} in tungsten hexachtoride using a self-quenched super-regenerative oscittator. At 23°C the Ct^{35} resonance occurs at 10. 525 mc/sec, and a positive temperature coefficient was observed. Using the usual assumption of 18% s-hybridization for the p-bonding orbitat of a chtorine in an appreciably ionic bond, this resonance frequency corresponds to an ionic character of approximatety 80%. (Contractor's abstract)

JHU. 07:001

[Johns Hopkins U. Dept. of Mathematics, Battimore, Md.]

PERIODIC SOLUTIONS OF DIFFERENTIAL EQUATIONS CONTAINING A PARAMETER, by D. C. Lewis. Dec. 18, 1953, 30p. (Technical rept. no. 1) [AFOSR-TN-54-3] (AF 18(600)665) AD 23315 Unclassified

Also published in Duke Math. Jour. v. 22: 39-56, Mar. 1955.

Consideration is given to a proof by Poincaré thai the existence of a known periodic sotution $x_1 = x_1(t) = x_1(t + 2\pi)$ when $|\mu| = 0$ of a system of differential equations of the iype $dx_i/dt = X_i(x_1, \ldots, x_n, \mu, t) = X_i(x, \mu, t)$, $i = 1, \ldots, n$, impties the existence of periodic sotutions for att sufficiently smati $|\mu| > o$, at teasi if the variationat equations have no nonirivial solutions with period 2π. Definite estimates are obtained for the range of convergence for a powers series expansion in μ, and in the anatytic case upper bounds are obtained for the remainder resulting from cutting the series off afier m terms. The estimates are obtained in terms of Lipschiiz conditions pertineni to functions consiructed from the X's and in terms of quaniities in the Green's matrix of the variational equations. The resuti does not depend expticitty on n. The method of integrat equations and successive approximations is modified in the anatytic case to yietd periodic sotutions for alt comptex values of μ whose absotuie values are bounded by a given positive constant L. A Cauchy criterion for the coefficients of a power series is apptied, and the result provides the desired information on the rapidity of convergence. The resutts for the analytic case are vatid for comptex domains; the resutis for the prior tnvestigaiion are vatid onty in reat domains.

JHU. 07:002

Johns Hopkins U. Dept. of Mathematics, Battimore, Md.

FAMILIES OF PERIODIC SOLUTIONS OF SYSTEMS HAVING RELATIVELY INVARIANT LINE INTEGRALS, by D. C. Lewis. June 20, 1954, 6p. (Paper no. 2) ([AF]OSR-TN-54-117) (AF 18(600)665) AD 36394 Unclassified

Also published in Proc. Amer. Math. Soc., v. 6: 181-185, Apr. 1955.

This repori generatizes to att systems having retatively invariant line integrals a known theorem about conservative Lagrangian systems, which is roughly to the effect that in any given family of periodic sotutions the period is at most a function of the energy atone. The energy function is hereby replaced by a certain function, $H(x_1, \ldots, x_n)$ which is known to be a first integral of the given system, $dx_i/dt = X_i(x_1, \ldots, x_n)$, $i = 1, \ldots, n$, and which furthermore satisfied retations of the form,

$$\sum(\delta A_i/\delta x_j - \delta A_j/\delta x_i)X_j = \delta H/\delta x_i, \quad i = 1, \ldots, n,$$

where the A's are known because of the known retatively invariant tine integrat. (Contractor's abstract)

JHU. 07:003

ON THE PERTURBATION OF A PERIODIC SOLUTION WHEN THE VARIATIONAL SYSTEM HAS NONTRIVIAL PERIODIC SOLUTIONS, by D. C. Lewis. Jan. 20, 1955, 35p. (Paper no. 3) ([AF]OSR-TN-54-325) (AF 18(600)665) AD 53288 Unctassified

Also published in Jour. Rational Mech. and Analysis, v. 4: 795-815, Sept. 1955.

An appraisat is made of the range of the parameter in the theory of perturbation of periodic sotutions, originated by Poincaré, in what may be considered to be the generat case when the variational equations have nontrivial periodic sotutions. The definition of this generat case implicitty excludes the presence of first integrats. The method consists of successive approximations, using a Green's matrix dependent upon the parameter and having a simple pole at $\mu = 0$. (Coniractor's abstract)

JHU. 07:004

Johns Hopkins U. Dept. of Mathematics, Battimore, Md.

ON THE ROLE OF FIRST INTEGRALS IN THE PERTURBATION OF PERIODIC SOLUTIONS, by D. C. Lewis. Apr. 1, 1955, 28p. (Paper no. 4) ([AF]OSR-TN-55-58) (AF 18(600)665) AD 60505 Unctassified

Also published in Ann. Math., v. 63: 535-548, May 1956.

An appraisat is made of the range of the parameter in the theory of perturbation of periodic sotutions, originated by Poincaré, in case the number of independent first iniegrals is equat to the number of tinearly independent periodic soiutions of the equations of variation. The method consists of successive approximations, use of a generalized Green's matrix, and a discussion of the bifurcation equations, which turn out to be identicatly satisfied. (Contractor's abstract)

JHU. 08:001

Johns Hopkins U. Dept. of Mathematics, Battimore, Md.

EQUIVARIANT EMBEDDINGS IN EUCLIDEAN SPACE,

by G. D. Mostow. Mar. 1957 [28]p. (AFOSR-TN-56-284) (AF 18(600)1474) AD 89494 Unclassified

Also published in Ann. Math., v. 65: 432-446, May 1957.

Let G be a group of transformations on a topological space E. If $P \in E$ we denote by G_p the set of transformations in G which keep p fixed. If H is a subgroup of G, we denote by (H) the totality of subgroups of G of the form xHx^{-1} with x in G. We denote by L(G, E) the totality of (G_p) as p varies over E. The orbits G_p and G_q through points p and q of E are called equivalent if $(G_p) = (G_q)$. Thus G has but a finite number of inequivalent orbits in E if and only if L(G, E) is a finite set. This is the case for example if E is a compact differentiable manifold and G is a compact group of differentiable transformations. Several theorems are derived and proven in this paper. Among other things they are particularly useful in enabling one (1) to obtain quite directly information about the conjugacy of subgroups of a compact Lie group, and (2) to find conditions under which L(G, E) is finite. (Contractor's abstract)

JHU. 09:001

Johns Hopkins U. Dept. of Mathematics, Baltimore, Md.

ON INTEGRATING FACTORS AND ON CONFORMAL MAPPINGS, by P. Hartman. Oct. 1956, 31p. refs. (Technical rept. no. 1) (AFOSR-TN-56-475) (AF 18-(603)41) AD 97359 Unclassified

Also published in Trans. Amer. Math. Soc., v. 87: 387-406, 1958.

The existence of (local) "integrating factors" for a linear differential form $\omega = P(x, y)dx + Q(x, y)dy$ with functions $T \neq 0$ and W such that $\omega = Tdw$. The first of two cases is where P and Q are real-valued and $P^2 + Q^2 \neq 0$. $1/T$ is called an integrating factor for ω and solution is through ordinary differential equations. The second case is where P and Q are complex-valued and $\mathrm{Im}(P\bar{Q}) \neq 0$. The problem here is conformalizing the Riemannian metric $ds^2 = \omega\bar{\omega} = |P|^2dx^2 + 2\mathrm{Re}(P\bar{Q})dxdy + |Q|^2dy^2$ by an elliptic system of partial differential equations. A positive definite binary ds^2 can be factored into $\omega\bar{\omega}$. P and Q are continuous and conditions are imposed on the set function $\Psi(E) = \int_J Pdx + Qdy$ with E a domain bounded by a rectifiable Jordan curve J. The appendix considers a related problem on indefinite forms in the theory of surfaces.

JHU. 09:002

Johns Hopkins U. [Dept. of Mathematics] Baltimore, Md.

SELF-ADJOINT, NON-OSCILLATORY SYSTEMS OF ORDINARY, SECOND ORDER, LINEAR DIFFERENTIAL EQUATIONS, by P. Hartman. Oct. 1956, 11p. refs. (Technical rept. no. 2) (AFOSR-TN-56-482) (AF 18-(603)41) AD 97366 Unclassified

Also published in Duke Math. Jour., v. 24: 25-36, Mar. 1957.

A differential equation $x'' + f(t)x = 0$ is called nonoscillatory on $0 \leq t < \infty$ if no (nontrivial) solution has arbitrarily large zeros. This notion is generalized to a self-adjoint system of equations $x'' + F(t)x = 0$ in which x is a vector and F(t) is a continuous Hermitian matrix on $0 \leq t < \infty$. Results concerning solutions of this system (and, more generally, of the system $(Px')' + Fx = 0$ in which P(t) is a continuous Hermitian positive definite matrix), analogous to known facts concerning solutions in the particular cases that F(t) is a scalar or a real Hermitian non-positive definite matrix, are obtained. (Math. Rev. abstract)

JHU. 09:003

Johns Hopkins U. Dept. of Mathematics, Baltimore, Md.

REMARKS ON A UNIQUENESS THEOREM FOR CLOSED SURFACES, by P. Hartman. Dec. 1956, 8p. (Technical rept. no. 3) (AFOSR-TN-56-589) (AF 18(603)-41) AD 115016 Unclassified

Also published in Math. Ann., v. 133: 416-430, 1957.

A strong maximum principle for a singular elliptic partial differential equation is made use of in obtaining versions of the theorems of Voss dealing with closed surfaces in Euclidean 3-space without the aid of his assumptions of analyticity.

JHU. 10:001

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

SPECTRAL PHONOCARDIOGRAPHY: PROBLEMS AND PROSPECTS IN THE APPLICATION OF THE BELL SOUND SPECTROGRAPH TO PHONOCARDIOGRAPHY, by V. A. McKusick, S. A. Talbot, and G. N. Webb. [1954] [12]p. incl. illus. diagrs. [AF 18(600)1040] Unclassified

Presented at meeting of the Amer. Physiol. Soc., Atlantic City, N. J., Apr. 12-16, 1954.

Published in Bull. Johns Hopkins Hospital, v. 94: 187-198, Apr. 1954.

Abstract published in Fed. Proc., v. 13: 522, Mar. 1954.

For optimum results the Bell sound spectrograph requires modification along the following lines: (1) provision for fine definition in both time and frequency in the same record is desirable; (2) display of frequency on a logarithmic scale (the ordinate) produces a more realistic record; (3) instrumentation for the simultaneous parallel recording of other physiologic data (for

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correlative and timing purposes) is essential; and (4) conversion from the use of direct-writing paper to photographic film negative improves intensity definition many-fold. Spectral phonocardiograms incorporate the timing, frequency, and intensity characteristics of heart sounds in a single, objective, detailed, standardizable display. The following hypotheses are discussed and illustrated: (1) spectral phonocardiograms match closely the mental image of the heart sounds. Therefore their interpretation is easy for the experienced stethoscopist; (2) their pedagogic value is considerable; (3) for purposes of clinical record spectral phonocardiography has advantages; (4) spectral phonocardiography permits precise definition in physical terms of the adjectives used in describing heart sounds and murmurs; and (5) information of physiologic and pathologic significance beyond the appreciation of either the ear or the current methods of phonocardiography is made available by spectral phonocardiography. (Contractor's abstract)

JHU. 10:002

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

SPECTRAL PHONOCARDIOGRAPHY: CLINICAL STUDIES, by V. A. McKusick, C. N. Webb and others. [1954] [21]p. incl. illus. diagrs. refs. [AF 18(600)-1040] Unclassified

Published in Bull. Johns Hopkins Hospital, v. 95: 90-110. Aug. 1954.

Spectral phonocardiograms of a variety of heart sounds and murmurs have been presented and discussed. Technical modifications which permit simultaneous display EKG, respirations, and other physiologic phenomena and those necessary for a logarithmic frequency scale are described briefly and examples of recordings presented. Since all features of the sounds are visually displayed, quality (timbre), which previously has eluded exact description, can now be defined in physical terms. This "sea-gull" diastolic murmur and terms such as ringing, rasping, rumbling, etc., are so defined. Preliminary observations are presented concerning the operation of one part of the stethoscope on sound reaching the surface of the chest, the operation of the thorax on sound generated in cardiovascular structures, and the dissection of heart sounds by this method. Crescendo, decrescendo, diamond-shaped and similar terms derived from the intensity characteristics as displayed by classical phonocardiography are found to apply to frequency characteristics as well. In general, freak frequency and over-all intensity vary in a parallel fashion in sounds of cardiovascular origin. In the case of one type of vascular sound (uterine souffle) the relation to the generating system and the operation of hemodynamic factors on this sound are discussed. The similarity of the uterine souffle to an arterial pulse pressure curve is pointed out. Spectral phonocardiograms resemble closely the mental image of heart sounds and murmurs. They facilitate the learning of clinical auscultation. And inasmuch as all three dimensions of sound are incorporated in a single detailed display, spectral phonocardiograms are valuable for permanent clinical records and for the detailed presentation of these sounds on the printed page. (Contractor's summary)

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Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

SOME HEMODYNAMIC EFFECTS OF THE HUFNAGEL OPERATION FOR AORTIC REGURGITATION by V. A. McKusick, D. P. Hahn and others. [1954] [16]p. incl. illus. diagrs. tables, refs. [AF 18(600)1040] Unclassified

Published in Bull. Johns Hopkins Hospital, v. 95: 322-337, Dec. 1954.

The following effects have been found: (1) the implantation of a ball-valve in the descending thoracic aorta in cases of aortic regurgitation results in decrease in mean diastolic pressure in the segment of the arterial tree proximal to the ball-valve and a decrease in the size of the diastolic murmur; (2) the size of the diastolic murmur correlates well with mean diastolic pressure in the proximal segment and poorly with the volume of regurgitation; (3) both the beneficial effect on volume of regurgitation and the adverse one on mean diastolic pressure are greater the smaller the segment proximal to the ball-valve; (4) the exaggeration (by the operation) of the depression of mean diastolic pressure in the proximal arterial segment may limit the over-all benefits of the operation; (5) splitting of the sound produced by the artificial valve is demonstrated by spectral phonocardiography. Asynchronous impingement of the valve on its seatings is suggested as the mechanism of this minute splitting; and (6) the opening and closing sounds of the artificial valve in situ occurs between the normal heart sounds. Systole is abbreviated distal to the artificial valve. (Contractor's conclusions, modified)

JHU. 10:004

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

DISEASES OF THE PERICARDIUM, by V. A. McKusick and A. M. Harvey. [1955] [44]p. incl. illus. diagr. refs. [AF 18(600)1040] Unclassified

Published in Advances in Internal Med., v. 7: 157-200, 1955.

A review is presented of the following diseases of the pericardium with emphasis on causes, methods of diagnosis, and treatment: (1) acute nonspecific; (2) purulent; (3) acute and subacute tuberculous pericarditis; (4) pericarditis of systemic lupus erythematosus; (5) chronic constrictive pericarditis, (6) metabolic pericarditis, (7) pericarditis secondary to other cardiovascular diseases; (8) pericardial cysts and diverticula; and (9) a number of less common disorders of the pericardium. Ranging in time from 1852 to 1954, 170 references are cited.

JHU. 10:005

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

ON CARDIOVASCULAR SOUND. FURTHER OBSERVATIONS BY MEANS OF SPECTRAL PHONOCARDIOGRAPHY, by V. A. McKusick, G. N. Webb and others. [1955] [22]p. incl. illus. diagrs. refs. [AF 18(600)-1040] Unclassified

Published in Circulation, v. 11: 849-879, June 1955.

Spectral phonocardiography is an adaptation of the method of sound spectrography devised at the Bell Telephone labs. It differs from conventional oscillographic phoncardiography principally in the fact that frequency spectrum is displayed as welt as the dimensions of time and inlensity. The dtsptay of frequency spectrum is responsible for three advantages of the method: (1) quality, or timbre, ts gtven physical definition; (2) resotution in the time dimension ts tmproved; and (3) a betie· dtsplay of the wide dynamic range of cardiovascular sound is attatned. This method can do, or can be made to do, all the ear can. It can probabty emulate the performance of the ear because (1) it is not wed to a particular frequency-intensity response curve; (2) it suffers from no "psychoacoustic" impediments; (3) it provides better resotution tn the time dimension; and (4) it produces permanent quantifiable records. Discussed here are selected features of mitral valve disease, gallops, systolic clicks, and extracardiac sounds. In general, intensity and peak frequency vary in a parallel manner in sound of cardiovascular origin. Artefacts due to noncardiovascular ambient noise and to electrical interference can be identified and disregarded in the heart sound analysis. (Contractor's abstract)

JHU. 10:006

Johns Hopkins U. Dept. oi Medtcine, Battimore, Md.

SPECTRAL PHONOCARDIOGRAPHIC DEMONSTRATIONS OF SELECTED VARIETIES OF CARDIOVASCULAR SOUNDS, by V. A. McKusick, E. W. Kline, and G. N. Webb. [1955] [23]p. incl. diagrs. refs. [AF 18-(600)1040] Unclassified

Published in Amer. Heart Jour., v. 49: 911-933, June 1955.

Demonstrated here is heart sound intensification of 4 types as to the principal factor responsible for the alteration: (1) increased velocity of valve closure; (2) increased force of valve closure; (3) fibrosis and other physical change in the coapting valve cusps; and (4) closure of valves from a wide-open position. Recordings of heart sounds were made on magnetic tape using a condenser-type microphone. Electrocardiogram and respiratory tracings were simultaneously recorded on the tape by means of frequency modulated carriers. A more valid recording was obtained, with less risk of introduction of physiologic artifact as a result of partial Müller or Valsalva experiment, by permitting quiet respiration during the recording. Since artifacts such as breath sounds are easily identified as such in the spectrat phonocardiogram, resptration dtd not interfere with the analyses. (Contractor's summary, modified)

JHU. 10:007

Johns Hopkins U. Dept. of Medicine, Battimore, Md.

THE ACOUSTIC BASIS OF THE CHEST EXAMINATION. STUDIES BY MEANS OF SOUND SPECTROGRAPHY, by V. A. McKusick, J. T. Jenkins, and G. N. Webb. [1955] [23]p. tncl. illus. diagrs. refs. [AF 18(600)-1040] Unclassifted

Published in Amer. Rev. of T. B. and Pulmonary Diseases, v. 72: 12-34, July 1955.

The features of respiratory sound tn health and dtsease have been studied by the method of sound spectrography. Most of the ftndings noted have been revealed or surmised previously by workers using other techniques. Nevertheless, by use of the method of sound spectrography, it has been possibte to demonstrate the respiratory sounds tn health and disease graphically to a greater extent than has previously been possible. The physical differences which characterize dull, resonant, and tympanitic percussion notes, the several types of breath sounds, and moist and dry rales are demonstrated. The change in whispered and spoken voice sounds in disease can be related to physical alterations in conducting and filtering properties of the lung and its covering tissues. The musicality of asthmatic rales results from the presence of conspicuous harmonics. (Contractor's summary)

JHU. 10:008

Johns Hopkins U. Dept. of Medictne, Baltimore, Md.

MUSICAL MURMURS, by V. A. McKusick, G. E. Murray and others. [1955] [41]p. tncl. tllus. diagrs. refs. [AF 18(600)1040] Unclassified

Published in Bull. Johns Hopkins Hospital, v. 97: 136-176. Aug. 1955.

A classification of musical murmurs has been proposed. Musicality is a function of the presence of harmonic pattern. A brief discussion is presented of the clinical pictures (with particular reference to the musical murmur) associated with retroverted aortic cusp, ball-valve atrial tumor, aberrant tendon of the ventricle, and dissecting aneurysm of the ascending aorta with musical late diastolic murmur. A musical early diastolic murmur can have an extra-cardiac and prognostically benign basis. The followtng hemodynamic and anatomtcal mechanisms tn the genesis of musical murmurs are of particular interest: (1) it is possible to dissect the

JHU. 10:009 - JHU. 10:012

systolic murmur of aortic cusp into musical elements related to the regular vibrations of an elastic structure and noisy components due to turbulence. Certain of these musical murmurs are the loudest known to medicine. Components of the same two general types may be present in the valve closure sound; (2) in general, frequency and intensity in aortic murmurs, both systolic and diastolic, vary directly with aorto-ventricular pressure differential; (3) selective transmission results in alteration in the timbre of the murmur of retroverted aortic cusp as heard at the apex. Resonant absorption apparently operates in changing the timbre of the same murmur as heard in the "aortic" area; and (4) the shape of the musical uterine souffle, which resembles an arterial pressure pulse curve, can be related to cyclical hemodynamic changes at the generator. (Contractor's summary)

JHU. 10:009

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

SYSTOLIC CLICKS (SO-CALLED SYSTOLIC GALLOPS): A STUDY OF THEIR CLINICAL SIGNIFICANCE (Abstract), by J. A. Reid and J. O. Humphries. [1955] [2]p. [AF 18(600)1040] Unclassified

Presented at meeting of the Johns Hopkins Med. Soc., Baltimore, Md., May 9, 1955.

Published in Bull. Johns Hopkins Hospital, v. 97: 177-178, Aug. 1955.

Patients with systolic clicks were studied by means of spectral phonocardiography. In general, the studies indicate that systolic clicks are of benign prognostic significance. The systolic click does not hold the same grave prognosis as does a diastolic gallop. For this reason, it is recommended that the term "systolic gallop" be abandoned. Late systolic clicks may be confused with split second sound or may, with the normal second sound, create a combination simulating second sound plus opening mitral snap. Circumscribed midsystolic murmurs introduced by a systolic click appear to be extra cardiac in origin and hold the same prognosis as do systolic clicks without murmurs. (Contractor's abstract, modified)

JHU. 10:010

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

THE SPLITTING OF HEART SOUNDS. A SPECTRAL PHONOCARDIOGRAPHIC EVALUATION OF CLINICAL SIGNIFICANCE, by V. A. McKusick, W. P. Reagan and others. [1955] [13]p. incl. illus. diagrs. refs. [AF 18(600)1040] Unclassified

Published in Amer. Jour. Med., v. 19: 849-861, Dec. 1955.

Normal and pathologic conditions resulting in splitting of heart sounds are reviewed. Because of much overlap of the degree of splitting with that occurring normally, splitting is of limited diagnostic value in the pathologic states with which it may occur: interatrial septal defect, bundle branch block, mitral or aortic regurgitation, and respiratory disease resulting in exaggerated cyclical variations in intrapleural pressure. In general however, splitting has more pathologic significance (1) when it occurs in adults than when it occurs in children, (2) when splitting is exaggerated with expiration rather than with inspiration (left bundle branch block), (3) when there is no clinical evidence of respiratory disease and labored respirations, and (4) when splitting persists throughout all phases of respiration (as usually is the case in interatrial septal defect). (Contractor's summary, modified)

JHU. 10:011

Johns Hopkins U. [Dept. of Medicine] Baltimore, Md.

HEART SOUNDS, by V. A. McKusick. [1956] [9]p. incl. illus. diagrs. [AF 18(600)1040] Unclassified

Published in Scient. Amer., v. 194: 120-122, 124, 126, 128-130, May 1956.

A review is presented of developments in the detection, study, and analysis of heart sounds. Special emphasis is placed on the new approach made possible by spectral phonocardiography. A number of examples are given to illustrate the possibilities of this latest advance in the field.

JHU. 10:012

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

A PHASE FILTER APPLIED TO SPECTRAL PHONOCARDIOGRAPHY, by F. H. Middleton, G. E. Gilbert and others. [1956] [9]p. incl. illus. diagrs. [AF 18(600)1040] Unclassified

Presented at IRE Instrumentation Conference and Exhibit, Atlanta, Ga., Nov. 28-30, 1955.

Published in I.R.E. Trans. of Professional Group on Instrumentation, v. I-5: 122-130, June 1956.

Spectral phonocardiography is the name applied to the process of analyzing heart sounds to provide a frequency-amplitude-time display. A segment of heart sound is recorded on a magnetic medium and then repeatedly analyzed by a heterodyne filter system. Because the bandwidth of a conventional filter determines both the frequency and the time resolution, a difficulty arises in that the selection of a wideband filter to obtain adequate time resolution leads to a poor frequency resolution and vice-versa. By making use of the fact that the phase-frequency characteristic of a filter is changing at resonance whereas its amplitude response is not, it is possible to obtain both good time and frequency resolution

at the expense of amplitude information. This paper describes the application of this principle to the design of a phase filter and shows that it produces an analysis having some of the features of the sense of hearing. The design, construction, and operation of the phase filter for this application are described. Included are several sets of sonograms comparing results obtained with the conventional filter and with the phase filter. Suggested changes that could be incorporated in subsequent models are discussed. (Contractor's summary)

JHU. 10:013

Johns Hopkins U. [Dept. of Medicine] Baltimore, Md.

INSTRUMENTATION FOR SPECTRAL PHONOCARDIOGRAPHY, by G. N. Webb and V. A. McKusick. [1956] [13]p. incl. illus. diagrs. [AF 18(600)1040] Unclassified

Presented at the WESCON IRE Convention, San Francisco, Calif., Aug. 25, 1955.

Published in I.R.E. Trans. of Professional Group on Medical Electronics, v. ME-5: 23-35, July 1956.

The development stages of the instrumentation system for displaying the three dimensions of heart sounds, time, frequency, and intensity are described. The heart sounds and physiological data are recorded on magnetic tape. The tape information is repetitively played back, filtered, and presented as intensity modulation on cathode-ray tubes having a slot TV type raster where the horizontal sweep represents time in the cardiac cycle and the vertical represents frequency. The resulting patterns which are photographed and visually monitored are used for research, teaching, and diagnosis. (Contractor's summary)

JHU. 10:014

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

SPECTRAL PHONOCARDIOGRAPHIC STUDIES IN CONGENITAL HEART DISEASE, by V. A. McKusick, O. N. Massengale, Jr. and others. [1956] [14]p. incl. illus. diagrs. refs. [AF 18(600)1040] Unclassified

Published in Brit. Heart Jour., v. 18: 403-416, July 1956.

The spectral phonocardiographic patterns in thoracic A-V fistula (exemplified by patent ductus arteriosus), in pulmonary stenosis, and in atrial septal defect are sufficiently distinctive to suggest the diagnosis from examination of the sound recordings alone. The pulmonary reversal snap of valvular pulmonary stenosis is highly diagnostic, particularly when combined with a murmur of the typical ejection stenosis type. Most reported cases of congenital mitral stenosis have not had completely typical auscultatory findings in terms of the experience with rheumatic mitral stenosis. A case is presented, however, in which typical ausculatory findings, including mitral opening snap, did occur. Such cases might be particularly favorable for valvotomy. Some features of the heart sounds in primary pulmonary hypertension have been demonstrated. (Contractor's summary)

JHU. 11:001

Johns Hopkins U. Dept. of Medicine, Baltimore, Md.

DYNAMIC COMPARISON OF CURRENT BALLISTOCARDIOGRAPHIC METHODS. PART I. ARTEFACTS IN THE DYNAMICALLY SIMPLE BALLISTOCARDIOGRAPHIC METHODS. II. EFFECT OF A PLATFORM IN BALLISTOCARDIOGRAPHIC DYNAMICS. PART III. DERIVATION OF CARDIOVASCULAR FORCE FROM BODY MOTIONS, by S. A. Talbot and W. K. Harrison, Jr. [1955] [36]p. incl. illus. diagrs. refs. [AFOSR-TN-56-439] (Sponsored jointly by [Air Force Office of Scientific Research] under AF 18(600)1107) and Public Health Service) AD 96782 Unclassified

Also published in Circulation, v. 12; 577-587; 845-857; 1022-1033, Oct.-Dec. 1955.

This study on ballistocardiography, the science concerning the dynamics (forces, momenta, and motions) of particular cardiovascular mechanisms (heart, great vessels) as deduced from the recorded motion of the body, is presented in 3 parts. In Part I, the nature and magnitude of force artefacts in the ballistocardiogram (BCG) arising from coupling the body to ground is considered. The effect of this grounding on the reading of cardiovascular motion, momentum, and force is explained, using the simple 1-mass dynamics in which the platform effect is negligible or absent. Part II deals with the effects on the BCG of a second mass, a platform supporting the body. The body itself is a cutoff filter of the resonant type because of its springy supporting tissues which couple the body and the platform masses. In the displacement BCG, this attenuated the upper frequencies recorded from stiffly sprung platforms, or from the direct body, whatever its coupling to earth. In the acceleration record, the body mass and spring cut off the lower ballistocardiographic frequencies, while platform mass and spring cut off the higher frequencies. The magnitude of these errors and their bearing on multilateral recording are discussed. In Part III, the validity of the standard assumptions of ballistocardiography, employed in Parts I and II, is examined. Using ballistocardiographic data taken with and without beds, and subtracting the effects of the supports, it is shown that mechanical errors still remain. Constraints to ground as stiff as the direct-body and Starr supports seem to result in more errors of body complexity than do the softer supports of Nickerson, Burger, or von Wittern, beyond the obvious resonance distortions.

JHU. 12:001 - JHU. 14:002

JHU. 12:001

Johns Hopkins U. [Dept. of Physics] Baltimore, Md.

TRANSIENT BEHAVIOR FOLLOWING BREAKDOWN AND ITS RELATION TO AFTERGLOW PROCESSES (Abstract), by D. E. Kerr and E. F. Tubbs. [1955] [1]p. [AF 18(600)363] Unclassified

Presented at meeting of the Amer. Phys. Soc., Schenectady, N. Y., Oct. 20-22, 1955.

Published in Phys. Rev., v. 100: 1231, Nov. 15, 1955.

Following application of a pulse of microwave power to form a helium discharge in a resonant cavity, there is a period of about one millisecond which is characterized by a transient behavior of both emitted light and rf properties, particularly transmitted power. In general, atomic radiation first rises sharply, then undergoes quasi-oscillatory behavior in approaching a stationary value. During the pulse, molecular radiation is generally weak but rises many-fold at the end of the pulse. Detailed measurements of certain transitions show atomic light falling abruptly in the afterglow; but molecular light rises sharply then falls more slowly. The radiation is usually characterized by more than one time constant, the larger one being markedly dependent upon pulse length and pressure. The abrupt rise of molecular radiation at the end of the breakdown pulse is strongly dependent upon the pulse length. Consequently the relative predominance of molecular or atomic radiation can be controlled by pulse length. This fact casts doubt on interpretations of afterglow mechanisms which depend upon predominance of either type of spectrum. Other rare gases are under study.

JHU. 13:001

Johns Hopkins U. Dept. of Physics, Baltimore, Md.

BOSON FAMILY FROM QUANTIZED FINITE-PARTICLE MAXWELL THEORY, by R. [L.] Ingraham and J. Ford Aug. 28, 1956; rev. Dec. 13, 1956 [12]p. incl. diagr. refs. (AF 18(603)143) Unclassified

Published in Phys. Rev., v. 106: 1324-1335, June 15, 1957.

Quantization of finite-particle Maxwell theory yields a family of free bosons of nonzero masses and spins 1 and 0. The existence of a mass spectrum is a direct consequence of the new degree of freedom of particle size. These are quanta of short-range (meson) forces. The force-free theory (i.e., uncoupled to a fermion field) is studied here as a preliminary to the coupled case. An automatic connection with the Pauli-Villars regulator theory is obtained. The nature and position of the singularities in the field commutators of quantum electrodynamics and meson theory is profoundly altered. (Contractor's abstract)

JHU. 14:001

Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.

THE INTERACTION OF GRIDS WITH TRAVELLING SHOCK WAVES, by D. C. Dosanjh. Dec. 1953, 29p. illus. refs. ([AF]OSR-TN-54-58) (AF 18(600)757) AD 26941 Unclassified

Experimental equipment used in the study included a shock tube, triggering and timing, grids, and their mounting, hot wire apparatus, and a shadowgraph arrangement. The shock tube consists of a steel box of uniform cross section (about 6 x 4 in. inside) which is divided into 2 chambers by a diaphragm that sustains a pressure differential between them. The total tube length is 29 ft. The grids (1/4-in. thick perforated steel plate with sharp edged holes) were mounted between 2 glass sections to permit the recording of shadowgraphs of the transmitted and/or reflected shocks and the associated turbulent flow. The speeds of incident, transmitted, and reflected shock waves were measured, and the pressure drop coefficient (defined on the basis of the pressure far upstream and the pressure far downstream from the location of the grid) was calculated. The drift flow behind the reflected shock was turbulent after its passage through the grid. The interaction of this turbulent region with the reflected-transmitted shock wave was optically observed. The investigation showed that the combined use of the shadowgraph and the hot wire anemometer was a reliable technique for studying the transient flow fields associated with the interaction of a traveling shock wave and grids mounted in its path.

JHU. 14:002

Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.

USE OF THE HOT-WIRE ANEMOMETER AS A TRIGGERING DEVICE FOR WAVE PHENOMENA IN A SHOCK TUBE, by D. S. Dosanjh. Dec. 15, 1953; rev. Aug. 23, 1954 [6]p. incl. illus. diagrs. refs. (AF 18-(600)757) Unclassified

Published in Rev. Scient. Instruments, v. 26: 65-70, Jan. 1955.

The hot-wire anemometer is principally used for turbulence investigations in both subsonic and supersonic flows. Its use has been extended to the observation of transient phenomena in shock tubes. Since its sensitivity to different phenomena varies, depending upon the operating conditions, the hot wire is quite well suited for timing very weak as well as strong traveling shock waves. A triggering and timing arrangement was developed pointing to further improvement. It was found that the hot-wire trigger is a reliable instrument under widely varying shock tube operations. (Contractor's abstract)

JHU. 15:001

Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.

GRAIN BOUNDARY MIGRATION IN ALUMINUM BICRYSTALS, by. K. T. Aust, E. H. Harrtson and others. July 31, 1955 [13]p. tncl. illus. dtagrs. table, refs. [AFOSR-TN-55-226] (Bound with tts technical rept. no. 6 (Ftnal) as Part I; AD 74873; [AF]OSR-TN-55-19) (AF 18(600)1012) AD 74873(a) Unclasstfied

Investtgatton was made to determine the effect of orientation dtfference and temperature on boundary migration tn stratn-free Al btcrystals, where the drtving force results from the reduction of boundary area. Tests were conducted with Al bicrystals havtng 2 different shapes: (1) V-shaped btcrystals in which the boundary was expected to move on annealtng in a direction toward the tip of the V, owing to a reductton of the boundary area; and (2) specimens in which the radius of curvature of the moving boundary is kept constant. No evidence of boundary migration was found tn the V-shaped bicrystals after annealing at temperatures up to 640°C for 90 hr. The grain boundary tn the second-type crystal was observed to mtgrate toward the center of curvature of the curved portton of the boundary. Boundary migration proceeded tn a step-like or discontinuous manner during a stngle annealtng cycle. Uniform boundary migration was plotted as a function of tsothermal annealtng at 640°, 600°, and 560°C for btcrystals having orientation dtfferences (θ) of 55° and 85° about a [110] specimen axts direction. It was apparent that a boundary separating crystals with θ = 85° migrated at a faster rate and wtth a smaller activation energy than a boundary with θ = 55°. The difference tn activatton energy for gratn boundary mtgration between bicrystals wtth θ = 55° and 85° was 22 ± 3 and 10 ± 3 kcal/g-atom, respectively. (ASTIA abstract)

JHU. 15:002

Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.

RESEARCH ON GRAIN BOUNDARIES. PART I. GRAIN BOUNDARY MIGRATION IN ALUMINUM BICRYSTALS. PART II. INTERFACIAL ENERGIES OF SYMMETRICAL TILT CRYSTAL BOUNDARIES IN SILVER. PART III. SHEAR ALONG GRAIN BOUNDARIES IN ALUMINUM BICRYSTALS AT ELEVATED TEMPERATURES, by K. T. Aust, E. H. Harrison and others. July 31, 1955 [34]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 6 (Final)) ([AF]OSR-TR-55-19) (AF 18(600) 1012) AD 74873(a), (b), and (c) Unclassified

Part II. The relative energy (γ_R) of symmetrical tilt boundaries in high purity silver crystals was determined for a series of different orientations, θ. It is shown that the boundary energy depends upon the orientation of the boundary. The results are in agreement with the dislocation model of the grain boundary. Part III. Preliminary research on shear along tilt grain boundaries in aluminum crystals is presented. It ts shown that at 400°C, the boundary durtng tnitial loadtng wtll undergo a pure shear that ts followed by boundary mtgration. (For Part I see ttem no. JHU. 15:001.)

JHU. 15:003

Johns Hopkins U. [Inst. for Cooperative Research] Baltimore, Md.

RELATIVE INTERFACIAL ENERGIES OF SYMMETRICAL TILT GRAIN BOUNDARIES IN SILVER, by K. T. Aust. [Jan. 3, 1956] [4]p. incl. illus. dtagrs. table, refs. [AF 18(600)1012] Unclassified

Published in Jour. Metals, v. 8: 1026-1029, Aug. 1956.

The relative interfacial energies of symmetrtcal tilt boundartes tn sttver of greater than 99.999% purity were measured as a function of ortentation difference θ between 9° and 36° about < 001 >. The results are tn good agreement with the dtslocation model of the grain boundary. The energy vs θ curve may be represented by the Shockley and Read equation in the form $E_o\theta$ (0.55 − In θ). (Contractor's abstract)

JHU. 16:001

Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.

CALIBRATION AND PERFORMANCE OF AN AEROSOL GENERATION SYSTEM, by J. F. Skrtvan and H. E. Hoetscher. Apr. 1956, 50p. tncl. ittus. diagrs. tables. (Technical note no. 1) (AFOSR-TN-56-135) (AF 18-(600)1176) AD 86011 Unclasstfied

The performance of an aerosol generation system has been studied wtth regard to particle stze and mass concentration, wtth particular emphasts on the latter phase. The aerosol generator used in the research was constructed following the design of Sinclair and Lamar. A photometer of commercial manufacture was calibrated with respect to the mass concentration of aerosol passing through it. Calibration curves were obtained for silicone oil and Esso motor oil and the slopes were the same for both. Using the caltbration curves, the vartables of the system were studied with respect to thetr tnfluence on mass concentration. The most important parameter of the system was the temperature of the liquid from whtch the aerosol is produced. Curves showing the effects of other variables are also presented. (Contractor's abstract)

JHU. 16:002

Johns Hopkins U. [Inst. for Cooperative Research] Baltimore, Md.

FLAME STUDIES IN A FLAT FLAME BURNER, by

JHU. 17:001 - JHU. 19:002

W. T. Biedler, III and H. E. Hoelscher. June 1956, 1v. incl. illus. diagrs. tables, refs. (Technical note no. 2) [AFOSR-TN-56-265] (AF 18(600)1176) AD 88985 Unclassified

A new type of device for measuring flame velocities has been developed. This device is a burner utilizing a stable planar flame front which permits the study of stable flat flames, free from contact with any surface. Flame velocity as a function of concentration of combustible in the unburnt mixture has been determined for an air-propane system. The effect of the geomctry of the system on flame properties is observed and discussed. Temperature and concentration measurements were made in the vicinity of the flame and are reported. (Contractor's abstract)

JHU. 17:001

Johns Hopkins U. [Inst. for Cooperative Research] Baltimore, Md.

OBSERVATIONS ON GRAIN-BOUNDARY MIGRATION IN ALUMINUM BICRYSTALS, by K. T. Aust, E. H. Harrison, and R. Maddin. [1956-57] [2]p. incl. diagrs. [AF 18(600)1587] Unclassified

Published in Jour. Inst. Metals, v. 85: 15-16, 1956-57.

The experimental technique suggested by Dunn, Daniels, and Bolton (Trans. Amer. Inst. Min. Met. Eng., v. 185: 708, 1949) for studying grain-boundary migration is shown to have considerable merit. The rates of grain-boundary migration have been measured at temperatures of 560°, 600°, and 640°C for strain-free bicrystals of aluminum having orientation differences of 55° and 85° about <110>. Activation energies of 43 and 20 kg cal/g-atom, respectively, were calculated from these data.

JHU. 18:001

Johns Hopkins U. Lab. of Astrophysics and Physical Meteorology, Baltimore, Md.

INTERFEROMETRY FOR THE FAR INFRARED, by J. Strong. [1956] [4]p. incl. diagrs. refs. [AF 18-(600)1307] Unclassified

Presented at meeting of the Opt. Soc. Amer., Lake Placid, N. Y., Oct. 18-20, 1956.

Published in Jour. Opt. Soc. Amer., v. 47: 354-357, May 1957.

This paper describes the current effort aimed to apply new interferometric procedures to far infrared spectroscopy, out to millimeter waves; and describes the beginnings of plans to use interferometry in a telescope above atmospheric absorption. (Contractor's summary)

JHU. 19:001

Johns Hopkins U. Lab. of Astrophysics and Physical Meteorology, Baltimore, Md.

STRUCTURE OF PERCHLORYFLUORIDE FROM HIGH RESOLUTION INFRARED SPECTRA, by R. P. Madden and W. S. Benedict. July 1956 [2]p. (AFOSR-TN-56-289) (AF 18(600)1557) AD 89500 Unclassified

Published in Jour. Chem. Phys., v. 25: 594-595, Sept. 1956.

The infrared spectrum of perchloryfluoride was examined between 525-625 cm^{-1} with an effective optical slit width of 0.11 cm^{-1}. Fine structure characteristic of a symmetric-top molecule was resolved in the parallel band ν_3 and the perpendicular band ν_5, confirming the structures and assignments made from the lower-resolution results.

JHU. 19:002

Johns Hopkins U. Lab. of Astrophysics and Physical Meteorology, Baltimore, Md.

IDENTIFICATION OF H_2O^{18} AND H_2O^{17} TELLURIC LINES IN THE INFRARED SOLAR SPECTRUM, by W. S. Benedict. [July 1956] [15]p. incl. diagrs. tables, refs. [AFOSR-TN-56-306] AD 90020 Unclassified

Presented at the Seventh International Congress on Astrophysics, Liège (Belgium), July 12-14, 1956.

Also published in Mém. Soc. Roy. Sci. Liège, 4th Series, v. 18: 556-571, 1957.

Abstract published in Mém. Soc. Roy. Sci. Liège, 4th Series, v. 18: 41, 1957.

In the solar spectra observed at the Jungfraujoch there are a number of weak telluric lines, varying with the water-vapor content, that cannot be interpreted as transitions between the known energy levels of H_2O^{16}. Fourteen such lines on the pure-rotation band (420-580 cm^{-1}) and more than 20 in the wings of the 6-μ band (1170-1445 and 1800-2053 cm^{-1}) have been identified as resulting from H_2O^{18}. In all cases where the line of H_2O^{16} is sufficiently strong, a satellite H_2O^{18} line either appears at the calculated frequency shift (which ranges from +1 to -11 cm^{-1}), or else is overlapped. In about 10 favorable cases, the line resulting from H_2O^{17} may be located halfway between the H_2O^{16} and H_2O^{18}. The relative intensities appear to be in agreement with normal isotopic abundances. (Contractor's abstract)

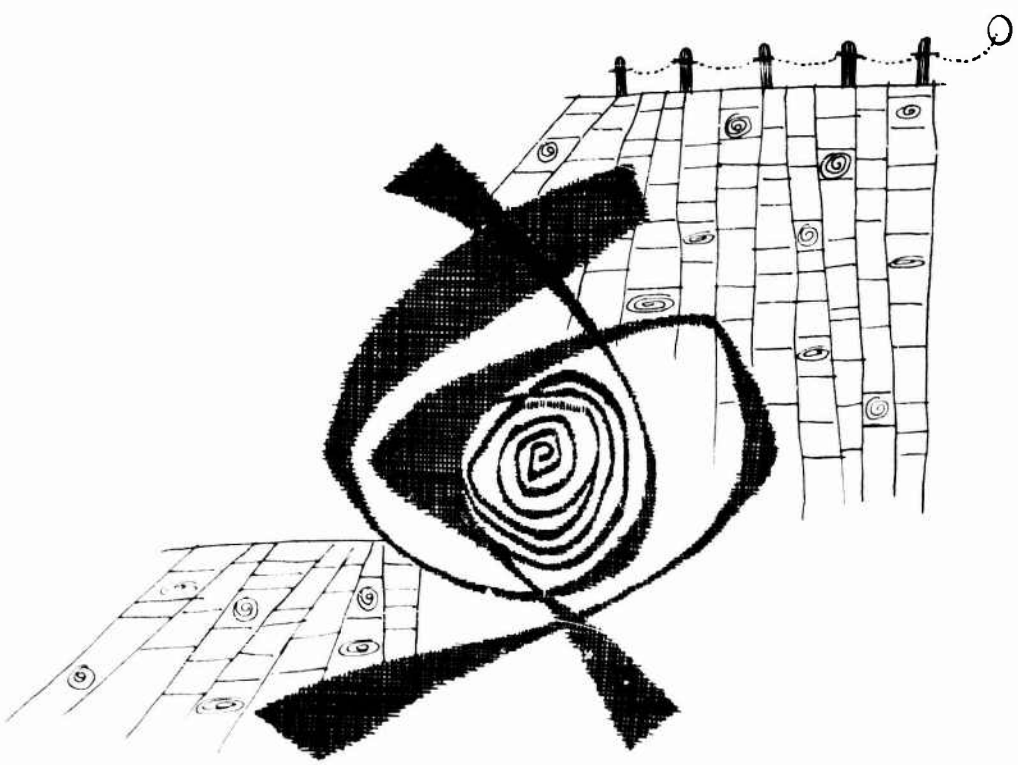
JHU. 19:003

Johns Hopkins U. Lab. of Astrophysics and Physical Meteorology, Baltimore Md.

INTERACTION OF STRETCHING VIBRATIONS AND INVERSION IN AMMONIA, by W. D. Benedict and E. K. Plyler. April 1956 [1]p. incl. tables. [AF 18-(600)1557] Unclassified

Published in Jour. Chem. Phys., v. 24: 904, Apr. 1956.

The effects of the inversion doubling of the energy levels of NH_3 have been accurately studied in the microwave region and in the fundamental and higher states of v_2, but little is known about the interactions of the other modes of vibration with the inversion. The purpose of this investigation was to study the absorption of NH_3, in the region from 2.15 - 2.47μ (4050-4720 cm^{-1}), with an effective resolution of 0.15 cm^{-1}. About 1000 lines were measured and all but the weakest were analyzed. Values of the molecular constants, ignoring the higher-order effects, are presented. Comparison is made between the energy-level differences due to inversion-doubling observed in the combination bands and those in the v_2 fundamental.



KAN. 01:001 - KAN. 01:006

KAN. 01:001

Kansas U. Dept. of Mathematics, Lawrence.

THEORY OF CAPACITIES, by G. Choquet. May 1954 179p. incl. refs. (Technical note no. 1) ([AF]OSR-TN-54-120) (AF 18(600)959) AD 35285 Unclasstfied

The theory of capacities is developed from a consideration of whether or not the interior Newtonian capactty of an arbitrary Boreltan subset X of the space R^3 is equal to the exterior Newtonian capactty of X. The theory is analogous to the classical theory of measurability and deals prtncipalty with nonaddttive set functions defined on arbttrary Hausdorff spaces. The theory ts developed under the following toptcs: (1) Boreltan and analytic sets in topological spaces; (2) Newtonian and Greenian capactties; (3) alternating and monotone functions (capacities); (4) the extension and reetrictton of a capactty; (5) operations on capactties and examples of capactties; (6) capacitability (fundamental theorems); and (7) extremal elements of convex cones and integral representations (applications).

KAN. 01:002

Kansas U. Dept. of Mathematics, Lawrence.

CONTRIBUTIONS TO POTENTIAL THEORY, by M. Brelot. Technical note no. 2. Feb. 1955, 149p. (Rept. no. KU-AF-TN2) ([AF]OSR-54-357) (In cooperation wtth Paris U. (France)) (AF 18(600)959) AD 52489 Unclassified

The following subjects are treated: (1) study and extensions of the Dtrichlet principle; (2) existence theorem for n capactties; (3) a new proof of the fundamental theorem of Kellog-Evans on the set of trregultr potnts tn the Dirtchlet problem; (4) the behavtor of harmonic functions in the netghborhood of an irregutar boundary point; and (5) assoctated funcitons and measures. (ASTIA abstract)

KAN. 01:003

Kansas U. Dept. of Mathematics, Lawrence.

STUDY AND EXTENSIONS OF THE DIRICHLET PRINCIPLE, by M. Brelot. [1954] 87p. incl. refs. ([Part 1] of tts Technical note no. 2; AD 52489) [AFOSR-TN-54-357(a)] [AF 18(600)959] AD 52489(a) Unclassified

Consideration is gtven to varieties more general than Euclidean domatns; these include Riemann surfaces (S_2-spaces) and analogous varietes with dimension number $n \geq 2$, but where the conditton of the existence of a Green's function is satisfted. In such a space, the approximating spheres of Bochner and their radii are replaced by the loci of G_p = constant and their orthogonal trajectories, respectively. Certain limit or radial functions can then be defined wtthout using any boundary. The Dirichlet prtnctple is interpreted by means of the projection of the origin on the set of the precised Beppo Levt functions introduced by Deny (Acta Math., v. 82: 107-183, 1950) which have the same radial as f, where the functions f are real-valued, finite, and continuous wtth ftnite, continuous, square summable gradient. (ASTIA abstract)

KAN. 01:004

Kansas U. Dept. of Mathematics, Lawrence.

EXISTENCE THEOREM FOR n CAPACITIES, by M. Brelot. [1954] [13]p. ([Part 2] of tts Technical note no. 2; AD 52489) [AFOSR-TN-54-357(b)] [AF 18(600)959] AD 52489(b) Unclassified

A proof is presented that given a positive integer N, and $\varepsilon > 0$, there exist in the Green's space, ε_0, N mutually disjotnt compact sets, each of capacity 1, such that the capactty of thetr union differs from N by less than ε, and these compact sets may even be chosen to be simple. This result can be extended to the statement that it is posstble to form a sequence of compacts K_n (even simple compact sets) each of capactty 1, with the property that gtven $\varepsilon > 0$, there exists an index n_0 such that the union of any number N of compact sets of the sequence wtth tndices greater than n_0 is a compact set of capacity lytng between N and $(N-N\varepsilon)$, or even between N and $N-\varepsilon$.

KAN. 01:005

Kansas U. Dept. of Mathematics, Lawrence.

A NEW PROOF OF THE FUNDAMENTAL THEOREM OF KELLOG-EVANS ON THE SET OF IRREGULAR POINTS IN THE DIRICHLET PROBLEM, by M. Brelot. [1954] [18]p. ([Part 3] of tts Technical note no. 2; AD 52489) [AFOSR-TN-357(c)] [AF 18(600)959] AD 52489(c) Unctassified

An independent and elementary proof is given that the set of trregular potnts ts a set such that any compact subset has a zero capacity. This is equivalent to the statement that a bounded harmonic function in a given bounded Euclidean domain is determined by tts limits at the regular points.

KAN. 01:006

Kansas U. Dept. of Mathematics, Lawrence.

ON THE BEHAVIOR OF HARMONIC FUNCTIONS IN THE NEIGHBORHOOD OF AN IRREGULAR BOUNDARY POINT, by M. Brelot. [1954] [22]p. ([Part 4] of tts Technical note no. 2; AD 52489) [AFOSR-TN-357(d)] [AF 18(600)959] AD 52489(d) Unclasstfied

Also published in Jour. Analyse Math. (Jerusalem), v. 4: 209-22t, t955/56.

The main results are given in 2 theorems. Theorem 1: Let Q be an irregular boundary point of a bounded Euclidean domain. (More generally, it may be supposed that Ω is a Greenian domain in a ξ-space, and that Q is an irregular boundary point different from A and from a point at infinity). Let u be a bounded harmonic function on Ω in a neighborhood of Q. It is supposed that u vanishes at every regular boundary point of Ω which is close enough to Q. Then $u(M_n)/G_{P_0}(M_n)$ tends to a limit independent of the sequence $M_n \longrightarrow Q$ when this sequence is completely irregular. This limit is the quotient of the pseudo-limits at Q of u and G_{P_0}, where G_{P_0} is the Green function. Theorem 2: Let Ω and Q be as in theorem 1 and let u be any bounded harmonic function on Ω in a neighborhood of Q. Then for any maximal sequence $M_n \longrightarrow Q(M_n \varepsilon \Omega)$, $u(M_n)$ tends to the pseudo-limit λ of u at Q.

KAN. 01:007

Kansas U. Dept. of Mathematics, Lawrence.

ON ASSOCIATED FUNCTIONS AND MEASUREMENTS, by M. Brelot. [1954] [8] p. ([Part 5] of its Technical note no. 2; AD 52489) [AFOSR-TN-54-357(e)] [AF 18(600)959] AD 52489(e) Unclassified

The detailed development of Choquet and Deny (Bull. de la soc. math. de France, v. 72: 118-140, 1944) on the properties of means in the Euclidean space R^τ, $\tau = 2$, is extended to the general R^τ space by the use of a new property of Laplace functions. This property provides that for any integer n, a system of independent homogeneous harmonic polynomials H_n of degree n (or the Laplace functions Y_n on the unit sphere) may be deduced by suitable rotations around the origin from a single arbitrary function not identically zero of this kind. (ASTIA abstract)

KAR. 01:001

Karolinska Inst. Dept. of Medical Physics, Stockholm (Sweden).

BIOPHYSICS OF BONE, by A. Engström. Technical note Oct. 1, 1955-Sept. 30, 1956. Oct. 31, 1956, 8p. incl. diagrs. (AF 61(514)861) Unclassified

Techniques have been developed for microradiography at high resolutions of thin biological specimens. Cameras utilizing monochromatic and polychromatic ultrasoft x-rays are described. Equipment for low angle x-ray diffraction studies of biological material with monochromatic x-rays is described. The techniques mentioned have been applied to the study of biophysics of bone. (Contractor's abstract)

KOF. 01.001

Koflink, W., Karlsruhe (Germany).

TABLES OF ALL IMPORTANT PARAMETERS CONCERNING THE BIFURCATED COMPRESSION SHOCKS IN A STEADY PLANE FLOW OF AIR, by W. Koflink. [1955] 63p. incl. diagrs. tables. [AFOSR-TR-55-24] (AF 61(514)638-C) AD 84918 Unclassified

The mathematical treatment of a bifurcated compression shock in a plane steady flow of an ideal gas with fixed quotient $\Upsilon = c_p/c_v$ of the specific heats (at constant pressure and at constant volume) leads to an algebraic equation of sixth degree in a suitable unknown variable. This equation was developed in earlier papers, (W. Koflink, Annalen der Physik, v. 9: 200, 401, 1951; v. 10: 200, 1952; W. Koflink and T. Vollmer, Zeitschrift für angewandte Mathematik und Mechanik, v. 33: 73, 1953). The algebraic equation has been solved for 374 bifurcated compression shocks in air ($\Upsilon = 1,405$), using the electronic computer G1 of the Max-Planck-Institute in Göttingen, Germany. For air, 2 regions of physically interesting solutions exist: Region I extends between the limits $1,190\ 83 \leq \omega_1 \leq 2,436\ 86$ and region II between the limits $1,672\ 33 \leq \omega_1 \leq 2,436\ 86$ of the dimensionless velocity ω_1 of the oncoming flow. (The upper limit is the maximum velocity.) An extensive table is included containing solutions for the 2 regions. (Contractor's abstract, modified)

KUE. 01:001

Kuessner, H. G., Göttingen (Germany).

INVESTIGATION OF THE OSCILLATING ELLIPTIC LIFTING SURFACE IN INCOMPRESSIBLE FLOW, by H. G. Kuessner. Tech. rept. Mar. 15-Dec. 15, 1955, 49p. incl. tables, refs. ([AF]OSR-TR-56-4) (AF 61-(514)819) AD 84464 Unclassified

Analytical solutions were obtained of the aerodynamics of a harmonically oscillating elliptic plate in steady, incompressible, nonviscous flow for flapping, pitching, rolling, and antisymmetric twisting. A new class of Jacobian hyperbolic functions, elliptic functions with complementary modulus, were introduced which permit a purely real representation of all coordinate transformations and potential functions with the same modulus. Lamé polynomials of the first and second kind, which appear in the doubly periodic solutions of Laplace's equation in ellipsoidal coordinates, are calculated up to the fifth order; they are represented by Weierstrassian and Jacobian functions. Additional representations are given in terms of associated Legendre functions. The characteristic functions G and H of the general lifting surface theory of Kuessner (Jour. Aeronaut. Sci., v. 21: 17-26, 1954 and v. 22: 227-230, 1955) were constructed. Two complex functions T_1 and T_2 occur in this theory which depend on integrals over the characteristic functions G and H but which are independent of the coordinates. Three methods of computing T_1 are given: 2 of these depend on the representation of Lamé polynomials of the second kind by associated Legendre functions of the second kind. (ASTIA abstract)

KUE. 02:001

KUE. 02:001

Kuessner, H. G., Göttingen (Germany).

RESEARCH ON THE OSCILLATING ELLIPTIC LIFTING SURFACE IN COMPRESSIBLE FLOW, by H. G. Kuessner. Annual rept. no. 1. Nov. 1, 1956-Oct. 31, 1957, 47p. incl. tables, refs. (AF 61(514)1081)
Unclassified

A survey of the ellipsoidal wave functions was made. The special cases of these functions represented by known auxiliary functions and mathematical tables are given in a form suitable for the Green function of the elliptic lifting surface. For the general case methods of representation by differential equations and by integral equations are discussed. Starting from the general equations of the lifting surface theory the integral representation of the pressure of the oscillating elliptic lifting surface by a given downwash on it was developed and proved. A method for the calculation of the weight functions of the singular part of pressure by an integral equation is given. According to this method the special cases of infinite aspect ratio and of the circular lifting surface were treated. Numerical values of the weight functions and of the aerodynamic derivatives were calculated for a bilinear downwash distribution and for steady flow. (Contractor's abstract, modified)

Laboratotre Mèdtterranèen de Recherches Thermodynamtques, Ntce (France). <u>see</u> Mèdtterranèen de Recherches Thermodynamtques, Ntce (France).

LAV. 01:001

Laval U. Depl. cf Chemtstry, Quebec (Canada).

HYDROGEN PEROXIDE: THE LOW TEMPERATURE HEAT CAPACITY OF THE SOLID AND THE THIRD LAW ENTROPY, by P. A. Giguère, I. D. Liu and others. [1954] [12]p. incl. diagrs. tables, refs. [AF 18(600)492] Unclassified

<u>Published in</u> Canad. Jour. Chem., v. 32: 117-128, Feb. 1954.

The heat capactty of crystalltne hydrogen peroxide between 12°K and the melting point has been determtned wtth a low temperature adiabatic calorimeter. The heat of fuston was also measured and found to be 2987 ± 3 cal/mole. The two samples of hydrogen peroxide used were 99.97 mote % pure as deduced from behavtor on melting and from premelting heat capacitles; the triple potnt was estimated to be 272.74°K. The only anomaly observed in the heat capactty measurements was the absorption of 1.3 cal/mole at 216.8 ± 0.15°K, the lower eutectic temperature of H_2O-H_2O_2 solutions. Such an effect is to be expected if the only stgntfttcant tmpurity ts water. The entropy of hydrogen peroxide as an ideal gas at 1 atm pressure and 25°C computed from the thermal measurements is 55.76 ± 0.12 cal/mole deg. Comparison of this datum wtth the recalculated statistical entropy leads to a value of 3.5 kcal/mole for the height of a hypothettcal stngle barrter hindertng internal rotation tn the molecule. From these results it ts concluded that hydrogen peroxide does not constst of two tautomeric modiftcations. (Contractor's abstract)

LAV. 01:002

Laval U. Dept. of Chemtstry, Quebec (Canada).

POLAROGRAPHY WITH A DROPPING GALLIUM ELECTRODE, by P. A. Giguère and D. Lamontagne. [1954] [2]p. tncl. diagrs. table. [AF 18(600)492] Unclassified

<u>Published in</u> Science, v. 120: 390-391, Sept. 3, 1954.

An oxide coating prevented gattium from wetttng glass. The dropping Ga electrode was erratic, especially with regard to dropping rate, which could not be reproduced from one run to another. The drops were about 5 ttmes targer than Hg drops from the same capillary, and the current intensity was proportionally higher. A current-voltage curve obtained with air-saturated 0.1N KCl showed that the potential of the dropping Ga electrode was -1.0v vs the saturated calomel electrode. A wave with half-wave potential of -1.26v corresponded to the reduction of gatlic tons produced from the metal by dissolved O; this was the half-wave potential of gatlic tons at a dropping Hg etectrode; the wave potential of gallic tons at a dropptng Hg electrode; the wave dtsappeared in an oxygen-free solution. H_2 was evolved at -1.6v. No altempt was made to study the reduction of other metal tons. (C.A., 1955:1443h)

LAV. 01:003

Lavat U. [Dept. of Chemtstry] Quebec (Canada).

[PROPERTIES AND STRUCTURES OF HYDROGEN PEROXIDE AND OF DEUTERIUM PEROXIDE] Propriétés et structures des peroxydes d'hydrogène et de deuterium, by P. A. Giguère [1954] [3]p. incl. diagrs. table, refs. (AF 18(600)492) Unclassified

<u>Pubttshed in</u> Bull. Soc. Chim. (France), v. 63: 720-723, June 1954.

A revtew ts presented in the form of an address to the French Chemtcal Society. A total of 18 references of international scope are ctted rangtng in time from 1931-1954.

LAV. 01:004

Laval U. [Dept. of Chemtstry] Quebec (Canada).

[SPECTROSCOPIC STUDY OF DISSOCIATED WATER VAPOR] Étude spectroscopique d'un isomère du peroxyde d'hydrogène, by P. A. Gtguère and E. A. Secco. [1954] [3]p. incl. dtagrs. table, refs. (AF 18(600)492) Unclasstfted

<u>Published in</u> Jour. Phys. et Radtum (Paris), v. 15: 508-510, June 1954.

During the preparation of peroxtde from etther D_2O or H_2O vapor dtssoctated tn an electrodeless discharge, a glassy depostt varying tn color from ltght yellow to dark brown is formed in a ltquid-air trap. This material was studted spectroscoptcally. Besides the well-known bands of tce and solid peroxtde, a few others were observed, particularly a strong, sharp one at 1305 cm^{-1}. This was first attributed to an isomertc molecule, H_2O-O. Further studies indicated that the molecule should have the O-O vibration at approximately 880 cm^{-1}, the same regton as in the normal H_2O_2 molecule. It does not appear possible to establish the presence of an isomer of H_2O_2 on the basis of the avattable spectroscoptc evidence. (C.A., 1957:5554a)

LAV. 01:005

Laval U. [Dept. of Chemtstry] Quebec (Canada).

RECOMMENDED VALUES FOR THE THERMODYNAMIC PROPERTIES OF HYDROGEN AND DEUTERIUM PEROXIDES, by P. A. Giguère and I. D. Liu. June 1955 [14 p. incl. diagrs. tables, refs. (Technical note no. 1) ([AF, OSR-TN-55-205) (AF 18(600)492) AD 76157 Unclassified

LAV. 01:006 - LAV. 01:008

Also published in Jour. Amer. Chem. Soc., v. 77: 6477-6479, Dec. 20, 1955.

Recent spectroscopic and calorimetric data on H_2O_2 have been used to re-calculate the thermodynamic functions of this compound. The contribution of the internal rotation mode was estimated using the potential barrier height obtained from the third law entropy value. Similar calculations were carried out for the isotopic molecules D_2O_2 and HDO_2. Various derived thermodynamic quantities of peroxide molecules are tabulated for convenience. From these the dissociation energy D_{HO-OH} is found to be 51 kcal. (Contractor's abstract)

LAV. 01:006

Laval U. Dept. of Chemistry, Quebec (Canada).

PRESSURE TRANSDUCERS AS RECORDING MANOMETERS IN CHEMICAL KINETICS, by P. A. Giguère and I. D. Liu. Dec. 1955 [9]p. incl. diagrs. tables. (Technical note no. 2) ([AF]OSR-TN-55-383) (AF 18(600)492) AD 83048 Unclassified

Pressure transducers of the "unbounded strain gage" type (made by Statham Laboratories, Los Angeles, Calif.) are suitable as recording manometers for studying the kinetics of gaseous reactions. Their accuracy and linearity are within ± 1% of full scale and their resolution is better than 0.1%. The output (20 to 40 mv) is sufficient to operate directly a recording potentiometer. Models are available in full-scale ranges from 2.5 mm Hg up to several atmospheres. They may be operated at temperatures from -50° to 120°C and can withstand mildly corrosive gases and vapors. Brief mention is made of certain precautions which are required when the transducers are used as absolute manometers. (Contractor's abstract, modified)

LAV. 01:007

Laval U. Dept. of Chemistry, Quebec (Canada).

HYDROGEN PEROXIDE AND ITS ANALOGUES. VI. INFRARED SPECTRA OF H_2O_2, D_2O_2, AND HDO_2, by O. Bain and P. A. Giguère. [1955] [29]p. incl. diagrs. tables, refs. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 33: 527-545, Mar. 1955.

The absorption spectrum of hydrogen peroxide was re-examined with a prism instrument in the region 1.5 to 25 μ. A pair of well-resolved perpendicular bands arising from torsional oscillation of the OH groups were found centered about 460 and 575 cm^{-1}. The overtone band at 3.8 μ was shown to be a hybrid with prominent rotational structure and some indications of doubling. Its assignment to the combination $\nu_2 + \nu_6$ implies a positive anharmonicity. Four new overtone bands were observed in liquid hydrogen peroxide. The infrared spectrum of deuterium peroxide was measured for the first time in the solid and vapor states. The vapor bands are quite different in appearance from those of hydrogen peroxide. One of the fundamentals, the asymmetric O — D stretching at 2661 cm^{-1}, was resolved sufficiently to allow calculation of the rotational constants of the isotopic molecule. Mixtures of the two peroxides containing around 40% of HDO_2 were also investigated; from the results the frequency of the as yet unobserved symmetric modes ν_1 and ν_2 could be estimated with fair certainty. The O — O stretching vibration at 11 μ was too weak to be located definitely in the spectra of the gaseous peroxides. The structural parameters of the H_2O_2 molecule are now established as follows:

$$r_{O-O} = 1.49 \pm 0.01\text{Å}$$

$$r_{O-H} = 0.97 \pm 0.01\text{Å}$$

$$\alpha_{OOH} = 100° \pm 2°$$

The O — H and O — D stretching bands were studied in solutions of the three isotopic peroxides in carbon tetrachloride.

LAV. 01:008

Laval U. Dept. of Chemistry, Quebec (Canada).

HYDROGEN PEROXIDE AND ITS ANALOGUES. VII. CALORIMETRIC PROPERTIES OF THE SYSTEMS H_2O-H_2O_2 AND D_2O-D_2O_2, by P. A. Giguère, B. G. Morissette and others. [1955] [17]p. incl. diagrs. tables, refs. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 33: 804-820, May 1955.

The heat of mixing of hydrogen peroxide and water and the heat of vaporization of the mixtures were measured over a wide concentration range at 0°C with a Bunsen ice calorimeter and at 26.9° with a diphenyl ether calorimeter. The heat capacities of the solutions were determined between these two temperatures. Similar measurements were carried out on the corresponding deuterium compounds. The heat of decomposition of hydrogen peroxide catalyzed by colloidal platinum was also measured at 26.9° as a function of concentration. Correlation of all the results leads to the following recommended values for the thermochemical properties of the pure peroxides in the liquid state at 25°C:

	H_2O_2	D_2O_2
Heat of decomposition (kcal/mole)	23.44 ± 0.02	23.41 ± 0.02
Heat of vaporization (kcal/mole)	12.34 ± 0.03	12.51 ± 0.05
Heat of mixing (cal/mole)	819 ± 2	807 ± 2
Heat capacity (cal/deg mole)	21.35 ± 0.05	22.9 ± 0.1

A number of related functions are given for convenience

in recalculating these quantities to other temperatures. Apart from their practical value the new data are of interest in connection with molecular association and hydrogen bonds. (Contractor's abstract)

LAV. 0I:009

Laval U. Dept. of Chemistry, Quebec (Canada).

ON THE INFRARED ABSORPTION OF WATER AND HEAVY WATER IN CONDENSED STATES, by P. A. Giguère and K. B. Harvey. [1955] [11]p. incl. diagrs. tables, refs. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 34: 798-808, June 1956.

The infrared spectra (from 2 to 30μ) of thin films of H_2O and D_2O were measured at various temperatures between 20° and -180°C. A strong absorption band due to the librational mode of the water molecule has its maximum around 710 cm^{-1} in the liquid. In ice it is shifted to 800 cm^{-1} at -15°C and 850 cm^{-1} at -170°C. The corresponding D_2O bands show the normal isotope shift. Thin films of water pressed between silver chloride plates could not be crystallized even at liquid air temperature as confirmed by their spectra, which were almost identical with those of the liquid. (Contractor's abstract)

LAV. 01:010

Laval U. Dept. of Chemistry, Quebec (Canada).

A 27°C ISOTHERMAL CALORIMETER, by P. A. Giguère, B. G. Morissette, and A. W. Olmos. [1955] [8]p. incl. diagr. tables, refs. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 33: 657-664, Apr. 1955.

The need for a Bunsen-type isothermal calorimeter operating as close as possible to the standard thermochemical reference temperature, 25°C, was fulfilled by means of diphenyl ether (mp 26.9°C) as the working substance. The instrument was calibrated electrically by comparison with the ice calorimeter and the constant was found to be 19.01 ± 0.02 cal/gm of mercury. From this and other known properties of diphenyl ether the density of the solid at the melting point was estimated at 1.188 gm/ml. Check determinations based on the heat of vaporization of water showed ether must first be melted inside by an amount equivalent to the heat to be measured. The calorimeter was operated in a large water-thermostat kept constant to within 0.001°C. With highly purified diphenyl ether there was no noticeable temperature drift during the measurements. Quantities of heat up to 600 cal could be measured with a reproductibility of the order of 0.2%. The new calorimeter is simpler to operate than the ice calorimeter and its sensitivity is more than three times as great. (Contractor's abstract)

LAV. 01:01I

Laval U. Dept. of Chemistry, Quebec (Canada).

KINETICS OF THE THERMAL DECOMPOSITION OF HYDROGEN PEROXIDE VAPOR, by P. A. Giguère and I. D. Liu. July 25, 1956 [27]p. incl. diagrs. tables, refs. (AFOSR-TN-56-397) (AF I8(600)492) AD 96055 Unclassified

Also published in Canad. Jour. Chem., v. 35: 283-293, Apr. 1957.

The kinetics of the thermal decomposition of H_2O_2 vapor were studied by the static method at low pressures (0.2 to 20 mm Hg) over the temperature range 300°-600°C and in specially treated glass vessels. In all cases the reaction was of the first order with respect to time and the final products were H_2O and O_2. Around 400°C the character of the reaction changed gradually from heterogeneous (surface effects, low activation energy) to homogeneous (reproducible rates in various vessels). With initial pressures of about 10 mm Hg the experimental rates from 400° to 500° lead to an apparent activation energy of 43 kcal and a frequency factor of about $10^{10.7}$. After correction for the residual surface decomposition and extrapolation of the rate constants to the high pressure limit k_∞ the rate equation becomes $k = 10^{13} \exp(-48,000/RT) sec^{-1}$ in good agreement with the most recent value for the O-O bond dissociation energy and with the theory of unimolecular reactions. Packing the reaction vessel with glass rods and adding various gases (including NO and propylene) produced no appreciable effect on the gas-phase reaction. Coatings of fused salts (boric oxide, etc.), claimed to be particularly inert, showed much greater activity than passivated glass and sometimes behaved erratically. The rate of decomposition of D_2O_2 was indistinguishable from that of H_2O_2 under comparable conditions. A mechanism is proposed for the homogeneous reaction in which chains play no significant role. (Contractor's abstract)

LAV. 01:012

Laval U. Dept. of Chemistry, Quebec (Canada).

INFRARED SPECTRUM OF SOLID SULFUR DIOXIDE, by P. A. Giguère and M. Falk. [1956] [3]p. incl. diagr. table. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 34: 1833-1835, Dec. 1956.

The spectrum in the range 2-25μ is measured at liquid-air temperature. The symmetric stretching, asymmetric stretching, and bending modes are assigned, respectively, to a band at 1144, a doublet at 1310-1322,

LAV. 01:013 - LEH. 01:002

and a doublet at 528-535 cm^{-1}. Satellttes of these bands are attributed to the isotoptc molecule, $S^{34}O_2$. An overtone at 2287 and a combination band at 2455 cm^{-1} are also found. The doublet splitting ts due to tnteraction of molecular vibrattons wtth those of the crystalline solid. (C.A., 1957:5554a)

LAV. 01:013

Laval U. [Dept. of Chemtstry] Quebec (Canada).

THE LIBRATIONAL FREQUENCY IN WATER AND ICE (Abstract), by P. A. Gtguère and K. B. Harvey. [1956] [1]p. [AF 18(600)492] Unclassified

Presented at Tenth Symposium on Molecular Structure and Spectroscopy, Columbus, Ohio, June 11-15, 1956.

The infrared spectrum of H_2O in condensed states was measured between 2 and 30μ. In the liquid a strong absorption band appears at 710 cm^{-1} due to the restrtcted rotation, or libration, of the H_2O molecule. Upon crystalltzation this band is shifted to 800 cm^{-1} at -15°C and 850 cm^{-1} at -175°C. The correspondtng frequencies in D_2O are at 530, 590 and 630 cm^{-1}. From the frequency of thts mode ν_R it is possible to dtfferenttate between supercooled water and tce. Thus it was found that, under certatn conditions, thin films of water do not crystallize even in ltquid air. The contrtbution of latttce vtbrattons to the low-temperature heat capactty of ice are discussed brtefly. (Contractor's abstract)

LAV. 01:014

Laval U. [Dept. of Chemistry] Quebec (Canada).

[ON THE ULTRAVIOLET SPECTRA OF PERACETIC ACID AND THE HYDROLYSIS OF PERACETATES] Sur le spectre ultravtolet de l'actde peracétique et l'hydrolyse des peracétates, by P. A. Giguère and A. W. Olmos. [1956] [3]p. incl. diagr. table. [AF 18(600)492] Unclassified

Published in Canad. Jour. Chem., v. 34: 689-691, May 1956.

The absorption spectra of the perhydroxyl ion, the peracetate ion, and peracetic acid have been obtained tn the region of 2300-3300 Å. The alkalinity of peracetate solutions has been calculated from the extinction coefftcients. Hydrotysis is discussed. (C.A., 1956:9871f)

LAV. 01:015

Laval U. Dept. of Chemistry, Quebec (Canada).

THE PRESUMED SPECTROSCOPIC EVIDENCE FOR TRAPPED HO_2 RADICALS, by P. A. Giguère and K. B. Harvey. [1956] [1]p. tnct. refs. [AF 18(600)492] Unclassified

Publtshed tn Jour. Chem. Phys., v. 25: 373, Aug. 1956.

The previous postulation (P. A. Giguère, Jour. Chem. Phys., v. 22: 2085, 1954) was revoked that the few unaccountable bands tn the tnfrared spectrum of the condensed products from dissociated water vapor could arise from HO_2 radicals trapped at liqutd-air temperature. The odd absorption bands belong to some extraneous matertal. It is concluded that the spectes responstble for the yellow color of the glassy deposit, the paramagnetic absorptton, and the evolution of gas and heat on warming are either infrared inactive or else tn such low concentrattons that lhetr ch..rac ristic bands are lost among those of solid H_2O and [illegible]. (C.A., 1956:16385f)

LEH. 01:001

Lehtgh U. Dept. of Physics, Bethlehem, Pa.

THE RANGE OF APPLICATION OF THE LAGRANGE FORMALISM, I, by P. Havas. Aug. 13, 1956, 26p. refs. (AFOSR-TN-56-314) (AF 18(600)1462) AD 94850 Unclassified

Also published in Nuovo Ctmento, Suppl., v. 5: 363-388, 1957.

Given a set of equations $G_i(q, \dot{q}, \ddot{q}, t) = 0$; (i = 1, 2, . . . , n), Helmholtz and others have estabtished the necessary and sufftctent conditions for the existence of a function $L(q, \dot{q}, t)$ such that $G_t = \mathscr{L}[L]$, where $\mathscr{L}[\ ]$ stands for the Lagrangian operator. The author extends the range of applicability of the Lagrange formalism to a set of equations $G_i^{\beta} = \ddot{q}_i + g_i(q, \dot{q}, t)$, and presents the conditions for the existence of "integrating factors" $f_i(q, \dot{q}, t)$ and functions $L^{\beta}(q, \dot{q}, t)$ satisfying $f_i G_i^{\beta} = \mathscr{L}[L^{\beta}]$. Five illustrative examples are treated. (Math. Rev. abstract)

LEH. 01:002

Lehigh U. [Dept. of Physics] Bethlehem, Pa.

GENERALIZED LAGRANGE FORMALISM AND QUANTIZATION RULES (Abstract), by P. Havas. [1956] [1]p. [AF 18(600)1462] Unclasstfted

Presented at meettng of the Amer. Phys. Soc., Chtcago, Ill., Nov. 23-24, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 337-338, Nov. 23, 1956.

It was shown recently that even if a set of equations $G_t = 0$ ts not derivable from a variational principle, there mtght exist an equivalent set $f_t G_t = 0$, obtainable with the hetp of "integrating factors" f_t, which ts so dertvable. The general probtem of equivatent sets has been tnvestigated. It has been found that for any set $G_t = \ddot{q}_t + g_t(q, t) = 0$ there always exist equivatent systems $\sum f_{ik}(q, t)G_k = 0$ whtch are the Euler-Lagrange

equations of a variational principle. As any system of differential equations is equivalent to a system of first-order equations, this implies that any system of nth order ordinary differential equations which may be solved algebraically for the nth order derivatives is derivable from a Lagrangian. In particular this is the case for Newton's equations of motion with arbitrary velocity-dependent forces. For a given set of equations many different Lagranglans exist; quantization by any of the presently available rules (often thought to be as general as the classical formalisms of Lagrange or Hamilton) is either impossible or ambiguous. Some implications are discussed. (Contractor's abstract)

LEY. 01:001

Leyden U. Lorentz Inst. (Netherlands).

ON THE NON-EQUILIBRIUM THERMODYNAMICS OF DISCONTINUOUS SYSTEMS, by J. Vlieger, P. Mazur, and S. R. de Groot. [1956] Iv. incl. diagrs. (AFOSR-TR-56-28) (AF 61(514)846) AD 90016
Unclassified

Thermodynamics of irreversible processes for continuous systems with heat conduction, diffusion, viscosity and cross-effects is applied to the special case of discontinuous systems. From the local conservation laws, entropy balance, phenomenological equations and reciprocal relations, the corresponding equations are obtained for this case. (Contractor's summary)

LEY. 01:002

Leyden U. Lorentz Inst. (Netherlands).

ON PRESSURE AND PONDEROMOTIVE FORCE IN A DIELECTRIC. STATISTICAL MECHANICS OF MATTER IN AN ELECTROMAGNETIC FIELD II, by P. Mazur and S. R. de Groot. [1956] [13]p. [AF 61(514)846]
Unclassified

Published in Physica, v. 22: 657-669, Aug. 1956.

A statistical mechanical derivation of the expressions for both pressure and ponderomotive force in a dielectric is given in terms of averages over microscopic quantities. The existence of microscopic long-range interactions leads to the possibility of defining pressure and ponderomotive force in different ways. A natural way is indicated of dividing the average of the microscopic force into long and short range contributions, which yields the form of the ponderomotive force proposed by Kelvin. It is also shown that, in stattstical equilibrium, one may obtain Helmholtz's expression for the ponderomotive force. In the two cases pressure must be defined differently. The relation between these pressures is as predicted by thermodynamic theory. (Contractor's abstract)

LEY. 01:003

Leyden U. Lorentz Inst. (Netherlands).

ON THE THEORY OF THE REFRACTIVE INDEX OF NON-POLAR GASES. I. QUANTUM MECHANICAL PART, by P. Mazur and M. Mandel. [1956] [10]p. [AF 61(514)846]
Unclassified

Published in Physica, v. 22: 289-298, Apr. 1956.

A quantum mechanical calculation is given for the effect of molecular interactions on the polarizability of spherical non-polar molecules in a periodic external electric field. The polarizability tensor is obtained from perturbation theory as a power series in the interaction tensor $T_{ik} = \nabla_i \nabla_k (1/v_{ik})$, where v_{ik} is the distance between two molecules i and k. It is found that the constants C_1 and C_2, introduced by Jansen and Mazur in the static case, and characterizing the influence of molecular interactions on the polarizability, in order T^2, become now frequency dependent. This frequency dependence is explicitly evaluated for helium at frequencies of the incident wave small compared to the frequencies of the softest absorption line. (Contractor's abstract)

LEY. 01:004

Leyden U. Lorentz Inst. (Netherlands).

ON THE THEORY OF THE REFRACTIVE INDEX OF NON-POLAR GASES. II. STATISTICAL PART, by P. Mazur and M. Mandel. [1956] [12]p. incl. diagrs. table, refs. [AF 61(514)846]
Unclassified

Published in Physica, v. 22: 299-310, Apr. 1956.

A calculation is presented of the Lorentz-Lorenz function for gases of non-polar molecules at moderate densities. Taking into account the influence of molecular interaction upon the polarizability, the results obtained constitute an extension of Yvon's theory of the index of refraction. It was found that for frequencies small compared to frequency of the softest absorption line, the increase of the Lorentz-Lorenz function with density is about twice as important as predicted in the basis of Yvon's theory with constant polarizability. The relative importance of the new effect, however, slightly decreases with increasing frequency in the frequency range considered. The total frequency dependance of the Lorentz-Lorenz function could not have been foreseen from the corresponding Clausius-Mosotti expression simply by replacing the polarizability $\alpha_0(0)$ by $\alpha_0(\omega)$. It was found that for frequencies such as $\omega^2/\omega_0^2 = 0, 1$, the correction to the Lorentz-Lorenz function was about 15% larger than the corresponding correction to the Clausius-Mosotti function. The present calculation may be considered as an extension of the theory given by P. Mazur and L. Jansen for the static case. (Contractor's abstract)

LIE. 01:001 - LIE. 01:004

Libre U., Brussels (Belgium). see Free U. of Brussels (Belgium).

LIE. 01:001

Liège U. Inst. of Experimental Therapeutics, Brussels (Belgium).

RADIOISOTOPE STUDY OF BONE SALT. [n.a.] [1954] 3p. (AF 61(514)647-C) Unclassified

The main constituent of bone mineral is a pseudopatite containing 10-1/2 ions of Ca/6 ions of P (Ca/P = 2.26/. This compound contains a half mole of Ca in excess of the theoretical amount in ideal hydroxyapatite (10 Ca/6 P; Ca/P = 2.14). No lattice position exists in the hydroxyapatite structure which can be occupied by the extra half mole of Ca. Several samples of bone salt (Ca/P = 2.26), freed of organic material, were treated with different quantities of HCl to produce a series of Ca/P compounds ranging down to 2.13. To determine if the extra half mole of Ca in bone apatite was chemically identical to the other 10 Ca ions in the unit cell, each member of the series was immersed separately in $CaCl_2$ solution containing Ca^{45} until equilibrium was reached; then the specific activity of each sample was measured. Results show the unireated pseudoapatite to have a greater specific activity than any of the acid-treated series. The percentage of exchange with the Ca^{45} solution was the same for each compound of the acid-treated bone salt series, as measured by the specific activity. These results indicate that the unireated bone salts contain adsorbed Ca; as the amount is quantitatively very small, a very high degree of exchange for adsorbed Ca is required to explain the observed specific activity. The acid-treated samples are stripped by the HCl of the physically-adsorbed Ca and contain only chemically-bound Ca ions. As the specific activity of all the acid-leached compounds was the same, all 10 1/2 Ca ions bound chemically in the pseudoapatite of Ca/P = 2.26 are apparently equally exchangeable with Ca^{45} when the salts are immersed in such a solution.

LIE. 01:002

Liège U. Inst. of Experimental Therapeutics, Brussels (Belgium).

THE RELATION BETWEEN BONE SALTS AND CERTAIN SYNTHETIC APATITES, by M. J. Dallemagne, C. Fabry, and A. S. Posner. [1956] [2]p. [AF 61-(514)647-C] Unclassifted

Presented at joint meeting of the Physiol. Soc. with the Belgian Physiol. Soc., University Lab. of Physiol., Oxford (England), Sept. 8-10, 1954.

Published in Jour. Physiol., v. 126: 18P-19P, Nov. 29, 1954.

When any of the synthetic pseudoapatites were suspended in a solution of lime (2 meq/l), the calcium content of the solid increased and stabilized at a Ca/P ratio of 2.26. During the formation and aging of the bone mineral, calcium is also fixed from physiological solution up to the point of a Ca/P ratio of 2:26 as found in adult bone. However, in the case of synthetic phosphates, 2:26 can only be attained if they are not heated above 37°C before their suspension in lime solution. If they are previously dried at 105°C the upper limit of the Ca/P is found to be only 2:14, the theoretical value for hydroxyapatite. Finally, both the calcium concentration in the lime solution in which the synthetic materials are suspended, and the calcium concentration in the biological fluids in contact with bone are of the same order of magnitude. In pseudoapatites where defect structures existed it was possible to fill the calcium defects; it was also possible to fix stoichiometric excesses of calcium.

LIE. 01:003

Liège U. Inst. of Experimental Therapeutics, Brussels (Belgium).

EXCHANGE OF BONE CALCIUM WITH Ca^{45}, by M. J. Dallemagne, C. Fabry, and P. Bodson. [1955] [2]p. incl. table. [AF 61(514)647-C] Unclassified

Published in Experientia, v. 11: 142-143, Apr. 15, 1955.

KOH-glycol ashed bone was exposed for 1 month to $Ca^{45}Cl_2$ solution and then filtered and dried; the specific activity of this preparation was 9.48×10^3. Fractions of this preparation were suspended for 10 min. After filtration and drying at 105°, Ca, P, and specific activity were ascertained for each sample. The weight loss of the samples in HCl solution increased with the increase of HCl used. As HCl concentration increased the specific activity of the liquid, very high for small amounts of HCl, decreased. However, the specific activity was always higher in the liquid than in the corresponding residual solid phase. For each experiment the liquid always contained more Ca than required for 9 Ca/6 P (Ca/P = 1.94). This excess represents the additional Ca ion content of bone structure. On the other hand, the Ca/P weight ratio in the solid phase decreased slowly to 1.98. The ratio, counts/min/excess Ca, had a constant value of about 62. It is concluded that the Ca^{45} exchanged by bone mineral is exclusively the excess 1¼ moles of Ca of the saturated pseudoapatite. (C.A., 1955:11036f)

LIE. 01:004

Liège U. Inst. of Experimental Therapeutics, Brussels (Belgium).

IONIC EXCHANGE OF CALCIUM AND RECRYSTALLIZATION OF THE MINERAL SUBSTANCE OF BONE, by M. J. Dallemagne, C. Fabry, and P. Bodson. [1955] [3]p. [AF 61(514)647-C] Unclassified

Published in Jour. Physiol. (Paris), v. 47: 153-155, 1955.

Bone salt, prepared by the method of Gabriel, was equilibrated with a radioactive Ca solution containing 6.2 mg $CaCl_2$/ml. Samples of this labeled bone salt were subsequently treated with 0.4-12.5 meq of HCl/g. The excess Ca (the Ca present in excess of the Ca/P ratio in $Ca_3(PO_4)_2$) was shown to be the most easily exchangeable. Bone salt was equilibrated with a radioactive Ca solution containing 18.3 mg $CaCl_2$/ml and then treated with successive extractions with HCl (0.2 meq/g). In this case the radioactive Ca was found in both exchangeable and lattice Ca, indicating that recrystallization had taken place in addition to exchange. Uptake of radioactive Ca occurred only if the solution caused a hydrolysis followed by recrystallization. Thus, 2 processes are responsible for the uptake of Ca by bone salt in vitro: (1) true exchange, which is concerned only with the excess Ca and not with the lattice Ca, and (2) recrystallization which occurs only to the degree that the Ca phosphate is attacked by the liquid phase. (C.A., 1956:6621g)

LIE. 02:001

Liège U. Inst. of Experimental Therapeutics, Brussels (Belgium).

STUDIES ON THE MINERAL FRACTION OF BONE, by M. J. Dallemagne, C. Fabry and others. Technical rept. June 1, 1955-May 31, 1956. 1v. incl. diagrs. tables, refs. (AFOSR-TN-56-258) (AF 61(514)858) AD 88978 Unclassified

The stoichiometric relations between PO_4, Ca, and CO_3 were studied to determine whether CO_3 can be substituted by PO_4 groups. The influence of the organic material of bone on the Ca exchange reaction and the structure of fundamental phosphate molecule of bone and teeth were also studied. Two exchange processes without chemical interactions between the solid and liquid phases occurred when a phosphate with a Ca/P ratio close to 2.14 is involved. The exchange reaction can be decomposed by (1) two steps which correspond to surface exchange and which are reversible and depend on the particles surface; and (2) a third step which corresponds to isotonic exchange in the bulk of the solid, which is probably also reversible, but this is followed by irreversible modifications (recrystallization) of the solid. Recrystallization increased with time and the $CaCl_2$ concentration of the liquid phase, but it was largely influenced by temperature. Chemical interactions appeared for phosphates with a Ca/P ratio higher than 2.14. The exchange percentage seemed to be proportional to the Ca/P ratio. Exchange between Ca^{45} and tricalctum phosphate with the Ca/P ratio of 1.94 was greatly affected by chemical interactions, and always followed by recrystallization of the solid. (ASTIA abstract, modified)

LIT. 01:001

[Litton Industries, Beverly Hills, Calif.]

VAPOR PRESSURE OF PLASTIC MATERIALS, by [A. Teets]. Technical paper [1956] [11]p. incl. diagrs. table. (AF 18(600)1498) Unclassified

Published in Jour. Appl. Phys., v. 27: 1460-1466, Dec. 1956.

This research was undertaken for the purpose of evaluating a group of flexible polymeric materials with a view to using these materials in vacuum systems operated in the 10^{-6} mm Hg range. Several methods for determining absolute vapor pressures were investigated but none proved to be too successful, consequently, it was decided that the equivalent nitrogen pressure of a permanent gas or vapor is a better indication of its behavior than absolute pressure, especially since the vast majority of high vacuum pressure measurements are already equivalent nitrogen measurements in the sense that they are made with a ionization gauge. The following polymers were evaluated: (1) polyethylene, (2) butyl rubber, (3) hycar rubber, (4) mylar, (5) saran, (6) vinyl, (7) nylon cloth, and (8) teflon.

LOC. 01:001

Lockheed Aircraft Corp. Missile Systems Div., Palo Alto, Calif.

THE CONSERVATION EQUATIONS FOR INDEPENDENT COEXISTENT CONTINUA AND FOR MULTICOMPONENT REACTING GAS MIXTURES, by W. Nachbar, F. Williams, and S. S. Penner. Mar. 15, 1957, 30p. (Rept. no. LMSD-2082) (AFOSR-TN-56-458) (AF 18-(603)146) AD 97074 Unclassified

The equations for conservation of mass, momentum, and energy are derived for a set of independent, coexistent continua obeying the laws of dynamics and thermodynamics. The idea of a control volume and a control surface for each continuum is used in the analysis. The derived results are practically identical with relations obtained previously by Th. von Kármán (Quoted in Penner, Introduction to the Study of Chemical Reactions in Flow Systems, Chapt. 2, 1955). A direct comparison is conducted between the continuum theory results and those obtained from kinetic theory by assuming that, for each of the species, the kinetic theory definitions apply. It is found that the new terms appearing in the conservation equations derived from continuum theory are precisely those which are required to make these equations identical with the results obtained from the kinetic theory of multicomponent, reacting gas mixtures. However, the continuum theory forms of the equations are not useful because they require knowledge of the transport properties for individual species in the mixture. (Contractor's abstract)

LOC. 01:002 - LOU. 01:003

LOC. 01:002

Lockheed Aircraft Corp. Missile Systems Div., Palo Alto, Calif.

A SOLUTION TO GREEN'S FIRST-ORDER PROBLEM, by W. Nachbar. [1956] [11]p. incl. diagrs. (Bound with Aerojet-General Corp. rept. "Some Properties of a Simplified Model of Solid-Propellant Burning," by L. Green, Jr. [AF 18(600)1048]) [AF 18(603)146] Unclassified

A solution is developed to Green's first-order problem. The basis of the solution stems from the following equation:

$$f(x) = ae^{\frac{-r_o x}{\alpha}} + b_1 e^{\lambda_1 x} + b_2 e^{\lambda_2 x}$$

where f(x) is the complex-valued function.

Lorentz Inst., Leyden (Netherlands). see Leyden U. Lorentz Inst. (Netherlands).

LSU. 01:001

Louisiana State U., Baton Rouge.

ADMISSIBILITY OF SEMIGROUP STRUCTURES ON CONTINUA, by R. J. Koch and A. D. Wallace. [1956] 18p. refs. [AFOSR-TN-56-590] (AF 18(603)89) AD 115017 Unclassifted

The structure of certain compact connected semigroups S which satisfy $S^2 = S$ are studied. Instances are shown where the multiplication must be continuous and associative in S. Dense connected sets are considered, as in the following S being a Hausdorff topological semigroup and continuum, $S^2 = S$ if and only if each dense ideal is connected. It is shown that if S is irreducible between its minimal ideal K and some other set and if $S^2 = S$ then S must have a unit, S is commutative, and S/K (in the metric case) is an arc. Maximal ideals are proved to be composants. Examples are given in some detail.

LOU. 01:001

Louvain U. Lab. for Inorganic and Analytical Chemistry, Brussels (Belgium).

COMPARATIVE STUDY OF C_2H_2/O_2 AND C_2H_2/N_2O FLAME SPECTRA, by A. Van Tiggelen, J. Vaerman, and G. Nenquin. [1956] [16]p. incl. illus. diagrs. tables. [AFOSR-TN-56-83] (Bound with its AFOSR-TR-57-27; AD 126445) [AF 61(514)814] Unclassified

Also published in Bull. Soc. Chim. Belg., v. 65: 435-452, May-June 1956.

A study has been made of the effect of the luminous-zone thickness of a flame on the intensity of spectral bands. It is shown that the measured intensity varies proportionally with the thickness for radicals which do not emit in the exterior mantle of the flame. The emission intensity of the OH, CH, and C_2 radicals have been measured for a series of mixtures of C_2H_2/N_2O and C_2H_2/O_2 with variable supporter of combustion/combustible ratios and increasing dilution by N_2. In addition, measurements have been made in C_2H_2/N_2O flames for the emisston of CN and NH. Application of a kinetic relation permits the determination of an activation energy for the chain-branching process. A good agreement is found, for certain radicals only, with the energies of activation being deduced from the propagation of flames in the same mixtures.

LOU. 01:002

Louvain U. Lab. for Inorganic and Analytical Chemistry, Brussels (Belgium).

THE INFLUENCE OF HYDROGEN ON CARBON MONOXIDE-OXYGEN FLAMES, by A. Van Tiggelen and P. J. Slootmaekers. [1956] [9]p. incl. diagrs. table. [AFOSR-TN-56-84] (Bound with its AFOSR-TR-57-27; AD 126445) [AF 61(514)814] AD 81539 Unclassified

Also published in Bull. Soc. Chim. Belg., v. 65: 425-434, May-June 1956.

The velocity of propagation of a flame in a mixture of CO and O_2 increases very rapidly when CO is progressively replaced by H_2. By the systematic study of this reaction, using a series of fixed H_2/CO ratio mixtures diluted increasingly with N_2, it is indicated that the reaction of chain branching in pure CO is replaced in the presence of H_2 by one which is valid for pure H_2. The data show that the apparent activation energy of the branching varies from 22 kcal (pure CO) to 18 kcal (pure H_2), and the apparent order of the branching reaction goes from 2 to 3.

LOU. 01:003

Louvain U. Lab. for Inorganic and Analytical Chemistry, Brussels (Belgium).

FLAME PROPAGATION IN GASEOUS MIXTURES CONTAINING NITROUS-OXIDE AS OXIDANT, by J. Van Wonterghem and A. Van Tiggelen. [1955] [18]p. incl. diagrs. tables. [AFOSR-TN-56-448] (Also bound with its AFOSR-TR-57-27; AD 126445) (Sponsored jointly by [Air Force Office of Scientific Research] under AF 61(514)814 and [Fonds National de la Recherches Scientifique (Belgium).]) AD 96793 Unclassified

Also published in Bull. Soc. Chim. Belg., v. 64: 780-797, 1955.

In this study, the burning velocity, flame temperature, and the distance between the striated and luminous cones were determined for constant ratios of C_2H_2,

H_2, NH_3, or CO and N_2O, increasingly diluted with N_2. The activation energies are all higher with N_2O than with O_2, but the same mechanism is indicated. The relationship between flame velocity, mean flame temperature, and the distance between cones using O_2 holds for N_2O.

LOU. 01:004

Louvain U. [Lab. for Inorganic and Analytical Chemistry] Brussels (Belgium).

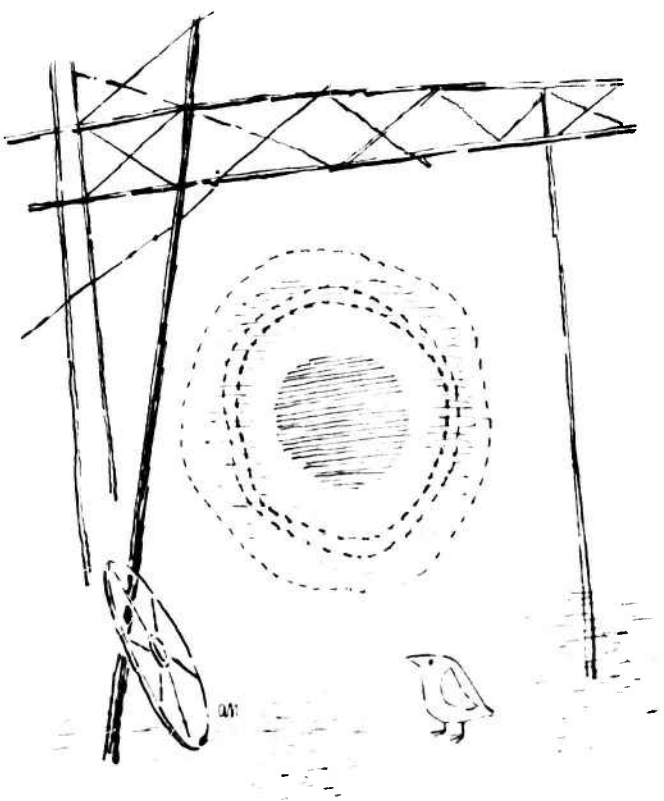
CHAIN BRANCHING AND FLAME PROPAGATION, by

LOU. 01:004

A. Van Tiggelen and J. Deckers. [1956] [5]p. incl. tables, refs. (AF 61(514)814) Unclassified

Published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn., (Aug. 19-24, 1956), N. Y. Reinhold, 1957, p. 61-65.

The primary purpose of this paper is to establish certain basic principles governing the reaction kinetics in stationary premixed flames. The individual, radical or free atom in the flame reaction zone has been considered. The good agreement with experimental data in all possible cases and the practical utility of the derived relations are the best justification of our point of view.



MMU. 01:001 - MMU. 01:006

MMU. 01:001

McMaster U. Hamilton Coll., Ont. (Canada).

EVIDENCE FOR A REGION OF EXTRA NUCLEAR STABILITY BETWEEN THE 82- AND 126-NEUTRON SHELLS, by B. G. Hogg and H. E. Duckworth. July 13, 1953, 1p. incl. diagr. (Technical rept. no. 2) (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)484], National Research Council of Canada, and Research Council of Ontario (Canada)) AD 41027 Unclassified

Also published in Phys. Rev., v. 91: 1289-1290, Sept. 1, 1953.

New atomic mass measurements reveal a region of extra nuclear stability, located approximately between the 82 and 126 neutron shells. Reference is made to recent work of de Shalit and Goldhaber which might explain this effect. (Contractor's abstract)

MMU. 01:002

McMaster U. Hamilton Coll., Ont. (Canada).

AN ATOMIC MASS STUDY OF NUCLEAR SHELL STRUCTURE IN THE REGION $28 \leqslant n \leqslant 50$ AND $28 \leqslant Z \leqslant 40$, by B. G. Hogg and H. E. Duckworth. Nov. 5, 1953 [12]p. incl. diagrs. tables, refs. (Technical rept. no. 1) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)-484, National Research Council of Canada, and Research Council of Ontario (Canada)) AD 60218 Unclassified

Also published in Canad. Jour. Phys., v. 31: 942-953, Sept. 1953.

New mass spectrographic masses are reported for some of the isotopes of gallium, germanium, arsenic, and selenium. These results are combined with previously reported mass data in order to study atomic mass trends in the region $28 \leqslant n \leqslant 50$ and $28 \leqslant Z \leqslant 40$. The only pronounced mass effects which occur in this region are those associated with 28 and 50 nucleons. No extra stability has been found which can be associated with the filling of the $f_{5/2}$, $p_{3/2}$, and $p_{1/2}$ subshells. A list of mass values used in this study is included. (Contractor's abstract)

MMU. 01:003

McMaster U. [Hamilton Coll.] Ont. (Canada).

ATOMIC MASSES FOR Ga, Ge, As, Se, AND Br (Abstract), by B. G. Hogg and H. E. Duckworth. [1953] [1]p. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)484], National Research Council of Canada, and Research Council of Ontario (Canada)) Unclassified

Presented at meeting of the Amer. Phys. Soc., Rochester, N. Y., June 16-20, 1953.

Published in Phys. Rev., v. 92: 848, Nov. 1, 1953.

New mass spectrographic measurements are combined with existing transmutation and microwave absorption data to give the following masses: Ga^{69} = 68.9478 ± 2 amu, Ge^{70} = 69.9460 ± 4 amu, Ge^{72} = 71.9449 ± 2 amu, Ge^{74} = 73.9447 ± 4 amu, Ge^{76} = 75.9460 ± 4 amu, As^{75} = 74.9454 ± 3 amu, Se^{74} = 73.9460 ± 4 amu, Se^{73} = 75.9432 ± 2 amu, Se^{77} = 76.9442 ± 2 amu, Se^{78} = 77.9420 ± 2 amu, Se^{80} = 79.9421 ± 6 amu, Se^{82} = 81.9431 ± 6 amu, Br^{79} = 78.9435 ± 4 amu, and Br^{81} = 80.9425 ± 5 amu. These constitute all the stable isotopes of these elements with the exception of Ga^{71} and Ge^{73}. (Contractor's abstract)

MMU. 01:004

McMaster U. Hamilton Coll., Ont. (Canada).

AN ATOMIC MASS STUDY OF NUCLEAR SHELL STRUCTURE IN THE REGION $82 \leqslant n \leqslant 126$, by B. G. Hogg and H. E. Duckworth. Feb. 24, 1954 [7]p. incl. illus. tables, refs. (Technical rept. no. 3) ([AF]OSR-TN-54-36) (AF 18(600)484) AD 101525 Unclassified

Also published in Canad. Jour. Phys., v. 32: 65-71, Jan. 1954.

A number of new atomic masses are reported in the region $82 \leqslant n \leqslant 126$ and are used to study nuclear stability in this region. No stability effects associated with a particular neutron number are noticed but rather there is a broad general increase in stability between the 82 and 126 neutron shells. (Contractor's abstract)

MMU. 01:005

McMaster U. Hamilton Coll., Ont. (Canada).

ATOMIC WEIGHTS OF THE MONOISOTOPIC ELEMENTS, by H. E. Duckworth. June 25, 1954 [4]p. incl. diagr. table. (Technical rept. no. 4) ([AF]-OSR-TN-54-352) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)484 and National Research Council of Canada) AD 60217 Unclassified

Also published in Nature, v. 174: 595-[598], Sept. 25, 1954.

Chemical atomic weights obtained or deduced from physical data are given for the 22 simple elements and are compared to their chemically determined counterparts. (Contractor's abstract)

MMU. 01:006

McMaster U. Hamilton Coll., Ont. (Canada).

ATOMIC MASSES OF Ru^{98}, Ru^{99}, Os^{189} AND Os^{192}, by E. M. Pennington and H. E. Duckworth. Feb. 24,

1955 [1]p. incl. table. (Technical rept. no. 5) ([AF]OSR-TN-54-354) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)-484, National Research Council of Canada, and Research Council of Ontario (Canada)) AD 60216 Unclassified

Also published in Canad. Jour. Phys., v. 32: 808, Dec. 1954.

Accurate physical masses are known for 17 of the 22 monoisotopic elements. A graph is presented in which the mass numbers of the even-even isotopes of the even-Z elements are plotted against the mass defects (mass defect, difference between atomic mass of a nuclide and its mass number). The tangent to the curves formed by these isotopes is a comparatively smooth line. By interpolating the 5 not accurately known monoisotopic elements (Cs^{133}, Tb^{159}, Tm^{169}, Ta^{181}, and Au^{197}), reliable estimates of their masses can be obtained. A table shows the determined and estimated isotopic, and physical and chemical atomic, weights of the 22 monoisotopic elements.

MMU. 01:007

McMaster U. Hamilton Coll., Ont. (Canada).

MASS SPECTROSCOPIC ATOMIC MASS DIFFERENCES, by H. E. Duckworth, B. G. Hogg, and E. M. Pennington. Feb. 24, 1955 [10]p. incl. tables, refs. (Technical rept. no. 6) ([AF]OSR-TN-54-355) (AF 18(600)484) AD 60215 Unclassified

Also published in Rev. Modern Phys., v. 26: 463-472, Oct. 1954.

A review is presented of the literature on atomic mass differences determined by the doublet method of mass comparison (A. J. Dempster's data obtained by the bracket method are excluded). Tables I and II show the masses of the secondary standards (H^1, D^2, C^{12}) as determined by various authors, and the mass differences of the doublets used to obtain these secondary standards. Table III tabulates the published nonfundamental doublet differences, with indication of the literature sources. Table IV reviews important mass measurements obtained by the helical orbit mass spectrometer which measures the time of flight of ions in a magnetic field.

MMU. 01:008

McMaster U. Hamilton Coll., Ont. (Canada).

CONCERNING THE MASSES OF THE STABLE ZINC ISOTOPES, by J. T. Kerr, N. R. Isenor, and H. E. Duckworth. Mar. 6, 1956 [2]p. incl. tables, refs. (AFOSR-TN-56-71) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)484], National Research Council of Canada, Ontario Research Foundation (Canada), and Shell Oil Co. of Canada) AD 81523 Unclassified

Also published in Zeitschr. für Naturforschung, v. 10A: 840-843, July 27, 1955.

The masses of Zn^{64}, Zn^{66}, Zn^{67}, and Zn^{68} have been studied mass spectroscopically by means of the O_2^{16}–$1/2\ Zn^{64}$, $1/2\ Xe^{132}$–Zn^{66}, $1/2\ Xe^{134}$–Zn^{67}, and $1/2\ Xe^{136}$–Zn^{68} doublets. These studies suggest that the currently accepted masses of Zn^{64} and Zn^{66} are too large by ~ 0.4 mmu. If these revisions are made, several existing discrepancies between transmutation and mass data disappear. (Contractor's abstract)

MMU. 01:009

McMaster U. Hamilton Coll., Ont. (Canada).

RELIABILITY OF ATOMIC MASSES IN THE CHROMIUM-GERMANIUM REGION, by J. T. Kerr, J. G. V. Taylor, and H. E. Duckworth. Mar 6, 1956 [3]p. (AFOSR-TN-56-72) (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)-484]. National Research Council of Canada, and Ontario Research Foundation (Canada)) AD 81524 Unclassified

Also published in Nature, v. 176: 458, Sept. 3, 1955.

In this study, attention is focussed on mass difference discrepancies in the Cr-Ge region. In the hope of discovering some systematic discrepancy between mass spectroscopic and transmutation data, calculations have been made of 30 mass differences in this region, using both sources of data. These calculations show that between stable nuclides of the same element, e.g., Fe^{57}-Fe^{56}, the transmutation- and mass-spectrographic differences are quite consistent. The only major inconsistency is in the case of the Zn^{67}-Zn^{66} difference. The situation is quite different, and much less satisfactory in the case involving stable nuclides of different elements, e.g., Fe^{54}-Cr^{53}. Only 4 of the 16 calculated differences agree within the stated probable-error limits. In 5 cases involving Ni, i.e., Ni^{58}-Fe^{57}, Ni^{60}-Fe^{57}, Cu^{63}-Ni^{62}, Ni^{64}-Cu^{63}, and Cu^{65}-Ni^{64}, the agreement is very poor, indicating that the masses of Ni determined mass spectroscopically are too low by $\sim 60 \times 10^{-5}$ amu. Therefore, it is hypothesized that the Ni masses are in error. It is concluded that the atomic mass values for the other elements in the Cr-Ge region may be used with reasonable confidence.

MMU. 01:010

McMaster U. Hamilton Coll., Ont. (Canada).

A NOTE ON THE EFFECT OF THE RESIDUAL GAS PRESSURE UPON THE SPACING OF MASS SPECTROSCOPIC DOUBLETS, by N. R. Isenor, G. R. Bainbridge and others. May 28, 1956 [3]p. incl. diagrs. (AFOSR-TN-56-471) (Sponsored jointly by Air Force Office of Scientific Research under

MMU. 01:011 - MMU. 01:014

AF 18(600)484, National Research Council of Canada, and Shell Oil Co. of Canada) AD 97355 Unclassified

Also published in Canad. Jour. Phys., v. 34: 993-995 Sept. 1956.

C_3H_6O-Ni^{58} and 1/2 Xe^{132}-Zn^{66} doublets were photographed at different pressures in a Dempster-type double-focusing instrument, using an accelerating voltage of 15,000 v. The evidence indicates that the former doublet spacing decreases with increasing pressure at a rate of 0.035 mmu per 10^{-6} mm Hg, in the range 5-60 x 10^{-6} mm Hg. Within experimental accuracy, the latter spacing was not markedly pressure dependent. Further investigation is contemplated.

MMU. 01:011

McMaster U. Hamilton Coll., Ont. (Canada).

THE LUMINESCENT RESPONSE OF SILVER ACTIVATED ZINC SULPHIDE TO LITHIUM IONS OF DIFFERENT ENERGIES, by C. F. Eve and H. E. Duckworth. May 28, 1956 [2]p. incl. diagrs. (AFOSR-TN-56-472) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)484, Ontario Research Foundation (Canada), and National Research Council of Canada) AD 97356 Unclassified

Also published in Canad. Jour. Phys., v. 34: 896-897, Aug. 1956.

The variation of luminescence intensity with Li ion energy over the range 15-40 kev was measured. A power law relation with an index of 2.5 was obtained.

MMU. 01:012

McMaster U. Hamilton Coll., Ont. (Canada).

ATOMIC MASSES OF Ni^{58} AND Ni^{60}, by P. C. Eastman, N. R. Isenor and others. Nov. 15, 1956 [2]p. incl. tables, refs. (AFOSR-TN-56-473) (AF 18(600)484) AD 97357 Unclassified

Also published in Phys. Rev., v. 103: 145-146, July 1, 1956.

Mass spectrographic measurements are reported of the mass differences $C_2H_4O_2$-Ni^{60} and C_3H_6O-Ni^{58}. These results are used, together with existing data, to discuss certain discrepancies between transmutation and mass spectroscopically determined masses in the Fe-Ni-Zn section of the atomic mass table. (Contractor's abstract)

MMU. 01:013

McMaster U. Hamilton Coll., Ont. (Canada).

A LARGE SEMI-CIRCULAR MASS SPECTROMETER FOR ATOMIC MASS DETERMINATIONS (Abstract), by H. E. Duckworth, J. T. Kerr, and G. R. Bainbridge. July 1956, 1p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)484, National Research Council of Canada, and Ontario Research Foundation (Canada)) Unclassified

Presented at Symposium on the Precision Determination of Nuclear Masses, Mainz (Germany), July 9-14, 1956.

A new large double focusing mass spectrometer, consisting of a semi-circular magnetic analyzer followed by a $\pi/2$ electrostatic analyzer has been constructed. This was constructed in two steps: (1) the magnetic analyzer and, (2) the electrostatic analyzer. The magnetic analyzer (radius of curvature = 2.74 meters) alone has a mass resolution of approximately 1/10000 at the base of the peaks, and was used to obtain mass information for some of the elements which can be obtained in gaseous form. The field of the magnetic analyzer is both stabilized and swept by a proton moment mechanism. The position of each mass spectral peak is given by the frequency of the proton signal and the doublet spacing, consequently, is obtained in terms of a frequency difference. The present performance and method of operating the instrument will be discussed, and some remarks will be made concerning future plans. (Contractor's abstract)

MMU. 01:014

McMaster U. Hamilton Coll. Ont. (Canada).

SOME RECENT MASS DETERMINATIONS AT McMASTER UNIVERSITY (Abstract), by H. E. Duckworth, G. R. Bainbridge and others. July 1956, 1p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)484, National Research Council of Canada, and Shell Oil Co. of Canada) Unclassified

Presented at Symposium on the Precision Determination of Nuclear Masses, Mainz (Germany), July 9-14, 1956.

The mass differences C_3H_6O-Ni^{58} = 106.52 ± 15 mmu and $C_2H_4O_2$-Ni^{60} = 90.82 ± 15 mmu was determined. The agreement between this and other work was discussed, as well as the agreement between transmutation- and mass spectroscopically-derived mass differences in the Fe-Ni-Zn section of the atomic mass table. An attempt was made to ascertain if the 1/2 Xe^{132}-Zn^{66} and C_3H_6O-Ni^{58} doublet spacings were sensitive to the residual gas pressure in the mass spectrograph. In the former case there appeared to be no pressure dependence in the pressure range 3.5 - 30 x 10^{-6} mm Hg. In the latter case the doublet spacing appeared to decrease with increasing residual gas pressure. In this work ions of 15,000 volts energy were employed in a Dempster-type double focusing mass spectrograph, approximately 2.3 times larger than that employed by Dempster and Sha., who first reported this pressure effect. (Contractor's abstract)

MMU. 01:015

McMaster U. Hamilton Coll., Ont. (Canada).

STANDARDS OF ATOMIC MASS FOR A > 30 (Abstract), by H. E. Duckworth. July 1956, 1p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)484 and National Research Council of Canada) Unclassified

Presented at Symposium on the Precision Determination of Nuclear Masses, Mainz (Germany), July 9-14, 1956.

The question was discussed of designating certain of the heavier atoms as secondary standards of atomic mass. It was hoped that atoms so designated would receive out-of-the-ordinary attention by persons engaged in mass spectroscopic mass determinations, with the result that a series of appropriately-spaced, accurately-known atomic masses would extend through the entire atomic mass table. These secondary standards would be highly useful as points of departure for calculations employing transmutation data. Some of the factors which should govern the choice of standards was discussed and a proposed list of such standards was presented.

MML. 01:001

McMillan Lab., Inc., Ipswich, Mass.

REFLECTION OF A PLANE WAVE BY A STRATIFIED MEDIUM, by A. F. Kay. Nov. 22, 1954, 39p. incl. diagrs. refs. (Document no. 1294) ([AF]OSR-TN-54-348) (AF 18(600)1044) AD 51019 Declassified

The reflections R of a plane wave by a stratified medium (one whose electromagnetic parameters depend only on the x-coordinate) satisfy Ricatti-type equations. A comparison of treatments of this subject by several authors leads naturally to more-or-less new physical models of reflection, which in turn suggest expansions of the exact reflection coefficients suitable for computation and useful for further theoretical study. Examples having both physical importance and mathematical simplicity are worked out and serve as a check on the approximations. In Part II, a medium with continuously varying parameters is regarded as limit of a pile of uniform sheets. Considering multiple reflection in such a pile gives rise to the notion of n-th order reflection. A proof is sketched that under certain general conditions R_n has a unique limit as the pile approximates a uniform medium and thus lt_n can be defined precisely even for continuous variation. A formula for R_o and a recursion formula for R_n permits numerical computation. It is shown that lim R_n satisfies the appropriate Ricatti equation, and lim R_n equals the true reflection. Thus is obtained, in principle, a means for approximating the reflection in this most general case. The work is guided by constant reference to the physical model; it leads to new results in the theory of Ricatti equations, which appear difficult to discover by mathematical means alone. (Contractor's abstract)

MML. 01:002

McMillan Lab., Inc. Ipswich, Mass.

SOME MATHEMATICAL ASPECTS OF ABSORBER DESIGN, by R. B. Barrar. Nov. 22, 1954, 20p. incl. diagrs. (Document no. 1295) ([AF]OSR-TN-54-349) (AF 18(600)1044) AD 51020 Declassified

Maxwell's equations for a medium whose electromagnetic constants vary only in the x-direction, are shown to reduce to the form of the equations for a non-uniform transmission line. In this way standard methods of transmission line theory are applied to absorber design. For certain cases explicit solutions are given for the reflection from an absorber with a continuously varying dielectric constant ε. (Contractor's abstract)

MML. 01:003

McMillan Lab., Inc., Ipswich, Mass.

SOME ABSORBING PANELS WITH VARIABLE DIELECTRIC COMPOSITION, by J. H. Sampson. Dec. 20, 1954, 52p. incl. diagrs. tables. (Document no. 1299) ([AF]OSR-TN-[55]-11) (AF 18(600)1044) AD 57113 Declassified

Results of computations of the complex reflection coefficient for several types of panels are discussed with respect to the design of thin broadbanded absorbers. The panels are backed by metal and have electrical characteristics which, with a suitable choice of rectangular coordinates x, y, and z, depend only on x, the distance from the metallic backing to an arbitrary point (x, y, z) in the panel. The reflection coefficient R is determined by the Riccati-type equation

$$\frac{dR}{dx} = \frac{\pi i\sqrt{\varepsilon - p}}{\lambda}\left[(R+1)^2 a - (R-1)^2 \frac{1}{a}\right]$$ with the

coefficients depending on the polarization of the incident wave, its angle of incidence θ and wavelength λ, and the dielectric constant $\varepsilon = \varepsilon(x)$ of the panel. Values of $|R|^2$ were obtained by high-speed digital computation for several panels. By considering $\varepsilon(x) = u(x) + i.v(x)$, 32 panels are described in the interval $0 \leq x \leq 1/2$ with the initial value $R = 1$ at $x = 0$. Data from the following functions appear promising: (1) $u = 20^{1-2x}$; (2) $u = 50^{1-2x}$; (3) $u = -6272\,x^3 + 4704\,x^2 - 882\,x + 50$; (4) $u = -2432\,x^3 + 1824\,x^2 - 342\,x + 20$; and (5) $\varepsilon(x) = \left[(E-1F)/(E^2 + F^2)\right]^{1/2}$ where E and F are defined in terms of x; the function appeared particularly promising. (ASTIA abstract)

MML. 01:004

McMillan Lab., Inc., Ipswich, Mass.

[THE MATHEMATICAL TREATMENT OF DIELECTRIC ABSORBING PANELS], by J. H. Sampson. Summary

MML. 01:005 - MML. 01:006

repl. Dec. 20, 1954, 16p. (Document no. 1301) ([AF]OSR-TN-55-12) (AF 18(600)1044) AD 57112 Declassified

The mathematical treatment of dielectric absorbing panels is summarized. The somewhat idealized case is considered of an infinite panel bounded by 2 parallel planes and with local electromagnetic properties depending only on the distance from one face. Summaries are presented of: (1) a report which considers propagation of waves in dielectric media as a one-dimensional phenomenon and expressible in terms of familiar parameters of transmission-line theory; (2) an analysis of approximate values of the reflection coefficients R_R and R_S with the term R^2 omitted from the relevant differential equation; and (3) reports which consider minimization of the expression

$$\int_{\lambda_1}^{\lambda_2}\int_{p_1}^{p_2} |R_\perp|^2 \, dp\, d\lambda + \int_{\lambda_1}^{\lambda_2}\int_{p_1}^{p_2} |R_\parallel|^2 \, dp\, d\lambda$$

by suitable choice of the dielectric constant $\epsilon(x)$, where $p = \sin^2\theta$, θ = angle of incidence, and the subscripts $\perp$ and $\parallel$ refer to the polarization. Sources of difficulty in applying the differential equation to the design of non-reflecting panels are reviewed. The minimum problem appears unsolvable. The reflection coefficients for 32 given functions of $\epsilon(x)$ which were evaluated by high-speed digital computation indicate the probability of attaining design criteria for effective thin absorbers. (ASTIA abstract)

MML. 01:005

McMillan Lab., Inc., Ipswich, Mass.

A MODIFIED TREATMENT OF SOME REFLECTION PROBLEMS, by J. H. Sampson. Dec. 31, 1954, 16p. (Document no. 1302) ([AF]OSR-TN-55-40) (AF 18(600)-1044) AD 57064 Declassified

Analyses previously presented (see item no. MML. 01:006) are expanded with respect to the application of the differential equation governing the reflection coefficient R of a dielectric panel to the design of panels leaving low reflection over a band of wavelengths λ and incidence angles. Solution of the minimum problem

$$\int_{\lambda_1}^{\lambda_2}\int_{p_1}^{p_2} \bar{R}_n \frac{\partial R_n}{\partial \epsilon_j} \, dp\, d\lambda = 0$$

for a piecewise constant is not near solution with respect to explicit calculation; computation of the minimizing values of $\epsilon_1 \cdots \epsilon_n$ for the integral

$$J(\epsilon_1, \bar{\epsilon}_1 \cdots \epsilon_n, \bar{\epsilon}_n) = \int_{\lambda_1}^{\lambda_2}\int_{p_1}^{p_2} |R_n|^2 \, dp\, d\lambda$$

may be completely beyond the capabilities of any computing machine likely to be developed in the near future. Two approaches are considered to the design of low-reflection panels. One considers the use of a finite difference equation; a stepwise procedure is described which yields a succession of ordinary minimum problems for the function of one (complex) variable. The number of layers does not materially affect the type of calculation.

MML. 01:006

McMillan Lab., Inc., Ipswich, Mass.

ON THE REFLECTION COEFFICIENT OF NON-HOMOGENEOUS MEDIA, by J. H. Sampson. Dec. 31, 1954, 16p. incl. diagrs. (Document no. 1303) ([AF]OSR-TN-55-46) (AF 18(600)1044) AD 57063 Declassified

The problem of suppression of reflection is considered for dielectric panels whose complex dielectric constant ϵ depends only on the distance x from one face. The complex reflection coefficient R of the panel is determined from the first-order differential equation

$$\frac{dR}{dx} = \frac{2\pi i v}{\lambda}\left[(R+1)^2 a - (R-1)^2 \frac{1}{a}\right],$$

where $v = \sqrt{\epsilon - p}$, $p = \sin^2\theta$, $a = \epsilon\sqrt{1-p}/v$ for parallel polarization and $a = v/\sqrt{1-p}$ for perpendicular polarization for $0 \le x \le 1$, $0 \le p \le 1$, $0 \le \lambda \le \infty$, λ = the wavelength of the incident wave, and θ = its angle of incidence. Minimization of the reflection for an entire band through an appropriate choice of dielectric constant is formulated as minimization of an integral of the form $\int_{\lambda_1}^{\lambda_2} d\lambda \int_{p_1}^{p_2} |R|^2 \, dp$. The function $\epsilon(x)$ is subjected to physically realizable values which is expressed by inequalities of the form $0 < \arg \epsilon \le \chi$, $\rho_1 \le |\epsilon| \le \rho_2$. For constant ϵ, the equation is explicitly solvable, and it is also explicitly solvable for a piecewise constant $\epsilon(x)$. To obtain satisfactory accuracy in applying the method, at least second-order, and probably higher order, terms of the power-series expansions must be retained. With restriction of ϵ to piecewise constant functions, minimization of J presents no theoretical difficulties and permits resolution of the mathematical problem.

Mallinckrodt Chemical Lab., Cambridge, Mass.
see Harvard U. Mallinckrodt Chemical Lab., Cambridge, Mass.

MAR. 01:001

Marseille U. Inst. of Fluid Mechanics (France).

THREE-DIMENSIONAL FLOW THROUGH AN AXIAL COMPRESSOR, by J. Valensi. July 30, 1955, 1v. incl. illus. diagrs. tables. (Technical rept. no. 1) (AFOSR-TN-56-134) (AF 61(514)425) AD 86010 Unclassified

A 0.50-m tip-diameter axial flow compressor stage was designed and operated at low speed (2460 rpm) to study individual blade row performance and secondary flow effects. The stage consisted of 30 inlet guide vanes, 31 rotor blades, and 34 stator blades with sections for the 3 rows computed theoretically. This stage had a hub-to-tip diameter ratio of 0.5, and was designed, with the assumption of perfect fluid and simple radial equilibrium, to give a total pressure-rise coefficient of 0.63 at a flow ratio of 0.48. The design allowed sufficient space between the rows for the instrumentation required in making a detailed analysis of blade-row flow distribution; the casing was made of transparent perspex in order to permit visual observations by smoke. The following studies were made: (1) description of the flow by the use of conventional type of instrumentation (pressure probes); (2) determination of individual blade-sections performance and over-all performance; (3) adaptation of the smoke method for visualizing the flow through the compressor; and (4) determination of the general features of the flow. Observations were made at 3 different values of the flow coefficient corresponding, respectively, to design, maximum pressure rise coefficient, and high rate of flow. Secondary flow effects were thoroughly analyzed and discussed. (Contractor's abstract)

MAR. 01:002

Marseille U. Inst. of Fluid Mechanics (France).

THREE DIMENSIONAL FLOW THROUGH AN AXIAL COMPRESSOR, VOLS. I AND II, by J. Valensi. (Final rept.) July 1956, 2v. incl. illus. diagrs. tables, refs. (AFOSR-TR-56-30) (AF 61(514)425) AD 95820 Unclassified

A 0.50-m tip diameter axial flow compressor stage was designed and built. It was operated at low speed (2460 rpm) on a test bed especially designed and built in order to investigate individual blade row performances and secondary flow effects. Investigation included: (1) description of the flow by the use of pressure probes; (2) determination of velocity diagrams and of overall compressor performances at design and at off design flow rates; and (3) investigation of rotating stall. Secondary flow effects are analyzed and discussed, and recommendations are given for the improvement of the design. (Contractor's abstract, modified)

MDU. 01:001

Maryland U. Dept. of Mathematics, College Park.

THE TOPOLOGY OF ALMOST UNIFORM CONVERGENCE, by J. W. Brace. Dec. 1956, 28p. refs. (AFOSR-TN-56-595) (AF 18(603)78) AD 115022 Unclassified

Also published in Portugal. Math., v. 14: 99-104, 1956.

Let $\{f_\alpha,\ \alpha \in A\}$ be a net of real or complex valued functions defined on a set S. Sirvint (Studia Math., v. 11: 71-94, 1950) introduced the notions of almost uniform convergence of such a net. $\{f_\alpha\}$ converges almost uniformly to the function f_0 on a set $T \subset S$ if and only if for every net $\{x_\beta\}$ defined from a directed set B to the set T,

$$\lim_{\alpha}\left[\lim_{\beta}\inf |f_\alpha(x_\beta) - f_0(x_\beta)|\right] = 0.$$

This paper concerns itself with the characterization of weak and weak* convergence on the conjugate X^* of a convex linear topological space X in terms of almost uniform convergence on certain types of subsets of X. The principal theorem states that the weak topology on X^* is equivalent to the topology of almost uniform convergence on bounded subsets of X. This provides a method of characterizing weak convergence on X^* without reference to X^{**}. The paper concludes with several theorems on weak continuity of linear transformations on X. In particular, the above characterization of weak convergence provides a short proof of the weak continuity of the adjoint of a weakly continuous operator. (Math. Rev. abstract)

MDU. 02:001

Maryland U. Dept. of Physics, College Park.

STATISTICAL MECHANICS OF TRANSPORT AND NONEQUILIBRIUM PROCESSES, by E. W. Montroll and M. S. Green. [Apr.] 1954, 63p. refs. [AFOSR-TN-54-54] [AF 18(600)1015] AD 32110 Unclassified

Also published in Ann. Rev. Phys. Chem., v. 5: 449-476, 1954.

A survey of literature is presented on the types of nonequilibrium processes and the statistical hypotheses used to discuss them. The transport properties of gases, dense gases, liquids, and quantum fluids are considered, as well as nonequilibrium phenomenon and the theory of random processes.

MDU. 02:002

Maryland U. Dept. of Physics, College Park.

FREQUENCY SPECTRUM OF VIBRATIONS OF A CRYSTAL LATTICE, by E. W. Montroll. Apr. 1954, 33p. incl. diagrs. refs. (Technical rept. no. 6) [AFOSR-TN-54-106] [AF 18(600)1015] AD 34621 Unclassified

MDU. 02:003 - MDU. 02:007

Also published in Amer. Math. Monthly, v. 61 (Supplement): 46-73, 1954.

The general characteristics of the frequency distribution g (v) of the Born-von Kármán model of crystal lattices is reviewed with special emphasis upon the existence of singularities. The discussion of the vibration of periodic lattices is introduced by an analysis of some 2-dimensional examples, and the discussion is generalized to 3-dimensional systems. Discussions are presented of: (1) the topological basis for the logarithmic singularities in the 2-dimensional frequency spectrum; and (2) the nature of the singularities in 3-dimensional lattices.

MDU. 02:003

Maryland U. Dept. of Physics, College Park.

THE STATISTICAL MECHANICS OF ELECTRICAL CONDUCTION IN FLUIDS, by M. S. Green. [1954] 7p. [AFOSR-TN-54-183] (AF 18(600)1015) Unclassified

Also published in Jour. Phys. Chem., v. 58: 714-716, Sept. 1954.

The theory was applied specifically to a model of an electrolyte in which certain molecular species carry electric charges and in which external fields are possibly present. Expressions are given for conductivities and other irreversible coefficients in terms of specific random processes.

MDU. 02:004

Maryland U. Dept. of Physics, College Park.

THEORY OF THE VIBRATION OF SIMPLE CUBIC LATTICES WITH NEAREST NEIGHBOR INTERACTIONS, by E. W. Montroll. Jan. 1955, 1v. incl. diagrs. refs. (Technical note no. BN-48) ([AF]OSR-TN-55-43) (AF 18(600)1015) AD 54838 Unclassified

A model is analyzed of a simple cubic lattice with interactions between nearest neighbors. Cubes of 1, 2, 3, and a very large number of dimensions are discussed. The number of normal modes is determined for a given frequency interval, and the distribution function of the location of a given atom with respect to its equilibrium position is shown to be Gaussian. Analytical expressions are obtained for the dispersion in terms of dimensionality, temperature, and interatomic forces. A method is outlined for the discussion of the effect of local disturbances such as impurities and holes on lattice vibrations. A brief calculation is made of the quantum mechanical zero point energy of the lattice model. (ASTIA abstract)

MDU. 02:005

Maryland U. Dept. of Physics, College Park.

ANHARMONICITY AND MONOMOLECULAR REACTIONS, by R. H. Tredgold. Feb. 1955 [8]p. incl. diagr. (Technical rept. no. 12) ([AF]OSR-TN-55-[54]) (AF 18(600)1015) AD 55588 Unclassified

Also published in Proc. Phys. Soc. (London), v. 68A: 920-923, 1955.

A brief summary is given of the present theories of monomolecular reactions and of the significance of anharmonicity. A model involving anharmonic forces is studied in which 3 bodies are constrained to move in a straight line; each body has a unit mass, and the degree of excitation is high enough so that classical mechanics can be used. Exact solutions are obtained, and the results indicate that a treatment of monomolecular reactions based on a purely harmonic model always yields a lower reaction rate than that actually observed. The effect of anharmonicity is not important at high pressures, but may make a substantial difference in reaction rate at medium and low pressures. (ASTIA abstract)

MDU. 02:006

Maryland U. Dept. of Physics, College Park.

EFFECT OF DEFECTS ON LATTICE VIBRATIONS [I], by E. W. Montroll and R. B. Potts. July 1955, 65p. incl. diagrs. refs. (Technical rept. no. 18) ([AF]OSR-TN-55-206) (AF 18(600)1015) AD 66842 Unclassified

Also published in Phys. Rev., v. 100: 525-543, Oct. 15, 1955.

The theory of the effect of localized defects such as impurities, holes, and interstitials on the vibrations of crystal lattices is developed. Although most of the analysis is concerned with 1-dimensional chains, the general approach to defects in 3-dimensional lattices is outlined through the example of a simple cubic lattice with nearest neighbor interactions. (Contractor's abstract)

MDU. 02:007

Maryland U. Dept. of Physics, College Park.

ON THE SOLID PHASE OF THE RARE GASES, by R. U. Ayres and R. H. Tredgold. Aug. 1955, 17p. refs. (Technical rept. no. 20) ([AF]OSR-TN-55-252) (AF 18(600)1015) AD 72639 Unclassified

Previous theoretical work on the crystal structure of the rare gases is discussed. A model is proposed which allows the overlap of adjacent atoms to be taken into account. The Van der Waal forces are studied in a reciprocal space representation. A series expansion

for the zero point energy associated with the dipole-dipole coupling is obtained, and it is shown that the overlap effect favors the stability of the face centered cubic (fcc) lattice as opposed to the close packed hexagonal lattice. It is suggested that this mechanism is responsible for the fact that, with the exception of helium, the rare gases crystallize in the fcc structure. The possibility of using this model to correlate the optical and thermal properties of these substances is also briefly discussed. (Contractor's abstract)

MDU. 02:008

Maryland U. Dept. of Physics, College Park.

EFFECT OF DEFECTS ON THE VIBRATIONS OF AN ALTERNATING DIATOMIC LATTICE, by P. Mazur, E. W. Montroll, and R. B. Potts. Nov. 1955, 27p. incl. diagrs. (Technical rept. no. 22) ([AF]OSR-TN-55-422) (AF 18(600)1015) AD 78474 Unclassified

In a perfect alternating lattice, the normal frequencies fall into 2 bands separated by a gap. For the monatomic lattice, localized modes can occur with discrete frequency levels out of the bands when the lattice contains such defects as isotopes. For the alternating lattice, 4 cases arise. When 1 of the lighter masses m is replaced by an isotope m', then if $m' < m$, one level jumps from the optical band into the region above, whereas if $m' > m$, one level jumps from the bottom of the optical band into the gap. When one of the heavy masses is replaced by a lighter isotope, one frequency jumps from the top of the acoustical band into the gap, while a second level jumps from the top of the optical band into the region above. When one of the heavy masses is replaced by a heavier isotope, no frequencies emerge. The defect level which rises out of the top of the acoustical band into the gap is of interest; as the defect mass approaches zero the level approaches the level at the gap center. The self energy of an isotope is computed, and the series solutions are obtained which cover the range of variation of the masses. The interaction energy between 2 isotopes is proportional to the inverse cube of the distance of separation and is attractive for 2 light or heavy isotopes and repulsive for a light and a heavy isotope.

MDU. 02:009

Maryland U. Dept. of Physics, College Park.

GENERAL THEORY OF INTERACTION OF DEFECTS IN THREE DIMENSIONAL LATTICES, by E. W. Montroll and R. B. Potts. Dec. 1955, 44p. refs. (Technical rept. no. 24) ([AF]OSR-TN-55-481) (AF 18(600)1015) AD 81689 Unclassified

The self energies and interaction energies of isotopes, holes, and source defects in simple cubic monatomic and diatomic lattices are derived by a general method. Results are also obtained for the interaction of defects with lattice boundaries. The consequences of letting the lattice spacings vanish are discussed, and the similarity is shown between the continuum limit of a lattice with holes and Wentzel's pair theory of the interaction of neutrons and protons.

MDU. 02:010

Maryland U. Dept. of Physics, College Park.

THEORY OF DILUTE HIGH POLYMER SOLUTIONS (THE PEARL NECKLACE MODEL), by A. Isihara and R. Koyama. Apr. 1956 [21]p. incl. diagrs. tables, refs. (Technical rept. no. 34) (AFOSR-TN-56-199) [AF 18(600)1015] AD 87512 Unclassified

Also published in Jour. Chem. Phys., v. 25: 712-716, Oct. 1956.

A theoretical expression is derived for the second virial coefficient A_2 of chain polymer solutions. The expression describes the empirical relation between A_2 and molecular weight M in which A_2 is proportional to M^{-a}, where a has a value of about 0.23 over a suitable range of molecular weight. Theoretically, $a \simeq 1/2 - 3/4 (\log 1.684\chi)$, where χ is a variable proportional to the square root of M, when χ becomes large. The theory agreed with the data of Krigbaum and Flory (Jour. Amer. Chem. Soc., v. 75: 1775, 1955). The determination of the potential function between polymer segments is discussed.

MDU. 02:011

Maryland U. Dept. of Physics, College Park.

ON THE CRYSTAL STRUCTURE OF THE RARE GASES, by R. U. Ayres and R. H. Tredgold. May 1956, 5p. (Technical rept. no. 39) (AFOSR-TN-56-200) (AF 18(600)1015) AD 87513) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago U., Ill., Nov. 25-26, 1955.

Abstract published in Phys. Rev., v. 100: 1257, Nov. 1, 1955.

Also published in Proc. Phys. Soc. (London), v. 69B: 840-842, 1956.

Quantitative investigations were made of the following effects which are likely to influence the lattice energy: (1) the interaction of the repulsive first-order overlap energy with the triple dipole forces, and (2) higher order multipole 3-body forces. The first effect was shown previously to be of insufficient magnitude to explain the face-centered cubic (fcc) crystal structure of rare gases. In the higher order triple multipole forces, the dipole-dipole-quadrupole forces are non-negligible and, because of their marked angular

MDU. 02:012 - MDU. 02:015

dependencs, the resulting energy terms arising from them in the 2 close-packed structures are shown to differ appreciably. The intsraction Hamiltonian is given for 3 atoms located at lattice sites 1, 2, and 3 in the form $H' = H_{dd}(12) + H_{dq}(23) + H_{dq}(31)$ for dipoles at 1 and 2 and a quadrupole at 3. The third-ordsr psrturbation energy is $E_{(3)} = \sum_{j,k}{}'' \frac{H'_{oj}H'_{jk}H'_{ko}}{(E_o - E_j)(E_o - E_k)}$; the other terms which usually appear in a third-order perturbation are zero in this case. The approximation $E_j - E_o = E_{ionization}$ reduces the perturbation energy to $E_{(3)} = \frac{\langle H'^3 \rangle_{oo}}{E^2_{ion}}$. The only nonzero contribution which arises from the cross term $\langle H_{dd}(12)H_{dq}(23)H_{dq}(31) \rangle$ for all permutations 1, 2, 3 is shown. Appropriate lattice sums were determined for the fcc and cph (close-packed hexagonal) lattices on a high-speed computing machine. Results indicate that the hexagonal structure represents the lowest energy state in solid rare gases but that, at higher temperatures, the fcc structure is stable and is frozen in on cooling. (ASTIA abstract)

MDU. 02:012

Maryland U. Dept. of Physics, College Park.

THE CORRELATION OF TWO ELECTRONS, by R. H. Tredgold and J. S. Evans. Aug. 21, 1956 [10]p. incl. diagrs. tables. (Technical rept. no. 55) (AFOSR-TN-56-415) (AF 18(600)1015) AD 96224 Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago U., Ill., Nov. 25-26, 1955.

Abstract published in Phys. Rev., v. 100: 1250, Nov. 15, 1955.

In this mathematical study, the exact ground-state solution for a system consisting of 2 electrons in a 3-dimensional harmonic-oscillator potential is obtained. The system is also studied by various well-known approximate methods, and the approximate solutions are compared with the exact solutions. It is shown that for all the approximate methods studied the wave functions fail badly for the region corresponding to small interelectronic spacings. (Contractor's abstract)

MDU. 02:013

Maryland U. Dept. of Physics, College Park.

SEARCH FOR A LATENT HEAT ASSOCIATED WITH THE MAGNETIC TRANSITION IN CHROMIUM IN THE REGION OF 475°K, by N. de Haas. Oct. 31, 1956 [4]p. incl. table, refs. (Technical rept. no. 58) (AFOSR-TN-56-525) (AF 18(600)1015)

AD 110343 Unclassified

The rssults of tiie tests for the heat content of the Cr sample and the capsule system with respsct to 0°C for temperatures in the range 440° - 509°K ars tabulated. The total heat content varies linearly with temperature and no latent hsat of transition is noticed.

MDU. 02:014

Maryland U. Dept. of Physics, College Park.

EFFECT OF DEFECTS ON LATTICE VIBRATIONS: INTERACTION OF DEFECTS AND AN ANALOGY WITH MESON PAIR THEORY, by E. W. Montroll and R. B. Potts. [1956] [13]p. incl. table, refs. [AF 18 (600) 1015] Unclassified

Published in Phys. Rev., v. 102: 72-84, Apr. 1, 1956.

An analysis is given of ths determination of additive functions of the frequencies of the normal mode vibrations of a lattice. The method is applied to the problem of calculating the self-energiss and interaction energies of dsfects in lattices of any dimension. In particular results are derived for the self-snergiss and interaction energies of isotopes, holes, and "source" defects in simple cubic monatomic and diatomic lattices. For sxample it is shown that two holes in a simple cubic lattice attract each othsr, the energy of interaction being inversely proportional to the cube of the distance of separation. The gensral method is also applied to the problem of the interaction of lattice defects with the boundaries of the lattice. Finally, if the lattice approaches the limit of a continuum, it is shown that the energy of interaction between two holes is just that obtained by Wentzel for the interaction between two fixed nucleons according to the scalar meson pair theory. (Contractor's abstract)

MDU. 02:015

Maryland U. [Dept. of Physics] College Park.

EFFECT OF DEFECTS ON LATTICE VIBRATION. II. LOCALIZED VIBRATION MODES IN A LINEAR DIATOMIC CHAIN, by P. Mazur, E. W. Montroll, and R. B. Potts. [1956] 11p. incl. diagrs. (AF 18 (600)-1015) Unclassified

Published in Jour. Wash. Acad. Sciences, v. 46: 1-11, Jan. 1956.

The electrical properties of semiconductors due to the influence of defects or local disturbances in otherwise regular media can easily be excited into a conducting state. In a perfect attenuating lattice the normal frequencies fall into two bands separated by a gap. It is shown that localized nodes can occur with discrete frequency levels out of the bands when the lattice contains defects such as isotopes. Four cases arise with the interchange of a lighter or heavier mass with a lighter or heavier isotope. The defect level arising

from the acoustical band into the gap can be interpreted as a surface mode due to the defect mass approaching zero. The self energy of an isotope is computed, and the series solutions obtained, one valid for $m \approx M$ and the other for $m \gg M$, together cover the whole range of variation of the masses. The interaction energy between two isotopes is proportional to the inverse cube of the distance of separation and is attractive for two light or two heavy isotopes and repulsive for a light and a heavy isotope.

MDU. 03:001

Maryland U. Dept. of Physics, College Park.

[SUMMARY OF U. S. CONTRIBUTIONS TO THE GEOPHYSICAL ASPECTS OF COSMIC RAYS] by S. F. Singer. [Sept. 1954] 8p. incl. refs. [AFOSR-TN-54-170A] (AF 18(600)1038) Unclassified

Presented at meeting of the International Union of Geodesy and Geophysics, Rome (Italy), Sept. 14-25, 1954.

Published in Trans. of the Rome Meeting of the Assoc. of Terrestrial Magnetism and Electricity (Sept. 14-25, 1954), IAGA Bulletin No. 15, Copenhagen, 1957, as Chapter VII, p. 247-255 (Title Cosmic Rays).

A brief survey article is presented on the properties of primary cosmic radiation, its composition and energy spectrum, the absence of low energy primaries and its interpretation, and the variety of fluctuations and variations of the cosmic ray intensity which has been studied in the past three years. Only work done in the United States is discussed. A bibliography of 50 references is included.

MDU. 03:002

Maryland U. [Dept. of Physics] College Park.

THE MOUSE, by S. F. Singer. [1954] [2]p. incl diagrs. [AF 18(600)1038] Unclassified

Published in Sky and Telescope, v. 14: 15, 17, Nov. 1954.

The development of the MOUSE (minimum orbital unmanned satellite of the earth) is proposed for observations from 190 miles above the earth's surface. It would circle the earth, maybe for only a few days and would weigh about 100 pounds. Automatic instruments, powered by lightweight solar batteries, would record data on astrophysical and other observations and transmit the data by radio to ground stations. The proposal is for a 3-step rocket with a few pounds of payload. The first step is planned to take the satellite vertically through the lower atmosphere and to begin its inclined flight. The 2nd step will take over immediately after burnout of the first stage, in order to reach the required altitude and direction of the motion. The 3rd step simply boosts the velocity up to its orbital value. At the point of burnout or fuel cutoff (controlled from the ground), the nose tip will open and the spinning sphere which is the MOUSE itself will begin to describe a relatively stable orbit around the earth. The total cost of 5 MOUSE satellites with their 3-stage rockets is estimated at about 5 million dollars. The IGY, 1957, is suggested as target date.

MDU. 03:003

Maryland U. [Dept. of Physics] College Park.

ORIGIN OF THE CHARGE SPECTRUM OF PRIMARIES (Abstract), by S. F. Singer. [1955] [1]p. [AF 18-(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 24, Jan. 27, 1955.

Evaporation theory, cosmic-ray data, and helium analyses of meteorites were used to determine the charge distribution of the primaries. The required mean path length is 6 g/cm^2. Points for the fragmentation hypothesis are: (1) it leads to the same velocity spectrum for all components. Certain injection mechanisms favor heavy nuclei. Crucial tests are: the presence of Li, Be, B in the primary radiation, as well as He^3 and H^3. Enhancement of heavy primaries during solar flare increases. (Contractor's abstract, modified)

MDU. 03:004

Maryland U. [Dept. of Physics] College Park.

THE ALBEDO CONTRIBUTION IN THE MEASUREMENT OF COSMIC-RAY PRIMARIES (Abstract), by R. C. Wentworth and S. F. Singer. [1955] [1]p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 23-24, Mar. 17, 1955.

The major uncertainty in the determination of the primary proton spectrum lies in the evaluation of the effects of albedo. A number of experiments have shown that the albedo contribution has a minimum in the vertical direction, but could not assign a value to it. This vertical minimum seems plausible by simple theoretical arguments. Calculation has been made of the "splash" albedo moving vertically upward near the top of the atmosphere at $\lambda = 56°$, using data from balloon emulsions and high energy accelerators. The results are compared with recent experiments. The difficulties inherent in our calculation and in the experimental approach are discussed. A time-of-flight telescope would give data of great value about

MDU. 03:005 - MDU. 03:008

upward-moving albedo. The theoretical treatment is extended to include the effects of geomagnetic albedo in n approximate way. (Contractor's abstract)

MDU. 03:005

Maryland U. [Dept. of Physics] College Park.

A NEW METHOD FOR MEASURING THE LOW ENERGY SPECTRUM OF PRIMARY COSMIC RAYS (Abstract), by S. F. Singer. [1955] [1]p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Measurements of the primary spectrum with balloons and also rockets suffer from the contribution of unknown amounts of albedo. High latitude measurements have established a "knee" in the spectrum caused by the marked paucity of primaries with momentum/charge less than 1.5×10^9 volts. The actual number is unknown but would be of great importance for our understanding of the relation of cosmic rays to events in the solar system. Present high latitude measurements may be inherently unsuitable because of complicating effects of the earth's quadrupole field and our inadequate knowledge of the shadow cone. An entirely different approach lies in measuring the cosmic ray intensity at the geomagnetic equator as a function of altitude starting at the top of the atmosphere, surmounting the cosmic ray "plateau" and extending the measurements to extreme distances from the earth. A preliminary calculation of the expected intensity variation with altitude has been carried out for the equatorial case, using geomagnetic theory and taking into account the geomagnetic shadow of the earth. The results demonstrate the potentialities of the proposed method for determining accurately the primary cosmic ray spectrum down to energies well below the "knee," away from albedo effects and distortions of the magnetic dipole field near the earth. (Contractor's abstract)

MDU. 03:006

Maryland U. [Dept. of Physics] College Park.

GEOMAGNETIC ALBEDO AT ROCKET ALTITUDES AT THE EQUATOR (Abstract), by H. Griem and S. F. Singer. [1955] [1]p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 8, Apr. 28, 1955.

Cosmic-ray secondaries above the "top" of the atmosphere ("albedo") present an unknown contribution in experiments designed to measure the flux of primary protons. The question of albedo is of particular importance at the geomagnetic equator; it enters into all considerations connected with the primary spectrum, in particular the energy balance. At the present time knowledge of the equatorial albedo is sparse: it is > 35 percent of the total flux at 45° zenith angle and made up mainly of minimum ionizing particles. In attacking the albedo problem theoretically, it is noted that at the equator the magnetic field confines charged secondaries to the altitude region in which they are produced. Depending on altitude and range they can make many loops between production and absorption, thus enhancing their contribution to the counting rate. This process has been studied in detail for protons and electrons of various energies, and their relative contribution to the albedo is discussed. (Contractor's abstract)

MDU. 03:007

Maryland U. Dept. of Physics, College Park.

STUDIES OF A MINIMUM ORBITAL UNMANNED SATELLITE OF THE EARTH (MOUSE). PART I. GEOPHYSICAL AND ASTROPHYSICAL APPLICATIONS, by S. F. Singer. [1955] [14]p. incl. diagrs. refs. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Rocket Soc., Baltimore, Md., Apr. 20, 1955.

Published in Astronautica Acta, v. 1: 171-184, 1955.

A MOUSE would provide a far-reaching extension of present high altitude rockets in the study of the upper atmosphere and extraterrestrial radiations. Lifetimes of even a few days and payloads as low as 50 pounds would be adequate to allow continuous observations of the solar ultraviolet and x-radiations which have a profound influence on the ionosphere and therefore on radio communications. The cause of magnetic storms and aurorae could be established with more certainty. Observations of cosmic rays would help clear up the question of their origin. Various other astrophysical phenomena, such as micrometeorites, could be brought under direct observation. Measurement of the earth's albedo (reflected sunlight) would give a measure of total world cloud coverage which could be used to predict long term climatic changes. Radio transmissions from MOUSE would send back all data and allow at the same time a study of the ionosphere. The change in the orbit and the lifetime would give information on drag and therefore upper atmosphere densities, while observation of a luminous trail of sodium emitted from the satellite would allow studies of winds, temperature, and turbulence in the outermost layers of the earth's atmosphere. (For Part II, see item no. MDU. 03:024) (Contractor's abstract)

MDU. 03:008

Maryland U. Dept. of Physics, College Park.

THE PRIMARY COSMIC RADIATION AND ITS TIME VARIATIONS, by S. F. Singer. May 22, 1956, 1v. incl. diagrs. tables, refs. (Technical rept. no. 40)

(AFOSR-TN-56-234) (AF 18(600)1038) AD 88354
Unclassified

Also published as a Chapter in Cosmic Ray and Elementary Particle Physics, Vol. IV, N. Y., Interscience, 1957.

The present status and some of the outstanding problems in the study of the primary cosmic radiation and of its variation with time are reviewed. Experimental data on primary radiation are analyzed to obtain its composition and the energy spectra of the various components. The results obtained indicated the following main conclusions: (1) an appreciable abundance of Li, Be, and B in the primary radiation, (2) the exponent for different ene gy spectra forms of the various components increases with the charge, (3) the possible difference between the originally injected and accelerated radiation, and the primary radiation is the result of fragmentation in interstellar space, and (4) the flux of very low energy primaries varies with the sunspot cycle. Changes in the primary radiation (especially during the large time variations) are discussed relative to solar flare increases, and Forbush type decreases.

MDU. 03:009

Maryland U. Dept. of Physics, College Park.

METEOROLOGICAL MEASUREMENTS FROM A MINIMUM SATELLITE VEHICLE, by S. F. Singer. Jan. 14, 1956, 1v. incl. illus. diagrs. tables, refs. (Technical rept. no. 30) [AF 18(600)1038] AD 121009
Unclassified

The purpose of this study is to examine some problems connected with the data-collecting satellite itself, its orbit, orientation, and instrumentation, and to indicate some of the applications of the data gathered to meteorology. It is demonstrated that the resolution attainable with the minimum satellite and simple detectors considered would provide information on: (1) global heal balance and general tropospheric circulation patterns; (2) long-term albedo changes and their relation to climatic changes; (3) synoptic albedo changes and the development and motion of storm areas; (4) long-range weather forecasting; and (5) variations in vertical O_3 distribution and stratospheric circulation. Calculations are carried out in appendixes I-III for determining vertical O_3 distribution, planetary temperatures as a function of albedo, and dependence of surface temperature on long-term albedo change. Appendix IV considers the use of the minimum satellite, equipped with a photocell, as a "storm-patrol" station.

MDU. 03:010

Maryland U. Dept. of Physics, College Park.

MEASUREMENTS OF INTERPLANETARY DUST, by S. F. Singer. Mar. 1956, 22p. incl. diagr. refs. (Technical rept. no. 33) [AF 18(600)1038]
Unclassified

In this study, some aspects of the hypothesis that particles of interplanetary dust carry an electric charge, and are therefore affected by electric and magnetic fields, as well as by gravity and radiation pressure, are developed. The following subjects are treated: (1) physical ideas about dust particles; (2) calculation of magnetic rigidity (momentum/charge); (3) calculation of the charge including photoelectric emission and electron accretion; (4) transient charge effects; (5) dynamics of dust particles including gravitational, electromagnetic, and radiation pressure effects, as well as friction with interplanetary gas; (6) magnetic rigidity spectrum; (7) latitude dependence of dust particle flux; (8) dust particle motion under combined magnetic and gravitational fields and the application of Liouville's theorem from statistical mechanics; (9) geophysical implications, e. g., dust density and total influx, auroral effects; (10) anisotropy, diurnal vibration; (11) impact zones; and (12) magnetic storm effects.

MDU. 03:011

Maryland U. Dept. of Physics, College Park.

MEASUREMENTS OF THE EARTH'S MAGNETIC FIELD FROM A SATELLITE VEHICLE, by S. F. Singer. Mar. 1956 [25]p. incl. diagrs. (Technical rept. no. 32) [AF 18(600)1038] Unclassified

The application of satellite observations to magnetic measurement on 3 different time scales is considered. Part A discusses the measurement of the earth's main field and its secular variations. The main advantages of the use of a satellite over other methods are described. Part B is concerned with short time variations of the field and atmospheric current systems. It is pointed out that the satellite magnetometer, being located above the ionosphere, observes the magnetic fields produced by atmospheric current systems in opposite phase when compared to sea level magnetometer measurements. Both instruments, however, observe currents external to the earth's atmosphere (the presumed Störmer ring current) in the same phase. As a result, this technique allows determinations to be made of the location and strength of the currents responsible for magnetic storms at low latitudes and in auroral zones, as well as for the disturbed and quiet diurnal variations. Part C focusses on transient variations. These variations, resulting from rapid motions of ionized gases near the earth, produce sudden magnetic commencements and other changes in the earth's field. A physical model is presented in which the approach and penetration of a magnetohydrodynamic shockwave results in a sudden commencement (SC) increase. It is noted that satellite observation data will indicate location of the SC currents and overcome the ionosphere shielding effects. Appendix I describes the proton-free precession magnetometer, its operation, sources of error, data-storage problems, and telemetering. Appendix II discusses a proposed model experiment to verify certain critical points concerning the magnetohydrodynamic shockwave treated in Part C. Appendix III considers some parameters of this

MDU. 03:012 - MDU. 03:016

shockwave in interplanetary space.

MDU. 03:012

Maryland U. Dept. of Physics, College Park.

THE ARTIFICIAL EARTH SATELLITE – PAST, PRESENT AND FUTURE, by S. F. Singer. Mar. 12, 1956, 9p. [AF 18(600)1038] Unclassified

The author discusses how satellite experiments lead to a better scientific understanding of our environment, which may have important consequences for our economy and way of life. The use of satellites for storm tracking and weather control are also briefly discussed.

MDU. 03:013

Maryland U. Dept. of Physics, College Park.

COSMIC RAY EFFECTS ON MATTER AT HIGH ALTITUDES, by S. F. Singer. [1956] [18]p. incl. diagrs. refs. (Technical rept. no. 14) [AF 18(600)-1038] Unclassified

Presented at meeting of the Aeromedical Assoc., Washington, D. C., Mar. 1955.

Published in Jour. Aviation Med., v. 27: 111-116, Apr. 1956.

In this study, major attention is focussed on nuclear effects resulting from cosmic radiation of matter. Though these effects are small, they are cumulative. Numerical values are presented for the effects, and a calculation is described for gauging their biological effectiveness. It is pointed out that the shielding problems against heavy primaries and nuclear disintegrations are similar. Calculations indicate that hydrogen materials (water, kerosene, etc.) provide optimum shielding. In addition, cosmic-ray induced radioactivity is discussed, particularly the radioactivity of the moon's surface.

MDU. 03:014

Maryland U. [Dept. of Physics] College Park.

SATELLITES FOR PHYSICISTS, by S. F. Singer. Apr. 1956 [3]p. incl. diagrs. [AF 18(600)1038] Unclassified

Published in Phys. Today, v. 9: 21-23, Apr. 1956.

In this brief summary, artificial space satellites are described as being indispensable tools of research for use in all branches of physics, including field theory. It is pointed out that these satellites can be used to measure the cosmic-ray intensity and composition; solar ultraviolet and x-rays on a continuous basis; magnetic field at high altitudes; intensity of meteoric dust; and other electromagnetic and corpuscular radiations. Additional applications are considered.

MDU. 03:015

Maryland U. [Dept. of Physics] College Park.

COSMIC-RAY PRODUCTION OF HELIUM-3 AND TRITIUM IN METEORITES, by M. Galli and S. F. Singer. [1956] [1]p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 231, Apr. 26, 1956.

The production of He^3 and H^3 in meteorites by cosmic-ray bombardment has important consequences for the origin of meteorites, as well as for the origin of cosmic rays. Earlier calculations have been extended to include the depth dependence of He^3. Various cosmic-ray data are considered as well as the recent accelerator measurements of Fireman, and of Libby's group. The results are applied to the problem of mass loss of meteorites in space and in the atmosphere. The "formation age," "solidification age," and "breakup (or cosmic-ray) age" of meteorites are clearly distinguished. Conclusions are drawn about the prehistoric cosmic-ray intensity by viewing the meteorite as an integrating cosmic-ray meter. (Contractor's abstract)

MDU. 03:016

Maryland U. [Dept. of Physics] College Park.

TRAPPED ORBITS IN THE EARTH'S DIPOLE FIELD, by S. F. Singer. [1956] 2p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Also published in Bull. Amer. Phys. Soc., Series II, v. 1: 229, Apr. 26, 1956.

Charged particles emitted by the sun or in its vicinity are usually deviated on approach to the earth by its magnetic field at a distance of about 10 earth diameters. Occasionally this field is sufficiently disturbed by large numbers of such particles to permit their closer approach and possible entrapment by the earth's field. The very complicated motions of these trapped particles can be discussed statistically. While some of the particles will be scattered out by perturbations in the earth's field, the majority remain in and are slowly depleted from this trapped region which extends down to the earth's surface in the auroral zone. Here depletion is greatest, with the particles moving in the earth's atmosphere where they are absorbed. However, only those randomly-oriented particles which move along the magnetic line of force enter the atmospheric portion of the trapped regions; the greater part are reflected back to the trapped region. Connections between this region of trapped particles and geophysical

phenomena are suggested. A current is formed by the drift of these particles around the earth, positive particles moving from west to east and negative particles vice versa, which produce a magnetic field observable on earth; this current has been identified with the hypothetical Störmer ring current, a suggested cause of magnetic storms. Particles entering the earth's atmosphere in the auroral zones are held responsible for the aurora, for the airglow, and probably for considerable atmospheric disturbance. Primary cosmic rays upon hitting the atmosphere generate secondaries some of which scatter into the trapped particle region and thus increase its population; their contribution is small however in comparison to that from low-energy solar corpuscular radiation.

MDU. 03:017

Maryland U. Dept. of Physics, College Park.

THE EFFECT OF METEORIC PARTICLES ON A SATELLITE, by S. F. Singer. May 1956 [20]p. incl. tables, refs. (Technical rept. no. 41) (AF 18(600)1038) AD 102634 Unclassified

In evaluating environmental effects on vehicles above the atmosphere the influence of meteoric dust is one of the least well known. The present paper deals primarily with the erosion phenomena due to impact of high velocity meteoric dust and constrasts them with radiation damage effects due to cosmic rays. A review is given of the penetration effects of large meteors. Collisions with gas leading to sputtering, and corrosion by highly reactive radicals are also briefly discussed. To calculate the sandblasting erosion of meteoric dust one needs data on the flux of micrometeors and on the effects of individual impacts. Some plausible physical models are developed; they lead to widely differing values for the erosion rate. Laboratory experiments with artificial dust particles accelerated to meteor velocities should furnish more reliable values. An experiment is described for measuring the skin erosion of the Vanguard satellite. It is based on a radioactive method which has many advantages in terms of sensitivity and simplicity. Some of the technical problems relate to the choice of radioactive material and to its incorporation into the skin of the satellite. The erosion experiment is of considerable scientific value in terms of improvement of our knowledge of: the micrometeor flux at normal times and during meteor streams; the electric charge of interplanetary dust; geomagnetic effects on charged dust particles; effectiveness of solar gas streams in sweeping particles from interplanetary space. (Contractor's abstract)

MDU. 03:018

Maryland U Dept. of Physics, College Park.

A METHOD FOR CALCULATING IMPACT POINTS OF HIGH ALTITUDE ROCKETS, by R. C. Wentworth and S. F. Singer. June 1, 1956 [13]p. incl. diagrs. (Technical rept. no. 42) [AF 18(600)1038] Unclassified

A method for calculating the impact point of a ballistic rocket is described which uses a reference system which is fixed with respect to the stars. The rotation of the earth is taken into account by two means: (1) by giving the rocket at burn-out a horizontal velocity component equal to the earth's surface speed due to its rotation; and (2) by finding the impact point (in the fixed coordinate system), calculating the time of flight of the rocket, and calculating, therefore, how far the earth has turned while the rocket has described its trajectory. This method has been found to be less tedious than the alternative method, which uses a coordinate system fixed with respect to the launching point.

MDU. 03:019

Maryland U. Dept. of Physics, College Park.

THERMONUCLEAR PROCESSES IN THE AURORA, by S. F. Singer. Aug. 1956 [19]p. incl. diagrs. tables, refs. (Technical rept. no. 52) (AF 18(600)1038) Unclassified

The purpose of this study is to point out the possibility that thermonuclear reactions exist in the aurora, and that they are initiated by the same fast particles which are responsible for the luminous displays and the ionization. Of particular interest are capture followed by γ-ray emission, i.e., (p,γ), (d,γ), (α,γ), reactions, since the γ-rays are highly penetrating, being obtained at much lower altitudes ($\sim$50,000 ft). It is noted that: (1) the γ-rays act as specific indicators of the characteristics, energy, and flux of the incident particles; (2) the prominent reactions are thermonuclear and lead to a considerable release of energy, one-half of this being propagated downward; (3) the nuclear effects in the upper atmosphere must be considered in the design of the skin of space vehicles; and (4) the isotropic transmutations have interesting geochemical consequences, e.g., the production of N^{15}, O^{17}, and O^{18}. The reaction $N^{14}(p,\gamma)O^{15} \xrightarrow{\beta^+} N^{15}$ is discussed in detail. The observation of these nuclear γ-rays provides a new method for studying the aurora.

MDU. 03:020

Maryland U. Dept. of Physics, College Park.

WHY EARTH SATELLITES, by S. F. Singer. [1956] [3]p. AF 18(600)1038] Unclassified

Published in Inst. Radio Engineers, Student Quart., v. 3: 3-4, 56, Sept. 1956.

Observations of the earth could be made by a satellite. Cloud distribution could be determined. The heat input into the earth's atmosphere by the sun could be studied. The reflected sunlight which goes back out into space could be measured. Quite importantly, the sun's ultraviolet and x-radiation could be measured by a satellite. By observing the satellite's orbit, information could be obtained on the effects of the earth's

MDU. 03:021 - MDU. 03:024

gravitational field, effects of the residual atmosphere, and the density of the atmosphere at various altitudes.

MDU. 03:021

Maryland U. Dept. of Physics, College Park.

THE APPLICATION OF AN ARTIFICIAL SATELLITE TO THE MEASUREMENT OF THE GENERAL RELATIVISTIC "RED SHIFT," by S. F. Singer. Mar. 1956 [11]p. incl. diagrs. (Technical rept. no. 31) [AF 18(600)1038] Unclassified

Also published in Phys. Rev., v. 104: 11-14, Oct. 1, 1956.

The use of a satellite vehicle to further verify the general theory of relativity is considered. At present, this theory is substantiated only by astronomical measurements, the most important of these being: (1) the advance of the perihelion of the planet Mercury; (2) the gravitational deflection of light rays; and (3) the gravitational displacement of spectral lines. The artificial satellite provides the possibility for testing the gravitational red shift by deriving the shift experienced by a clock located in the satellite with respect to a clock located on the earth's surface. Details of this derivation are presented in an appendix Relativistic Effects of Satellite Clocks. It is pointed out that with respect to an earth clock, the shift is calculated to be a "red shift" for low-altitude orbits, zero shift for an orbit one-half the earth's radius, and a "violet shift" for higher altitudes where it approaches 7×10^{-10}. Some experimental schemes for the measurement of the clock shift are discussed. It is stated that a digital or counting method best fits the needs of the experimental tests, being of great accuracy, and avoiding signalling problems created by the motion of the satellite.

MDU. 03:022

Maryland U. Dept. of Physics, College Park.

GEOPHYSICAL RESEARCH WITH ARTIFICIAL EARTH SATELLITES, by S. F. Singer. [1956] [67]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 53) [AF 18(600)1038] Unclassified

Published in Advances in Geophys., v. 3: 301-367, 1956.

A review is presented of geophysical experiments which have been suggested for a satellite. A number of additional experiments are also offered for suggestion. All applications are limited to a "minimum" satellite (that is, one which is not very large or heavy and therefore capable of being launched within the next few years). The approach used primarily describes geophysical applications from the core of the earth outward into space regardless of their relationship or causual connections. A discussion is provided of the ionosphere and solar ultraviolet radiation which produces the ionosphere. A group of related subjects are presented as an organic whole, e.g., the complex of meteorological measurements, and the complex of solar-terrestrial phenomena. The technical problems are analyzed and the design features of satellites and requirements which they have to fulfill in order to be capable of various types of observations are discussed.

MDU. 03:023

Maryland U. [Dept. of Physics] College Park.

A NEW MODEL OF MAGNETIC STORMS AND AURORAE (Abstract), by S. F. Singer. [1956] [1]p. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Geophys. Union, Washington, D. C., May 1956.

The following model is proposed to explain the sudden commencement (SC) of magnetic storms, the SC and pre-SC disturbances. The solar eruption produces a shockwave which arrives at the earth 22-34 hr later. High velocity particles having a smaller interaction precede the shockwave and cause the pre-SC bay-like disturbances at high altitudes. The shockwave itself is retarded by the body forces produced by the geomagnetic field, splits and enters the auroral zones. In pushing out lines of force it creates the polar SC events. Charge separation in the shockwaves produces the driving force for the SC currents which flow in the atmosphere (in accordance with Vestine's analysis). The storm decrease following about 9 hr after the shockwave, is produced by the high velocity particles which enter, because of field perturbations, into the normally inaccessible Störmer regions around the dipole. Here they are trapped and will drift producing the ring current which gives rise to the storm decrease. Particles with pitch angle < 2-1/2° however can reach the earth's atmosphere and will produce aurora, some of the airglow, and ionsphere disturbances. These particles are replenished by perturbations produced by solar influences having a 27-day recurrence. Many other particles are absorbed or scattered out of the trapping regions so that their number diminishes rapidly in a day or so, concomitant with the magnetic-storm decrease.

MDU. 03:024

Maryland U. Dept. of Physics, College Park.

STUDIES OF A MINIMUM ORBITAL UNMANNED SATELLITE OF THE EARTH (MOUSE). PART II. ORBITS AND LIFETIMES OF MINIMUM SATELLITES by S. F. Singer. [1956] [20]p. incl. diagrs. table. [AF 18(600)1038] Unclassified

Presented at meeting of the Amer. Rocket Soc., New York, Nov. 30-Dec. 3, 1954.

Published in Astronautica Acta, v. 2: 125-144, 1956.

The (elliptical) orbit of an artificial satellite is described in terms of the launching conditions (i.e., at

"burnout"); in particular minimum and maximum altitudes of the ellipse are given as a function of launching altitudes and of errors in launching velocity and angle. Criteria are then developed for controlling the launching conditions. The subsequent behavior of the orbit is investigated under the influence of the drag of the upper atmosphere. The "lifetime" of the satellite depends on its area and mass, and is related to the upper atmosphere densities; hence, these densities can be determined from measured changes of the orbit by methods discussed in detail. Both circular and elliptic orbits are investigaged using appropriate approximation methods. Three appendices are included which take up: (1) some features of orbit theory; (2) upper atmosphere densities; and (3) critical examination of approximation methods. (For Part I, see item no. MDU. 03:007) (Contractor's abstract, modified)

MDU. 04:001

Maryland U. Dept. of Physics, College Park.

VARIABLE MICROLEAK, by J. L. Davis. Nov. 15, 1956, 4p. incl. diagrs. (Technical rept. no. 59) (AFOSR-TN-56-569) (AF 18(600)1582) AD 110390
Unclassified

A satisfactory method of testing helium sensitive mass spectrograph leak detectors is presented. The detector is evacuated to a pressure within its operating range and then the pressure is raised to a standard amount by admitting a gas mixture containing a known concentration of helium. The resulting indication is a direct measure of the sensitivity. A valve or leak that can be varied is essential to raise the pressure the known amount. A valve which is easily made and fulfills all the requirements for this method of testing is described as well as an apparatus for preparing a known concentration of helium. The soft brass valve body is made on a lathe and the seat is formed by reaming with a 5/0 standard taper pin reamer. It is recommended that the reaming be done on a lathe to insure accurate centering. The threads on the stem were cut after the body was threaded, and the body was used as a gage for the diameter of the stem threads. The leakage rate was variable from 0 to 4 x 10^{-7} standard liters/sec with about 1/2 turn of the stem. It was possible to control the pressure in the leak detector to within ± 3 x 10^{-7} mm Hg. With an Octoil Manometer, it is possible to measure a concentration of helium in air of about 1 part in 3000 to about 10^{7}.

MDU. 05:001

Maryland U. Glenn L. Martin Inst. of Tech., College Park.

HARMONIC GENERATION BY CRYSTALS AT MICROWAVE AND MILLIMETER WAVE FREQUENCIES, by Y. C. Hwang. Final rept. Jan. 31, 1956. 79 p. incl. illus. diagrs. refs. (Rept. no. EE-2505) (AFOSR-TR-56-20) (AF 18(600)1246) AD 88025
Unclassified

An investigation was made to study existing methods of harmonic generation in order to determine the reason for low efficiency, to determine the required physical properties of a semiconductor device for higher efficiency harmonic generation and the effect of low temperature on the performance of harmonic generators, and to study polyphase harmonic generators. The art of crystal harmonic generation at microwave and millimeter wave frequencies is reviewed. The causes of low efficiency are discussed. Multipliers were constructed which gave better performance by 4 to 10 db for the 2nd and 3rd harmonics. Improvement was achieved by improving the power transfer to the crystal and by controlling the length, contact, and pressure of the whisker. Some improvement was obtained by a 2-phase arrangement; this arrangement is not promising for higher harmonics. In many cases, power inputs of about 30 mw were used with harmonic outputs exceeding 1 mw. (ASTIA abstract)

MDU. 06:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE LAMINAR JET MIXING OF TWO COMPRESSIBLE FLUIDS, by S. I. Pai. Feb. 11, 1952, 10p. diagrs. (Technical rept. no. BT-1) (AF 33(038)10481) U22949
Unclassified

Also published in Proc. Second Midwestern Conference on Fluid Mechanics, Ohio State U., Columbus (Mar. 17-19, 1952), Columbus, Coll. of Engineering (Bull. no. 149 of OSU Engineering Exper. Station), 1952, p. 297-307.

The laminar jet mixing of 2 compressible fluids is investigated theoretically under the assumptions that the mixture is a continuous medium, there is no reaction between the fluids, and the fluids are perfect gases. The fundamental equations for 2-dimensional steady flow are derived and solved for jet mixing of 1 compressible fluid and for isothermal and isovel[illegible] mixing of 2 compressible fluids. Numerical exa[illegible]s are worked out for the mixing of a uniform strea... of CO_2 with one of air and for a 2-dimensional jet of CO_2 issuing into surrounding moving air. Results indicate that the spread of mass is wider than that of velocity, and that the momentum of the jet fluid is an important factor in the jet mixing problem.

MDU. 06:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

PHYSICAL PHENOMENA IN GAS JETS, by D. Bershader, B. [illegible] B. [illegible] Cary and others. Final rept. Oct. 1952, 53p. illus. tables, refs. (AF 33(038)10481) AD 2221
Unclassified

The investigation is concerned with the optical study

MDU. 06:003 - MDU. 06:005

of compressible jets; the supersonic flow of a two-dimensional jet in a uniform stream; the axially symmetrical jet mixing of a compressible fluid; problems in the study of turbulence; and the growth of a laminar boundary layer behind a shock wave. Considerable effort has been devoted to the design and construction of a 6-in. Mach Zehnder interferometer and some preliminary experiments on a small jet have been performed. A theoretical analysis has been made of a supersonic jet issuing into a uniform stream. The theory of Pai for the 2-dimensional mean velocity and temperature distribution in both laminar and turbulent jet mixing regions has been extended to the axially symmetrical flow. Experimental studies of the flow on the boundary of the jet have been carried out by optical devices and have yielded results in good agreement with the theory of Pai. Through the study of simple models of turbulence some understanding has been gained on the mechanism of turbulence in jets. Some experimental work in a shock tube has been accomplished as an associated research project.

MDU. 06:003

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

OPTICAL STUDY OF COMPRESSIBLE JETS, by D. Bershader and B. [B.] Cary. [1952] [36]p. incl. illus tables, refs. (Pt. 1 of its Final rept. AD 2221) [AF 33(038)10481] AD 2221(a) Unclassified

Instrumentation problems and techniques for the study of jets are discussed. Construction and operation of a nozzle and a gimbal assembly for use with a 6-in. Zehnder-Mach interferometer is described, and the interferometric evaluation of 2-dimensional flows is discussed. Over-all features of an M = 1.7 nozzle and jet were analyzed, showing the cases of overpressure, full expansion, and underpressure. Studies were made at full expansion but without glass windows to show the growth of turbulent mixing for a jet with 4 free boundaries. Density profiles were measured across the mixing zone at several stations up to 8 jet half-widths downstream of the orifice: the temperature profiles can be computed from the density profiles. The technique of interferometry is shown to be practicable for the quantitative study of the jet mixing problem, and this can be extended to axially symmetric flow. Agreement exists between a constant-exchange coefficient theory of turbulent 2 dimensional mixing applied to compressible flow and the experimental results for a small jet discharging air into the atmosphere under full expansion at M = 1.7. Full-expansion jets were produced which were 2-dimensional up to 15 orifice half-widths from the extrapolated origin, with or without glass walls beyond the orifice. The divergence of a supersonic jet was smaller than that of a slower speed jet. The value for the coefficient of eddy kinematic viscosity was 4.75 sq cm/sec, while the ratio of the turbulent to the laminar exchange coefficient was 1.26 x 10^3, which is of the same order of magnitude as the ratio for incompressible flow.

MDU. 06:004

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

ON SUPERSONIC FLOW OF A TWO-DIMENSIONAL JET IN UNIFORM STREAM, by S. I. Pai. [1952] [18]p. incl. illus. (Pt. 2 of its Final rept. AD 2221) [AF 33(038)10481] AD 2221(b) Unclassified

Also published in Jour. Aeronaut. Sciences, v. 19: 61-65, Jan. 1952.

It is well known that a supersonic gas jet issuing from a reservoir into a medium at rest has a periodic structure if the difference of pressure of the jet from the medium is not large. This investigation considers a similar situation when a supersonic gas jet is issuing into a uniform stream. It is found that if the uniform stream is subsonic, the supersonic jet has almost periodic structure, and the approximate wavelength increases with the Mach number of the surrounding stream for a given Mach number of the jet. If the uniform stream is supersonic, the supersonic jet does not have periodic structure. The transmission and the reflection of small disturbances at the boundary of the jet, i.e., a vortex sheet, are investigated. Factors of transmission and reflection of disturbances on the vortex sheet are found. They are functions of the Mach numbers of the jet and that of the uniform stream. The reflection wave may be of the same sign or of the opposite sign of the incident wave or zero according to the Mach numbers of the two streams. (Contractor's abstract)

MDU. 06:005

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

AXIALLY SYMMETRICAL JET MIXING OF A COMPRESSIBLE FLUID, by S. I. Pai. [1952] [13]p. incl. illus. (Pt. 3 of its Final rept. AD 2221) [AF 33-(038)10481] AD 2221(c) Unclassified

Also published in Quart. Appl. Math., v. 10: 141-148, July 1952.

The problems of the flow of a 2-dimensional jet of a compressible fluid issuing from a finite opening into a uniform stream and of the uniform mixing of 2 streams of compressible fluid have been studied (Pai, S. I., Two-Dimensional Jet Mixing of a Compressible Fluid, Jour. Aeronaut. Sciences, v. 16: 463-469, 1949). Both the laminar and the turbulent cases were considered. The effects of compressibility owing to large temperature difference and those resulting from high velocity were treated simultaneously. In the present study, this analysis is extended to the case of an axially symmetrical jet of a compressible fluid issuing into a uniform stream. The flow of the jet is assumed to be under full expansion from a nozzle, i.e., the pressure of the flow at the exit of the nozzle is exactly equal to that of the surrounding stream. The pressure gradient

in the jet is assumed to be negligible. Both the laminar and turbulent cases are considered. First, laminar flow is treated. The usual assumptions of boundary layer theory are adopted to simplify the Navier-Stokes equations. A solution by the method of small perturbations is obtained, and the exact solution is examined. A numerical integration method is used to compute the velocity and the temperature distributions in the jet for the exact solution. Turbulent flow is then considered. The fundamental equation of motion of an axially symmetrical jet is derived by using Taylor's hypothesis concerning the transport of vorticity and Reichardt's assumption of free turbulence, i.e., the assumption that the exchange coefficient over each cross-section of the mixing zone is constant. By suitable transformation of variables, the equations of turbulent flow become identical to those of laminar flow. Therefore the solution obtained for laminar flow can be applied in turbulent flow provided that the empirical quantity of eddy viscosity has been evaluated by experiment.

DU. 06:006

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

PROBLEMS IN THE STUDY OF TURBULENCE, by R. Betchov. [1952] [16]p. incl. illus. refs. (Pt. 4 of its Final rept. AD 2221) [AF 33(038)10481; continued by AF 18(600)86] AD 2221(d) Unclassified

The thermal inertia of the hot-wire anemometer is discussed. Results of computations of the distribution of temperature along the wire with a linear differential equation did not check with experiment. Approximations and experiments were used to predict the difference between the time lags due to fluctuations in wind speed and electric current. No visible difference between the 2 time lags occurred either with platinum or tungsten wires. The hot wire was shown to be a possible technique for the study of shock-wave phenomena. The difference between the theoretical time lags was smaller than the experimental error. Electronic instruments were studied for multiplying 2 signals and measuring mean cubes and statistical distributions in turbulence. Multiplication techniques were examined, including nonlinear characteristics, diode-chain multipliers, and chains of pentodes. A 12-tube chain of pentodes operated within 7% error under difficult conditions. A diode-chain circuit gave the mean cube of a signal, having approximately gaussian probability distribution, with an error less than 10%. A statistical analyzer gave the amplitude distribution of an electric signal, falling within the spectral region 10 to 10,000 c, and 3 nearly perfect gaussian distributions. Turbulent flow was compared with a nonlinear system excited by random impulses. This approach amounts to studying solutions of a simplified Navier-Stokes equation in which the partial derivatives are replaced by ordinary derivatives. An electric network analogy was suggested by the transformed equation, and a turbulence model was constructed. The solutions of the system and their stability are discussed. No large differences occurred between the model and the flow observed in a pipe by means of a hot-wire anemometer. (ASTIA abstract)

MDU. 07:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SUPERSONIC ROTATIONAL FLOW OVER TWO-DIMENSIONAL OGIVES, by S. I. Pai. [1953] 15p. incl. illus. tables. [AF 18(600)86; continuation of AF 33(038)10481] Unclassified

Also published in Proc. Third Midwestern Conference on Fluid Mechanics, Minnesota U. Inst. of Tech., Minneapolis (Mar. 23-25, 1953), Minneapolis, Univ. Press, June 1953, p. 303-317.

The supersonic flow fields behind attached curved shock over plane ogives are calculated by the theory of linearized rotational flow for two cases: One is a sinusoidal ogive, and the other is a wedge with blunt nose. It is found that the finite slope of the surface of the ogive at the tip will cause a big difference between rotational flow and the corresponding irrotational flow. When this slope at the tip is zero, even though the basic disturbance generated from the surface of the ogive is very nearly the same as that of the corresponding irrotational flow case, there is still considerable difference in the resultant velocity field between these two cases because of the reflecting disturbance from the shock. The variation of shock angle of the curved shock is a function of the variation of the slope of the surface of the ogive. (Contractor's summary)

MDU. 07:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

TWO-DIMENSIONAL SUPERSONIC SHEAR FLOW AROUND A CORNER, by S. I. Pai. Jan. 15, 1954, 26p. diagrs. (Technical rept. no. BT-25) [AFOSR-TN-54-91] (AF 18(600)86) AD 29263 Unclassified

Also published in Proc. Second U. S. National Congress on Applied Mechanics, Michigan U., Ann Arbor (June 14-18, 1954), N. Y., Amer. Soc. Mech. Engineers, 1955, p. 637-642.

An approximate solution for two-dimensional supersonic rotational flow of a perfect gas in the neighborhood of a corner around which the flow expands is given. The solution is applied to two cases: (1) a parallel shear flow over a wall with an edge and (2) a parallel shear flow discharging into a medium of constant but lower pressure. (Contractor's summary)

MDU. 07:003

Maryland U. Inst for Fluid Dynamics and Applied Mathematics, College Park.

THE LOW TURBULENCE WIND TUNNEL OF THE UNIVERSITY OF MARYLAND, by R. Betchov. Mar.

MDU. 07:004 - MDU. 07:007

1954, 33p. incl. diagrs. (Technical note no. BN-29) ([AF]OSR-TN-54-173) (AF 18(600)86) AD 36968 Unclassified

A description is given of a low turbulence wind tunnel with closed circuit. The test section is 20- by 20-in., being 15 ft long. Velocities obtainable range from 3 to 150 ft/sec. The tunnel is designed to reduce turbulence, noise, and vibrations.

MDU. 07:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON TURBULENT JET MIXING OF TWO GASES AT CONSTANT TEMPERATURE, by S. I. Pai. June 1954, 27p. incl. diagrs. (Technical note no. BN-33) ([AF]-OSR-TN-54-174) (AF 18(600)86) AD 36967 Unclassified

The fundamental equations of both two-dimensional and axially symmetrical turbulent jet mixing of two gases at constant temperature are derived and discussed. A general method of solution of these equations is given. The most important factors in these equations are the turbulent exchange coefficient for velocity distribution and that for density distribution. In general, these coefficients are not equal. If we assume that these coefficients are the same, an analytic solution for the mixing of two uniform streams is found which is an extension of Görtler's solution for the case of homogeneous fluids. The first order effect of the difference in densities of the two gases in the mixture on the velocity distribution is small. For two-dimensional and axially symmetrical jet from small opening, if the turbulent exchange coefficients are assumed to be the same, the velocity distribution for the case of homogeneous fluid is the first order approximation of the velocity distribution in the jet of the mixing of two gases and the density distribution is the same as the velocity distribution. Finally the effect of the difference in the two turbulent exchange coefficients is discussed. It is found that the ratio of turbulent exchange coefficient for density distribution to that for velocity distribution is larger than one, and may be as high as 2, and the ratio increases as the difference in density of the two gases increases. The larger this ratio is, the wider the spread of the density distribution than that of velocity distribution will be. (Contractor's summary)

MDU. 07:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

AN INSTRUMENT TO STUDY RELAXATION RATES BEHIND SHOCKWAVES, by E. L. Resler, Jr. and M. Scheibe. Aug. 1954, 23p. incl. illus. diagrs. table. (Technical note no. BN-39) ([AF]OSR-TN-54-188) (AF 18(600)86) AD 38864 Unclassified

The instrument comprises a combination of a schlieren system photomultiplier tube and oscilloscope. The sensitivity and properties of the instrument were checked in a series of experiments using commercial CO_2. Oscillograms are presented of shock waves in CO_2 at 1/2- and 1-atm pressures for M = 1.73, 2.16, 2.36, 2.69, and M = 1.42, 1.86, and 2.05, respectively. This technique for measuring relaxation times has the advantages of good space resolution, high sensitivity, and simplicity of interpretation and application. The instrument was originally intended for use in studying the transition zone behind very strong shock waves; however, the light given off behind the waves by the hot gas itself is difficult to separate from the light used in the light beam. In such cases, other techniques must be utilized.

MDU. 07:006

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE STABILITY OF ISOTROPIC TURBULENCE, by R. Betchov. Sept. 1953 [26]p. incl. diagrs. (Technical rept. no. BT-15) [AFOSR-TN-54-345] (AF 18(600)86) AD 18501 Unclassified

Presented at meeting of the Amer. Phys. Soc., Penn. State Coll., University Park, July 1-3, 1953.

Abstract published in Phys. Rev., v. 91: 1031, Aug. 15, 1953.

An analysis of isotropic turbulence indicated that the invariant $\psi = |S_{ik}|$, where S_{ik} is a symmetric tensor, has an upper and a lower limit closely related to the rate of energy dissipation by viscosity. In isotropic turbulence, the average of ψ was proportional to the skewness coefficient S. Experimental evidence suggested that S approaches its maximum value as the Reynolds number tends toward zero. The mean value of the determinant $|U_{ik}|$ was zero for incompressible isotropic and homogeneous turbulence. With certain restrictions and approximations, a perturbation of an incompressible, isotropic and homogeneous field of turbulence had at least one unstable root. The growth of such a perturbation increased with S. (ASTIA abstract)

MDU. 07:007

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON A MODEL OF TURBULENCE, by R. Betchov. June 24, 1952, 22p. incl. diagrs. (Technical rept. no. BT-2) [AFOSR-TN-54-346] (AF 18(600)86) U24664 Unclassified

Presented at meeting of the Amer. Phys. Soc. Columbia U., New York, Jan. 31-Feb. 2, 1952.

Abstract published in Phys. Rev., v. 86: 601, May 15, 1952.

Turbulent flow is compared with the behavior of a nonlinear system excited by random impulses. This approach amounts to studying solutions of a simplified Navier-Stokes equation in which the partial derivatives are replaced by ordinary dertvattves in 1 vartable. An electrical network analogy ts suggested by the transformed equation. The solutions of the system and the stability of the solutions are discussed. An analog computer and feed-back amplifier were used to study the solutions for changes in the inhomogeneous term. There seemed to be no large differences between the model and the flow observed in a pipe by means of a hot-wire anemometer.

MDU. 07:008

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

ON TRIPLE CORRELATIONS IN ISOTROPIC TURBULENCE (Abstract), by R. Betchov. [1954] [1]p. [AF 18(600)86] Unclassified

Presented at annual meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 783, May 1, 1954.

In a turbulent flow, the three points-three velocities correlation functions form a tensor depending on the two displacement vectors A and B. This tensor can be developed in a double power series in A and B with coefficients defined at one point only. Assuming Incompressibility and isotropy relative to rotations and reflexions about one point, we found that the coeffictents of the cubic terms in A^3, AB^2, etc., are all proportional to the mean cube of the local acceleration, that is to the skewness coefficient. Investigations on the stability of such a turbulent flow for perturbations of moderately high-wave numbers lead to the eigenvalues of certain kinematic determinants. The mean values of these determinants are proportional to the skewness coefficient and this parameter appears therefore as an essential quantity Experimental measurements in a turbulent flow behind a grid agree with various consequences of isotropy and confirm the relation between the skewness and the Reynolds number of the turbulence. Furthermore, we found that the mechanism responsible for the skewness coefficient is highly intermittent. (Contractor's abstract)

MDU. 08:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

AN INTRODUCTION TO STRUCTURAL ANALYSIS OF HIGH-SPEED WINGS, by P. J. Theodorides. June 22, 1953. 42p. refs. (Technical rept. no. BT-14) (AF 18-(600)428) AD 57080 Unclassified

This is a review of the present (June 1953) status in analysis of wing structures for aircraft and missiles in high subsonics and beyond. The physical background is emphasized, and the mathematical approach discussed as to research methods and results. The considered wings are thin ones, of low aspect ratio, with sweep and spanwise variation of local rtgidity. It is outlined how their dynamic behavior became predictable by thin plate theory for the solid wtng of constant thickness only. Its static behavior, however, was analytically clarifted by solutions for variable thickness also. As for wings of the stiffened shell type, the Extended Grid method is summarized. It is proceeding with the aid of Green coefficients of tnfluence for determining the alar deformability. Another important new method is surveyed. It achieved a more complete structural analysis by extending the thin plate theory to the reinforced, laminate placoid. The theories are discussed, and the respective solutions are compared as to implications and limitations. Finally it is hinted that work is under way in view of a combined theory for improving this structural analysis. (Contractor's abstract)

MDU. 08:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

LIMITS AND CLASSIFICATION OF SUPERSONIC FLOWS, by T. Theodorsen. Mar. 1954, 26p. diagrs. tables. (Technical note no. BN-23) ([AF]OSR-TN-54-90) (AF 18(600)428) AD 30293 Unclassifted

Necessary and sufficient conditions are presented for the existence or nonexistence of supersonic flow fields. The analysis of the equations of motion of a compressible flow reveals that 2 and only 2 separate and distinct classes of flows exist depending upon whether $(dp/ds)^2 < (1/R^2)f(p)$ or $(dp/ds)^2 > (1/R^2)f(p)$. The first condition is referred to as the sublimit field, and the second is called the translimit field. In both cases, R denotes the radtus of curvature. The sublimit field is exemplified by a potential flow past an airfoil with a supersonic embedded region, and the translimit field is exemplified by the supersonic flow in a Laval nozzle. The 2 fields cannot be joined; a compression flow in a Laval nozzle is prohibited by the second law of thermodynamics whereas a compression flow is the only type possible in the sublimit field. Prandtl-Meyer flow around a corner and the parallel flow represented by a point in the hodograph plane represent a trivial intermediate condition between the sublimit and translimit fields and occur only when $(dp/ds)^2 = (1/R^2)f(p)$.

MDU. 08:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ELASTIC THEORY OF THE COMPOSITE PLACOID IN STRUCTURAL ANALOGY TO A HIGH SPEED WING, by P. J. Theodorides. July 5, 1954, 47p. incl. diagrs. refs. (Technical note no. BN-37) ([AF]OSR-TN-54-169) (AF 18(600)428) AD 40639 Unclassified

MDU. 08:004 - MDU. 09:001

A theory for the elastic behavior of the composite placoid (plate-like) cantilever as an alar type for high-speed aircraft and missiles is presented which accounts for previously neglected shearing effects in rod-like longitudinats of variable rigidity. The structural analysis combines ideas related to the solid wing and the semimonocoque flattened shell. The theory is based on a quasi 3-dimensionat state for the alar skin and a 2-dimensional state for the longitudinat stiffeners. General analytic expressions are derived for the coefficients of elastic interaction between the alar skin and its swept longitudinals with regard to a structural plagiotropy (the coefficient of rod rigidity (unitary, flexural) as contributed by the i^{th} longitudinat is not equat to zero for atl differing i's) of the exosketeton. Three distinct boundary conditions can be satisfied separately by this analysis, and previously known relations are obtained as special cases of the new theory.

MDU. 08:004

Maryland U. Inst. for Ftuid Dynamics and Applied Mathematics, College Park.

AERODYNAMIC INTERFERENCE OF CASCADE BLADES tN SYNCHRONIZED OSCILLATION, by C.-C. Chang and W.-H. Chu. June 1954 [23]p. incl. diagrs. table, refs. (Technical note no. BN-35) ([AF]OSR-TN-54-170) (AF 18(600)428) AD 36966 Unclassified

Also published in Jour. Appl. Mech., v. 22: 503-508, Dec. 1955.

The failure of a compressor is sometimes due to flutter of the blades. Essentially, this problem is equivalent to a cascade in oscillation. The present analysis is to find the aerodynamic load on cascade in synchronized harmonic oscillations, pitching and flapping. Conformal mapping is used. Two characteristic parameters are involved in the force and moment. One is μ which is related to the gap-chord ratio. The other is k which is known as reduced frequency. The main results are expressed in terms of these two parameters. Most can be reduced to closed form. The rest are given in graphs. The wake interference involves one new function $C(\mu, k)$ which is related to a ratio of two hypergeometric functions and which reduces to Theodorsen's function C(k) in the limit of infinite gap. tn a certain range of frequency and gap-chord ratio, the analysis shows quantitatively that single oscillation airfoil theory may lead to inaccurate estimation of interference effect between blades. (Contractor's abstract)

MDU. 08:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

FLOW THROUGH A CASCADE tN FLAPPING OSCILLATION, by C.-C. Chang and W.-H. Chu. 1954, 5p. (AF 18(600)428) Unclassified

Published in Proc. Second U. S. National Congress of Applied Mechanics, Michigan U., Ann Arbor (June 14-18, 1954), N. Y., Amer. Soc. Mech. Engineers, 1955, p. 617-621.

tn a uniform flow, a cascade of ftat-ptate airfoils is subject to smalt flapping oscillation, and is treated analytically with conformal mapping technique. Normal force and moment are given essentially in closed forms. The interference effects among the cascade airfotls are so significant that the usual approximation with single-airfoil theory is questionabte. An example is given to demonstrate this point. The wake tnterference ts expressed in ratio of hypergeometrical functions involving parameters, such as reduced frequency and gap chord ratio. As the gap goes to infinity, it reduces to Theodorsen's function as a special case. (Contractor's abstract)

MDU. 08:006

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

[MULTI-PARAMETRIC VISCOSITY AS A BASIS OF A QUASI-CONTINUUM THEORY OF THE COMPRESSION FRONT FOR POLYATOMIC GASES] Mehrparametrige Zähigkeit als Grundlage einer Quasi-Kontinuumtheorie der Kompressionsfront für Mehratomige Gase, by P. J. Theodorides. 1956, 9p. incl. diagrs. refs. (AF 18-(600)428) Unclassified

Presented at Joint Conference of the Technical Committees for Fluid Dynamics, Göttingen (Germany), Oct. 6-8, 1955.

Published in Zeitschr. Angew. Math. Mech., Sonderheft, Aug. 1956, p. 38-46.

The present work postulates: (1) symmetry of the stress tencor; and (2) three tndependent viscosity mass parameters, one for the linear volume viscosity, and one for each linear and nonlinear shear viscosity. Through a superposition of transposed matrices, the tensors of the speed of deformation and total stress are symmetrized; the dynamic equations are presented in three-dimensional form; the laws for obtaining mass, impulse, and energy are confined to the uniaxial, constant case, with the equation of state combined and transformed. The integration for the case of temperature-dependent characteristics of all gas properties is discussed.

MDU. 09:001

Maryland U. Inst. for Fluid Dynamtcs and Applied Mathematics, College Park.

AN EXTENSION OF THE CLASSICAL STURM-LIOUVILLE THEORY, by H. F. Weinberger. Oct. 13, 1953, 24p. refs. (Technical rept. no. BT-16) (AF 18(600)573) AD 21420 Unclassified

Also published in Duke Math. Jour., v. 22: 1-14,

Mar. 1955.

An explicit solution is given of the eigenvalue problem of a self-adjoint differential operator with a given set of self-adjoint boundary conditions in terms of the Green's function, eigenfunctions, and eigenvalues of another problem having the same operator but different boundary conditions. The theory leads to some new separation theorems of the classical Sturm-Liouville theory. An application to the theory of vibrations is given.

MDU. 09:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

AXIALLY SYMMETRIC PUNCH AND CRACK PROBLEMS, by L. E. Payne. Oct. 1953, 30p. incl. refs. (Technical rept. no. BT-17) (AF 18(600)573) AD 21418 Unclassified

A formulation of axially symmetric punch and crack problems is presented for a medium with transverse isotropy. Complete solutions to general problems are obtained without solving dual integral equations. The formulation reduces to that of solving simple potential problems and permits the convenient introduction of curvilinear coordinates. Solutions to the problem of determining the stress distribution in a semi-infinite isotropic elastic medium when the plane boundary is indented by a perfectly rigid, axially symmetric punch are presented for the case in which the indenting surface is flat, a segment of a sphere, an oblate sphere, or a parabolic segment. Solutions are presented for a spherical, oblate-spherical, and paraboloidal pressure distributions. The stress distribution in an infinite elastic medium where the pressure is prescribed on a disk-shaped crack is considered, and solutions are presented for constant, parabolic, and spherical pressure distributions. Solutions are also presented for the crack problem when the displacement is prescribed. The problems of a point force in the z-direction in the interior of a semi-infinite body $z \geq o$ as well as the corresponding problem in a medium with transverse isotropy are discussed.

MDU. 09:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

RIEMANN'S METHOD FOR PARTIAL DIFFERENTIAL EQUATIONS OF HYPERBOLIC, PARABOLIC, AND ELLIPTIC TYPES, by J. B. Diaz and M. H. Martin. Dec. 9, 1953, 32p. (Technical rept. no. BT-18) (AF 18(600)573) AD 21775 Unclassified

Also published in Ann. Mat. Pura Appl., v. 36: 335-359, 1954.

An investigation is made of partial differential equations of second order, $L(u) = a^{ij}u_{x_i x_j} + a^{i}u_{x_i} = 0$, in 2 independent variables x_1, x_2. Instead of the adjoint equation by Riemann a second partial differential equation $M(v) = b^{ij}v_{x_i x_j} + b^{i}v_{x_i}$ is taken, and its coefficients are determined, together with 2 multipliers λ, μ, such that

$\lambda L(u) + \mu M(v) = \frac{\partial A^1}{\partial x_1} \quad \frac{\partial A^2}{\partial x_2}$, where A^1, A^2 are bilinear forms in the 4 arguments u_{x_1}, u_{x_2}, v_{x_1}, v_{x_2}.

When this is completed the line integral $1 = \int\left[-A^2 dx_1 + A^1 dx_2\right]$ vanishes around closed paths, provided u, v are regular solutions of $L(u) = 0$ and $M(v) = 0$. These considerations are used to unify the treatment of the problem of Cauchy for hyperbolic equations, the initial value problem for parabolic equations, and the Dirichlet problem for equations of the elliptic type. (ASTIA abstract)

MDU. 09:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

FLOW PROBLEMS FOR RING-SHAPED BODIES WITH APPLICATION TO TORSION PROBLEM, by G. Weiss and L. E. Payne. Dec. 1953, 23p. incl. illus. refs. (Technical rept. no. BT-19) (In cooperation with Naval Ordnance Lab., White Oak, Md.) [AFOSR-TN-54-2] [AF 18(600)573] AD 22953 Unclassified

An extension was made of the method of generalized electrostatics (Bull. Amer. Math. Soc., v. 59: 20-38, 1953) so that it will be applicable to flow or torsion problems for ring-shaped bodies. The flow and torsion problems involving toroidal boundaries are presented as special examples. A method was developed for obtaining the flow about a generally axially symmetric n-dimensional body with doubly connected section. The cases for n = 2, 3, and 5 have immediate physical interpretation. The methods proposed can be easily extended to handle problems involving 2 or more bodies which may or may not have simply connected sections. The solution of the problem of a 5-dimensional axially symmetric body in a uniform stream of inviscid incompressible fluid flowing parallel to the axis of symmetry of infinity is shown to be related to the torsion problem for a beam with an axially symmetric cavity. Solutions to the flow problem are obtained for the torus and the torsion problem for a near-cylindrical shaft with a toroidal cavity.

MDU. 09:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE ISOPERIMETRIC INEQUALITY ON SURFACES

MDU. 09:006 - MDU. 09:009

OF VARIABLE GAUSSIAN CURVATURE, by A. Huber. Jan. 1954, 17p. (Technical rept. no. BT-20) [AFOSR-TN-54-8] (AF 18(600)573) AD 25539 Unclassified

Also published in Ann. Math., v. 60: 237-247, Sept. 1954.

An isoperimetric inequality which includes inequalities given by T. Carleman (Math. Zeitschr., v. 9: 154-160, 1921) and F. Fiala (Comm. Math. Helv., v. 13: 293-346, 1940-41) is proved for any sufficiently regular abstract surface. The demonstration is based on an inequality for subharmonic functions and generalizes a result of Carleman and its extension by Beckenbach and Radó (Trans. Amer. Math. Soc., v. 33: 662-674, 1933). A new method of proof of Fiala's inequality is suggested which is valid under less restrictive regularity assumptions, and the inequality is used to characterize surfaces of non-negative curvature.

MDU. 09:006

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

UPPER AND LOWER BOUNDS FOR HARMONIC FUNCTIONS, DIRICHLET INTEGRALS, AND BI-HARMONIC FUNCTIONS, by L. E. Payne and H. F. Weinberger. Jan. 1954, 29p. incl. refs. (Technical note no. BN-21) ([AF]OSR-TN-54-21) (AF 18(600)-573) AD 25455 Unclassified

A method is presented for obtaining arbitrarily close upper and lower bounds for a harmonic function, its gradient, and its Dirichlet integral when the boundary values of the function or its normal derivative are prescribed. The bounds are obtained by means of a harmonic function which approximates the given boundary data.

MDU. 09:007

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE CAUCHY PROBLEM FOR THE WAVE EQUATION AND THE EQUATION OF EULER-POISSON-DARBOUX, by A. Weinstein and E. K. Blum. Jan. 1954, 38p. incl. refs. (Technical note no. BN-22) [AFOSR-TN-54-23] (AF 18(600)573) AD 26066 Unclassified

Consideration is given to the general Euler-Poisson-Darboux equation which depends on a parameter k and which reduces to the wave equation for k = 0. A recently developed method is presented for the solution of the corresponding singular Cauchy problem with data on the singular hyperplane t = 0 for all values of k. The method utilizes neither a fundamental solution nor a Green's identity. For sufficiently large values of k the solution is written explicitly, and for other values of k the Cauchy problem is solved with the aid of 2 simple recurrence formulas for functions of one variable t. The negative odd integral values of k play an exceptional role with no counterpart in the theory of equations with regular coefficients, a new solution for these cases is appended.

MDU. 09:008

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

A TRANSONIC APPROXIMATION, by J. B. Diaz and G. S. S. Ludford. Mar. 1954, 21p. illus. refs. (Technical note no. BN-24) ([AF]OSR-TN-54-79) (AF 18(600)573) AD 28934 Unclassified

Also published in Proc. Second U. S. National Congress on Applied Mechanics, Michigan U., Ann Arbor (June 14-18, 1954), N. Y., Amer. Soc. Mech. Engineers, 1955, p. 651-657.

This approximation is based on obtaining that pressure-density relation which best fits that of a polytropic gas near the sonic point, while retaining the analytical simplicity of the Tricomi gas. Third-order contact can be obtained at the sonic point, and there still remains a parameter, which can be chosen in two ways so as to give good supersonic agreement. These two choices give practically identical results. For this approximation the general solution of the partial differential equation for the stream-function is expressible in terms of Bessel functions, as also are the product solutions. (Contractor's abstract)

MDU. 09:009

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON TWO METHODS OF GENERATING SOLUTIONS OF LINEAR PARTIAL DIFFERENTIAL EQUATIONS BY MEANS OF DEFINITE INTEGRALS, by J. B. Diaz and G. S. S. Ludford. Apr. 1954, 9p. refs. (Technical note no. BN-26) ([AF]OSR-TN-54-87) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)573 and Office of Ordnance Research under DA-36-034-ord-1486) AD 30295 Unclassified

Also published in Quart. Appl. Math., v. 12: 422-427, Jan. 1955.

A connection is established between Bergman's integral operator method (Amer. Jour. Math., v. 74: 444-474, 1952) and a classical method of Le Roux (Annales de l'Ecole Normale Supérieure, 3rd Series, v. 12: 227-316, 1895) for generating solutions of linear differential equations by means of definite integrals with variable limits of integration. A proof is presented that a theorem of Bergman and its modification to include functions of a complex variable are a restatement of part of Le Roux's results. The latter formulation is considered to be simpler in the fluid dynamical application. (ASTIA abstract)

MDU. 09:010

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE ELASTIC SPHERE UNDER CONCENTRATED TORQUES, by A. Huber. May 1954 [11]p. incl. diagrs. (Technical note no. BN-28) ([AF]OSR-TN-54-101) (AF 18(600)573) AD 34622 Unclassified

Also published in Quart. Appl. Math., v. 13: 98-102, Apr. 1955.

Consideration is given to an elastic sphere subject to 2 concentrated torques acting at the end points of a diameter. The stress function is considered as a generalized axially symmetric potential (Bull. Amer. Math. Soc., v. 59: 20-38, 1953) so that the solution is obtained by a simple potential-theoretic argument. The solution is proved to be unique and to possess the right type of singularities.

MDU. 09:011

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON A PROBLEM OF TYPE, WITH APPLICATION TO ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS, by R. Finn. Apr. 1954 [21]p. incl. diagrs. refs. (Technical note no. BN-27) ([AF]OSR-TN-54-119) (AF 18(600)573) AD 31757 Unclassified

Solution of variational problems $\delta \iint F(\zeta_x^2 + \zeta_y^2)$ dx dy, which are defined for all (x, y), are studied with regard to their behavior under conformal mapping. Conditions are formulated under which a surface represented by such a solution cannot be mapped conformally onto the unit disc. This result is applied to discuss the behavior in the large of solutions of non-linear elliptic equations. (Contractor's abstract)

MDU. 09:012

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE GROWTH OF SOLUTIONS OF NON-LINEAR ELLIPTIC PARTIAL DIFFERENTIAL EQUATIONS, by R. Finn. May 1954. 18p. (Technical note no. BN-32) ([AF]OSR-TN-54-133) (AF 18(600)573) AD 34015 Unclassified

Consideration is given to equations of the form $\mathfrak{M}(x, y, \zeta, p, q)_x + \Lambda(x, y, \zeta, p, q)_y = 0$, where $p = \zeta_x$, and $q = \zeta_y$. It is shown that the condition $\mathfrak{M}^2 + \Lambda^2 \cdot 1$ on the integrals of the coefficients with respect to their arguments, together with the ellipticity condition $4\mathfrak{M}_p\Lambda_q - (\mathfrak{M}_q + \Lambda_p)^2 > 0$ is sufficient to permit an a priori estimate on the growth of a solution; but it is not sufficient to permit a corresponding estimate on the derivatives. The analysis depends on the concept of quasi conformality of a mapping. This concept is defined: let $\omega = u + iv$ be a complex valued function of class C''' defined in a domain D of the $z = y + iy$ plane; ω represents a quasi-conformal mapping of eccentricity not larger than ε, $1 \leq \varepsilon < \infty$, provided that (1) the Jacobian $\left(\frac{uv}{xy}\right)$ of the transformation vanishes only at isolated points, and (2) at all points where the Jacobian is different from zero, $(u_x^2 + u_y^2 + v_x^2 + v_y^2)\left(\frac{x\ y}{u\ v}\right) \leq 2\varepsilon$.

MDU. 09:013

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE GENERALIZED RADIATION PROBLEM AND THE EULER-POISSON-DARBOUX EQUATION, by A. Weinstein. June 1954; 26p. refs. (Technical note no. BN-36) ([AF]OSR-TN-54-148) (AF 18(600)573) AD 35529 Unclassified

Also published in Summa Brasiliensis Math. (Rio de Janeiro), v. 3, Fasc. 7: 125-146, 1955.

The classical radiation problem for the wave equation is reformulated in such a way that a problem for the Euler-Poisson-Darboux equation in two independent variables includes as a special case the problem of Tricomi and more recently Germain and Bader (Office National d'Etude et de Recherche Aeronautique, No. 54, 1952, and Sur le probleme de Tricomi Rendiconti del Circolo Matematico di Palermo, Series 2, v. 2: 53, 1953). The latter problem is concerned with transonic flows in which arbitrary data are given on the sonic line and prescribed to be zero on a Mach line. Precise conditions are given under which the radiation problem can be solved, and new formulas are obtained for the solution of the problem for the Tricomi equation. (ASTIA abstract)

MDU. 09:014

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON A THEOREM OF LE ROUX, by J. B. Diaz and G. S. S. Ludford. Aug. 1954, 6p. (Technical note no. BN-38) ([AF]OSR-TN-54-166) (Sponsored jointly by "Air Force" Office of Scientific Research under AF 18-(600)573 and Office of Ordnance Research under DA-36-034-ord-1486) AD 36551 Unclassified

Also published as Interim technical rept. no. 19. Mar. 1956, 4p. DA-36-034-ord-1486; AD 88238.

An extension to definite integrals with singular kernels is given of a theorem of Le Roux (Annales de l'École Normale Supérieure, Series 3, v. 12: 227-316, 1895) which concerns the generation of solutions of linear partial differential equations by means of definite inte-

MDU. 09:015 - MDU. 09:018

grals. The extended theorem is as follows: Let R be an open region of the x, y plane where the coefficients of $L(u) \equiv U_{xy} + a(x,y)u_x + b(x,y)u_y + c(x,y)u = 0$ are continuous, and let $U(x,y,\alpha) = \widetilde{U}(x,y,\alpha)/(x-\alpha)^{\lambda}$, with $0 < \lambda < 1$, be a solution of $L(u) = 0$ for all (x,y) in R, wherever $\alpha_0 \leq \alpha < x$. Let U be such that $\widetilde{U}$, $\widetilde{U}_x$, $\widetilde{U}_y$, $\widetilde{U}_{xy}$, $\widetilde{U}_{\alpha}$, $\widetilde{U}_{\alpha x}$, $\widetilde{U}_{\alpha y}$, $\widetilde{U}_{\alpha xy}$ are continuous on the 3-dimensional region consisting of all (x,y,α) with (x,y) in R and $\alpha_0 \leq \alpha \leq x$. Then

$$u(x,y) = \int_{\alpha_0}^{x} \frac{\widetilde{U}(x,y,\alpha)}{(x-\alpha)^{\lambda}} f(\alpha)\, d\alpha$$

is, for an arbitrary once continuously differentiable function $f(\alpha)$, a solution of $L(u)$ in R. Throughout the discussion, α is a parameter and α_0 is a constant. (ASTIA abstract)

MDU. 09:015

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

A RAYLEIGH-RITZ PROCEDURE GIVING UPPER AND LOWER BOUNDS FOR EIGENVALUES, by H. F. Weinberger. Sept. 1954, 30p. (Technical note no. BN-41) ([AF]OSR-TN-54-264) (AF 18(600)573) AD 44269 Unclassified

Presented at meeting of the Amer. Math. Soc., Laramie, Wyo., Aug. 31-Sept. 3, 1954.

If A and P are positive self-adjoint elliptic differential operators with A of higher order than P, the Rayleigh-Ritz method gives upper bounds for the eigenvalues of $Au = \lambda Pu$. If another such eigenvalue problem, $Bv = \mu Qv$, where B has the same principal part as A and Q is of the same order as P, can be solved and if its eigenfunctions are used in the Rayleigh-Ritz method, the error in the upper bounds for the λ_k is explicitly bounded. The error bound can be made arbitrarily small by using enough eigenfunctions. The eigenvalues of any sufficiently regular ordinary differential operator as well as many partial differential operators may be approximated in this way. (Contractor's abstract)

MDU. 09:016

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE SINGULAR CAUCHY PROBLEM FOR A GENERALIZATION OF THE EULER-POISSON-DARBOUX EQUATION IN TWO SPACE VARIABLES, by J. B. Diaz and G. S. S. Ludford. Oct. 1954, 25p. incl. refs. (Technical note no. BN-34) ([AF]OSR-TN-54-280) (AF 18(600)573) AD 44333 Unclassified

Also published in Ann Mat. Pura Appl., Series IV, v. 38: 33-50, 1955.

An existence and uniqueness theorem is presented for the singular Cauchy problem for the nonhomogeneous Euler-Poisson-Darboux equation in 2 space variables, $u_{xx} + u_{yy} - u_{tt} - \frac{k}{t}u_t = f(x,y,t)$, $t > 0$, $k > 0$, $u(x,y,o) = u_t(x,y,o) = 0$. The solution of this problem is used to prove, by Picard's method of successive approximations, an existence and uniquesness theorem for the following singular Cauchy problem:

$u_{xx} + u_{yy} - u_{tt} - \frac{k}{t}u_t - h(x,y,t)u = 0$, $t > 0$, $k > 0$,

$u(x,y,o) = g(x,y)$, $u_t(x,y,o) = 0$.

MDU. 09:017

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

INEQUALITIES FOR EIGENVALUES OF MEMBRANES AND PLATES, by L. E. Payne. Nov. 1954, 19p. (Technical note no. BN-43) ([AF]OSR-TN-54-324) (AF 18(600)573) AD 47553 Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 4: 517-529, May 1955.

In the first section of this paper relationships are obtained involving the eigenvalues of a membrane fixed on a given boundary and those of a membrane with vanishing normal derivative on the boundary. In the second section a conjecture of A. Weinstein is proved which relates certain membrane eigenvalues with those of the buckling problem for a clamped plate of the same shape. (Contractor's abstract)

MDU. 09:018

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON AN INEQUALITY OF FEJÉR AND RIESZ, by A. Huber. Dec. 1954, 29p. refs. (Technical rept. no. BT-45) ([AF]OSR-TN-54-341) (AF 18(600)573) AD 49708 Unclassified

Also published in Ann. Math., v. 63: 572-587, May 1956.

The following theorem by Fejér and Riesz (Math. Zeitschr., v. 11: 305-314, 1929) and some of its extensions are generalized. Suppose the function $f(z)$ is regular analytic on $|z| \leq 1$. Then the inequality $\int_{-\pi}^{\pi} |f(e^{it})|^{\lambda} dt \geq 2 \int_{-1}^{1} |f(\rho, e^{i\theta})|^{\lambda} d\theta$ holds for any θ $(0 \leq \theta \leq 2\pi)$ and arbitrary $\lambda > 0$. Equality is attained if and only if $f \equiv 0$. The constant 2 is the best possible. The main result of the generalization is also stated as a theorem. Let the function $u(z)$ be defined on the closed unit circle $|z| \leq 1$ as a difference of 2 subharmonic functions $u(z) = u_1(z) - u_2(z)$. Suppose that $u_2(|\zeta| < 1) = \alpha < \infty$, where $u_2(e^{i\zeta})$ denotes the meas-

ure associated with $u_2(z)$. Then the inequality $\int_{-\pi}^{+\pi} e^{u(e^{it})} dt \geq 2\cos(\frac{\pi\alpha}{2}) \int_{-1}^{1} e^{u(\rho e^{i\theta})} d\rho$ holds for any θ ($0 \leq \theta < 2\pi$). Equality holds if and only if $0 < \alpha < 1$ and $u = \log |F^1(z)[F(z)]^{-\alpha}(1-F^2(z))^{\alpha-1}| + C$, where $F(z)$ denotes any conformal transformation of $|z| < 1$ onto itself which maps the diameter $(e^{i\theta}, -e^{i\theta})$ on the real axis; C is an arbitrary real constant. The integrals of the theorem do not necessarily exist under the given hypothesis, but the proof implies that if the integral on the left exists then so does the integral on the right and the inequality holds.

MDU. 09:019

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

REFLECTION PRINCIPLES FOR LINEAR ELLIPTIC SECOND ORDER PARTIAL DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS, by J. B. Diaz and G. S. S. Ludford. Dec. 1954, 17p. refs. (Technical note no. BN-44) ([AF]OSR-TN-54-361) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)573 and Office of Ordnance Research under DA-36-034-ord-1486) AD 51841 Unclassified

Also published in Ann. Mat. Pura Appl., Series IV, v. 39: 87-95, 1955 (Title varies).

Reflection principles, analogous to the classical Schwarz reflection principle for harmonic functions, are obtained for solutions of linear elliptic second order partial differential equations with constant coefficients. The boundary conditions employed are supposed to be satisfied in a limiting sense only, and do not require (a priori) the existence of derivatives on the boundary. (Contractor's summary)

MDU. 09:020

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

INEQUALITIES FOR CERTAIN EIGENVALUES OF A MEMBRANE (Abstract), by L. E. Payne. [1954] [1]p. (AF 18(600)573) Unclassified

Presented at meeting of the Amer. Math. Soc., Laramie, Wyo., Aug. 31-Sept. 3, 1954.

Let D be a closed domain with boundary C in the xy plane and let u(x, y) satisfy the differential equation, $\Delta u + ku = 0$ in D, (where k is a positive constant) and either (1) $u = 0$ on C or (2) $\partial u/\partial n = 0$ on C. We denote the eigenvalues in case (1) by $\lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \ldots$, and in case (2) by $0 = \mu_1 \leq \mu_2 \leq \mu_3 \leq \ldots$. It has been shown by Szegö (Jour. Rat. Mech. and Analysis, v. 3: 354, 1954 that $\mu_2 \leq p\lambda_1$, where p is the constant giving equality if D is a circle. In this article, we obtain for a convex domain D the following inequalities: (3) $\mu_2 \leq \lambda_1 - \frac{2}{(\rho h)_{max}}$ and (4) $\mu_3 \leq \lambda_1 - \frac{(\sqrt{2}-1)}{(\rho h)_{max}} \leq \lambda_1$, where ρ is the radius of curvature of C, and the value of h at any point P on C is the distance from an arbitrary origin inside D to the line tangent to C through P. (Contractor's abstract)

MDU. 09:021

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

THE METHOD OF AXIAL SYMMETRY IN PARTIAL DIFFERENTIAL EQUATIONS, by A. Weinstein. [1954] [11]p. refs. (AF 18(600)573) Unclassified

Published in Atti del Convegno Internaz. sulle Equazioni alle Derivate Parziali (Trieste), Aug. 1954, p. 86-96.

The theory presented here deals with a class of elliptic as well as hyperbolic differential equations. Some recent development in the theory of hyperbolic equations are reviewed. A number of problems concerning the Euler-Poisson-Darboux equation are also discussed.

MDU. 09:022

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON AXIALLY SYMMETRIC CRACK AND PUNCH PROBLEMS FOR A MEDIUM WITH TRANSVERSE ISOTROPY, by L. E. Payne. [1954] [8]p. (AF 18-(600)573) Unclassified

Published in Proc. Cambridge Philos. Soc., v. 50: 466-473, Pt. 3, 1954.

This paper presents a straightforward method for solving the general axially symmetric crack and punch problems for media with transverse isotropy. This method permits one to write down immediately in an appropriate system of curvilinear coordinates the solution to the general axially symmetric proolem.

MDU. 09:023

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics] College Park.

NOTE ON A THEOREM OF OSTROWSKI, by A. Huber. [June 1954] [2]p. (AF 18(600)573) Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 335-336, June 1954.

MDU. 09:024 - MDU. 09:028

The author proves a theorem which is equivatent to the following statement: Let T be a set of reaI numbers, unbounded above, and for each tεT, let F_t be a real continuous function in (a, b); if $\lim_{t\to\infty} F_t(X) =$ F(X) for every Xε (a,b) and F is continuous, then (a, b) contains a point of uniform convergence (a uniforia Cauchy point, in the terminology of Pettis) of $\{F_t\}$. This theorem (as weII as that of Ostrowski) is contained in stronger results obtained by Gordon and McArthur in more generaI situation; in particular, the set of uniform Cauchy points of $\{F_t\}$ is residuat in (a, b), and the continuity of F may be omitted from the hypotheses. (Math. Rev. abstract)

MDU. 09:024

Maryland U. Inst. for Ftuid Dynamics and Applied Mathematics, College Park.

ELLIPTIC AND HYPERBOLIC AXIALLY SYMMETRIC PROBLEMS, by A. Weinstein. [Sept. I954] [6]p. refs. [AF I8(600)573] Unctassified

Publishe'. , Proc. Internat. Congress of Mathematicians, A sterdam, v. 3: 264-269, Sept. 2-9, t954.

This paper presents a short review of the various problems concerning the equation: $\frac{\partial^2 u}{\partial y^2} + \frac{k}{y}\frac{\partial u}{\partial y} = L[u]$ for a function $u = u(x_1, \ldots, x_m, y)$ where L is a linear differential operator in the variables x_1, x_2, ..., x_m with constant or variabte requtar coefficients. k denotes here a reat parameter, $-\infty < k < \infty$. We shatl be mainty concerned with two cases in which L is either $-\Delta u$ or $+\Delta u$, where $\Delta u = \sum_{i=1}^{m} \frac{\partial^2 u}{\partial x_i^2}$. (Contractor's abstract, modified)

MDU. 09:025

Marytand U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

TORSION OF A SHAFT WITH A TOROIDAL CAVITY, by G. Weiss and L. E. Payne. [Oct. 1954] [8]p. refs. (AF 18(600)573) Unclassified

Published in Jour. Appt. Phys., v. 25: I32t-1328, Oct. t954.

A solution is given to the torsion probtem for a near-cytindrical shaft of circular section having a toroidal cavity. Since the interpretation of the axially symmetric problem as a flow problem in 5 dimensions is wetl known, the first part of the paper is devoted to developing a method for handling the ftow problem about an n dimensional ring-shaped body of generat cross section. In the second part of the paper this method is applied to the case of an n-dimensional torus ring. The case n = 3 then yields the solution to the classical ftow problem, and n = 5 gives the sotution to the torsion problem under consideration. (Contractor's abstract)

MDU. 09:026

Maryland U. Inst. for Ftuid Dynamics and Applied Mathematics, Cottege Park.

ON A CLASS OF PARTIAL DIFFERENTIAL EQUATIONS OF EVEN ORDER, by A. Weinstein. Jan. I955, I8p. (Technical note no. BN 16) ([AF]OSR-TN-55-14) (AF I8(600)573) AD 52283 Unclassified

Atso pubtished in Ann. Mat. Pura Appt., v. 39: 245-255, I955.

The general sotutions of the biharmonic equation (theory of ptates), the iterated wave equation, and the equation of Friedrichs are given in terms of generalized axiatly symmetric potentiats and sotutions of the Euler-Poisson-Darboux equation. (Contractor's abstract)

MDU. 09:027

Marytand U. Inst. for Fluid Dynamics and Apptied Mathematics, Cottege Park.

THE ELASTIC SPINDLE UNDER CONCENTRATED TORQUES APPLIED AT THE POLES, by L. E. Payne. Mar. I955, 8p. refs. (Technicat note no. BN-49) ([AF]OSR-TN-55-74) (AF I8(600)573) AD 58484 Unclassified

Atso pubtished in Jour. Science and Engineering, v. I: 37-42, Jan. I957.

The problem of an etastic spindte subjected to 2 concentrated couptes apptied at the potes is considered. The introduction of dipolar coordinates permits a convenient representation for the stress function in terms of Legendre functions. Simpte expressions for the stress function and the stresses are obtained, and the nonvanishing component of the displacement is catcutated for the case of the sphere.

MDU. 09:028

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON A REGULAR CAUCHY PROBLEM FOR THE EULER-POISSON-DARBOUX EQUATION, by R. M. Davis. Apr. 1955, 47p. incl. diagr. refs. (Technical note no. BN-50) ([AF]OSR-TN-55-104) (AF 18(600)573) AD 61001 Unctassified

Atso published in Ann. Mat. Pura Appl., v. 42: 205-226, 1956.

The n-dimensional Eu[illegible] Poisson-Darboux equation (EPD equation) is given

$L_x[u] = u_{x_o x_o} - \sum_{i=1}^{n-1} u_{x_i x_i} + \frac{k}{x_o} u_{x_o} = 0$, where

$x = (x_o, x_1, \ldots, x_{n-1})$ denotes a point in a space-time of n-dimensions, and where k is any real number, $-\infty < k < \infty$. This equation yields the wave equation as a special case for $k = 0$. In this study, the solution of a regular Cauchy problem for the EPD equation with initial conditions

$u(t_o, x_1, \ldots, x_{n-1}) = f(x_1, \ldots, x_{n-1})$ and

$u_x(t_o, x_1, \ldots, x_{n-1}) = 0$ is found. To obtain the solution, the method of Marcel Riesz, developed only for self-adjoint differential equations is extended to cover the non self-adjoint EPD equation. This method of solution involves constructing a function $V^\alpha(x,y)$ depending on a parameter α such that $M_y[V^{\alpha+2}] = V^\alpha = L_x[V^{\alpha+2}]$, where M is the adjoint operator to L, and such that $V^\alpha(x,y)$ and its first derivatives vanish on the characteristic cone with vertex x. (Contractor's abstract)

MDU. 09:029

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

A MAXIMUM PROPERTY OF CAUCHY'S PROBLEM, by H. F. Weinberger. Apr. 1955, 12p. refs. (Technical note no. BN-51) ([AF]OSR-TN-55-110) (AF 18(600)573) AD 62165 Unclassified

Also published in Ann. Math., v. 64: 505-513, Nov. 1956.

It is shown that if the coefficients of the hyperbolic equation $M[u] + eu \equiv (au_x)_x - (bu_y)_y + (cu)_x + (du)_y + eu = 0$ satisfy certain inequalities, and if the Cauchy data u and $\frac{\partial u}{\partial y}$ are nonpositive on an initial arc, then u is nonpositive in the domain of influence of the initial arc. It follows that the Riemann function is nonnegative, and hence that for fixed Cauchy data, u decreases as $M[u] + eu$ increases. An application to ordinary differential equations results in the generalization of a theorem of Bochner on double eigenfunction expansions. (Contractor's abstract)

MDU. 09:030

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

MULTIVALUED FUNCTIONS IN GENERALIZED AXIALLY SYMMETRIC POTENTIAL THEORY, by L. E. Payne. May 1955, 18p. (Technical note no. BN-52) ([AF]OSR-TN-55-146) (AF 18(600)573) AD 66847 Unclassified

Also published in Estratto dagli Ann della Scoula Normale Superiore (Pisa), v. 10: 135-145, 1956.

A representation is obtained for the many-valued function conjugate to the Neumann function for a half plane. This Neumann function is identified as the potential of a source ring, and the conjugate function is identified as the stream function for the same ring. Toroidal coordinates are introduced to obtain a representation of the stream function as a sum of 2 terms. The first term is an arc cotangent a multivalued quantity which displays the cyclic nature of the stream function; the second term is single-valued and vanishes at the branch point. This latter quantity is written as an integral or as a sum of Legendre functions. The solution for the stream function of the source disk is represented in the same manner. New representations for the stream function for a vortex ring to the potential of a source ring are presented. The stream function for a source disk can be represented as the sum of the stream function for a source ring and a quantity which is related to the potential of a vortex ring. The analytical character of all of these functions is exhibited.

MDU. 09:031

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON FUNCTIONS SUBHARMONIC IN A HALF-SPACE, by A. Huber. May 1955, 26p. refs. (Technical note no. BN-53) ([AF]OSR-TN-55-155) (AF 18(600)573) AD 66848 Unclassified

Also published in Trans. Amer. Math. Soc., v. 82: 147-159, 1956.

A study is presented of functions which are subharmonic in an n-dimensional half-space and whose upper limit is nonpositive at all finite boundary points. The method used is based upon a 1:1 correspondence between these functions and a class of functions which are defined and subharmonic in an entire (n + 2)-dimensional space and possess a certain type of symmetry. (Contractor's abstract)

MDU. 09:032

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE REFLECTION PRINCIPLE FOR POLYHARMONIC FUNCTIONS, by A. Huber. Sept. 28, 1955, 15p. (Technical note no. BN-61) (AFOSR-TN-55-175A) (AF 18(600)573) AD 73028 Unclassified

Presented at Symposium on Partial Differential Equations, California U., Berkeley, June 20-July 1, 1955.

Also published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955), N. Y., Interscience Publishers, Inc., 1955, p. 173-180.

MDU. 09:033 - MDU. 09:036

Also published in Communications on Pure and Appl. Math., v. 9: 471-478, Aug. 1956.

A proof is given of the following theorem: suppose that the function $w(x_1, x_2, \ldots, x_n)$ is harmonic of order p (p is a positive integer) in a region G in n-dimensional space, the boundary of which contains an open subset S of the hyperplane $x_1 = 0$, and that w/x_1^{p-1} assumes the boundary value 0 on S; then w can be continued analytically across S into the reflected domain G* by the relation $w(-x_1, x_2, \ldots, x_n) = \sum_{k=0}^{p-1} \frac{(-x_1)^{p+k}}{(k!)^2} \Delta^k \left(\frac{w(x_1, x_2, \ldots, x_n)}{x_1^{p-k}} \right)$.

As an application, the following Phragmen-Lindelöf type of theorem is obtained: suppose that $w(x)$ is harmonic of order p throughout the half-space $x_1 > 0$ and that w/x_1^{p-1} assumes the boundary value 0 on $x_1 = 0$, then $w = o(|x|^p)$ implies $w \equiv 0$.

MDU. 09:033

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

UPPER AND LOWER BOUNDS FOR EIGENVALUES BY FINITE DIFFERENCE METHODS, by H. F. Weinberger. Aug. 1955, 17p. (Technical note no. BN-56) ([AF]OSR-TN-55-247) (AF 18(600)573) AD 69565 Unclassified

Presented at Symposium on Partial Differential Equations, California U., Berkeley, June 20-July 1, 1955.

Also published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955). N. Y., Interscience Publishers, Inc., 1955, p. 315-325.

Also published in Communications on Pure and Appl. Math., v. 9: 613-623, Aug. 1956.

A finite difference method is presented which gives a lower bound for the lowest eigenvalue of the membrane problem for any plane domain. Under certain assumptions on the domain, both upper and lower bounds for this eigenvalue are found by solving a single finite difference problem. The difference between the bounds can be estimated a priori and made arbitrarily small by choosing the mesh size sufficiently small. (Contractor's abstract)

MDU. 09:034

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE THICK ELASTIC SPHERICAL SHELL UNDER CONCENTRATED TORQUES, by J. H. Bramble. July 1955, 17p. (Technical note no. BN-54) ([AF]OSR-TN-55-249) (AF 18(600)573) AD 69583 Unclassified

In this study, a thick elastic spherical shell subjected to concentrated torques at the end points of a diameter is considered. It is proved that the solution is determined uniquely, and an explicit expression is derived for it. Extensive use is made of the fact that the stress function is closely related to an axially symmetric harmonic function, defined in a 7-dimensional space.

MDU. 09:035

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SOME RECENT RESULTS IN LINEAR PARTIAL DIFFERENTIAL EQUATIONS, by J. B. Diaz. Sept. 1955, 36p. refs. (Technical note no. BN-55) ([AF]-OSR-TN-55-328) (AF 18(600)573) AD 73043 Unclassified

Also published in Atti del Convegno Internaz. sulle Equazioni alle Derivate Parziali (Trieste), Aug. 1954, p. 1-29.

Studies on linear partial differential equations are reviewed under the following topics: (1) Riemann's method and generalization of the Lagrange-Green identity; (2) 2 methods of generating solutions of linear partial differential equations by means of definite integrals; (3) a transonic approximation relative to the flow of a polytropic gas; (4) the singular Cauchy problem for a generalization of the Euler-Poisson-Darboux equation in 2 space variables; and (5) upper and lower bounds for quadratic functionals. (ASTIA abstract)

MDU. 09:036

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SOME RESULTS ON GENERALIZED AXIALLY SYMMETRIC POTENTIALS, by A. Huber. Oct. 1955, 15p. incl. refs. (Technical note no. BN-58) ([AF]OSR-TN-55-366) (AF 18(600)573) AD 74510 Unclassified

Also published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 147-155.

Some properties of the solutions of the elliptic partial differential equation $L_k[u] \equiv \sum_{i=1}^{n} \frac{\partial^2 u}{\partial x_i^2} + \frac{k}{x_n} \frac{\partial u}{\partial x_n} = 0$,

where k a real constant, are discussed. The method of generating solutions is given by 2 principles. (1) Let k be a positive integer, then the function $u(x_1, x_2, \ldots, x_n)$, defined in a subregion of the half-space $x_n > 0$, is a solution of $L_k[u] = 0$ if and only if the function $W(\xi_1, \xi_2, \ldots, \xi_{n+k}) \equiv v(\xi_1, \xi_2, \ldots, \xi_n, 1)$

$\sqrt{\xi_n^2 + \ldots + \xi_{n+k}^2}$) is harmonic in the corresponding domain in (n+k)-dimensional space. (2) If u is a solution of $L_k[u] = 0$ in a region G not intersecting with $x_n = 0$, then the function $v = ux_n^{k-1}$ satisfies $L_{2-k}[v] = 0$ and vice versa.

MDU. 09:037

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE EULER-POISSON-DARBOUX EQUATION, INTEGRAL OPERATORS, AND THE METHOD OF DESCENT, by J. B. Diaz and G. S. S. Ludford. Nov. 1953, 31p. refs. (Technical note no. BN-64) ([AF]-OSR-TN-55-411) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)573 and Office of Ordnance Research under DA-36-034-ord-1486) AD 77325 Unclassified

Also published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 73-89.

The problem of determining a real valued function $u(x_1, \ldots, x_m, t)$ which satisfies the Euler-Poisson-Darboux equation $\Delta u = u_{tt} + \frac{k}{t} u_t$, where Δ is the Laplacian, and meets the initial conditions $u(x_1, \ldots, x_m, 0) = f(x_1, \ldots, x_m)$; $u_t(x_1, \ldots, x_m, 0) = 0$, with f a given real valued function defined for all real values of x_1, x_m, is explicitly solved for all values of t, with $-\infty < t < +\infty$. An application of LeRoux's ideas is made to the generation of solutions of the canonical form of the linear hyperbolic differential equation in 2 independent variables: $L(u) = u_{xy} + a(x,y)u_x + b(x,y)u_y + c(x,y)u = 0$. The method of descent is applied to the solution of the Helmholtz equation: $H_n(u) \equiv \nabla_n u + \lambda u = 0$, where $\nabla_n = \sum_{i=1}^{n} \frac{\partial^2}{\partial x_i^2}$, and λ = a real constant. (ASTIA abstract)

MDU. 09:038

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

TWO INEQUALITIES FOR EIGENVALUES OF MEMBRANES, by L. E. Payne and H. F. Weinberger. Nov. 1955, 15p. (Technical note no. BN-65) ([AF]-OSR-TN 55-420) (AF 18(600)573) AD 77324 Unclassified

The first part proves the following isoperimetric inequality. Let R be an N-dimensional region. Let μ_2 be the second (first nonzero) eigenvalue of the problem $\Delta u + \mu u = 0$ on R with the boundary condition $\partial u/\partial n = 0$. Let μ_2^* be the second eigenvalue for the same problem in the N-sphere of the same N-volume as R. Then $\mu_2 \leq \mu_2^*$. The second part deals with the problem $\Delta u + \lambda u = 0$ with the boundary condition $\partial u/\partial n + ku = 0$, $k \geq 0$. Lower bounds for the lowest eigenvalue of this problem on a 2- or 3-dimensional region R are given in terms of k, and the maximum length of line segments in R parallel to the coordinate axes. The inequalities become equalities for rectangles and rectangular parallelopipeds. Similar lower bounds are given for the second eigenvalue when R is symmetric with respect to the coordinate axes or planes. (Contractor's abstract)

MDU. 09:039

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON A CLASS OF PLANE AND AXIALLY SYMMETRIC PROBLEMS IN ELASTICITY, by L. E. Payne. Dec. 1955, 41p. refs. (Technical note no. BN-66) ([AF]OSR-TN-55-454) (AF 18(600)573) AD 79702 Unclassified

Presented at the First Indian Congress on Theoretical and Appl. Mech., Kharagpur (India), Nov. 3, 1955.

Also published in Proc. First Indian Congress on Theoretical and Appl. Mech., 1955, p. 1-18.

Plane and axially symmetric problems are studied in which certain stresses and/or displacements are known either on the boundary of a semi-infinite region or on the 2 boundaries of an infinite strip. Consideration is also given to cases in which isolated singularities act at an interior point in the strip or semi-infinite medium. The formulation chosen is a decomposition of the biharmonic function which reduces the problems in question to classical problems in potential theory. (ASTIA abstract)

MDU. 09:040

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

NEW BOUNDS IN HARMONIC AND BIHARMONIC PROBLEMS, by L. E. Payne and H. F. Weinberger. [1955] [17]p. refs. [AF 18(600)573] Unclassified

Published in Jour. Math. and Phys., v. 33: 291-307, Jan. 1955.

The purpose of this paper is to give a method for obtaining arbitrarily close upper and lower bounds for a harmonic function, its gradient, and its Dirichlet integral when the boundary values of the function or its normal derivative are prescribed. These bounds are obtained by means of a harmonic function which approximates the given boundary data. (Contractor's abstract, modified)

MDU. 09:041 - MDU. 09:045

MDU. 09:041

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE REFLECTION PRINCIPLE FOR POLYHARMONIC FUNCTIONS, by A. Huber. [1955] [7]p. (AF 18-(600)573) Unclassified

Published in Pacific Jour. Math., v. 5: 433-439, Sept. 1955.

The author shows that if $w(x_1, \ldots, x_n)$ satisfies the differential equation $\Delta^p w = 0$ in a region G whose boundary contains an open subset S of $x_1 = 0$ and if w/x_1^{p-1} assumes the boundary value 0 on S, then w may be continued analytically across S into the reflection of G. (Math. Rev. abstract)

MDU. 09:042

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

PROOF OF AN EXISTENCE AND UNIQUENESS THEOREM OF PICARD FOR A NON-LINEAR HYPERBOLIC PARTIAL DIFFERENTIAL EQUATION, BY MEANS OF AN ANALOGUE OF CAUCHY'S POLYGON METHOD, by R. H. Moore. Jan. 1956, 19p. (Technical note no. BN-67) (AFOSR-TN-56-41) (AF 18(600)-573) AD 80553 Unclassified

Following the general method used in proving the existence and uniqueness of the solution of the Cauchy problem for the first order ordinary differential equation by means of Cauchy polygons of approximation, this study considers the existence and uniqueness of the solution of an analogous boundary value problem for a second order hyperbolic partial differential equation by means of approximate solutions which are essentially surfaces of approximation. As in the method for the ordinary equation, a set of convergence inequalities is first obtained, and then it is shown, by means of these inequalities, that the sequence of approximate solutions defined converges uniformly to a unique solution of the hyperbolic equation. (Contractor's abstract)

MDU. 09:043

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE INTEGRATION METHODS OF BERGMAN AND LEROUX, by J. B. Diaz and G. S. S. Ludford. May 1956, 9p. (Technical note no. BN-69) (AFOSR-TN 56-140) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)573) and Office of Ordnance Research under DA-36-034-ord-1486) AD 86017 Unclassified

Also published in Quart. Appl. Math., v. 14: 428-432, Jan. 1957.

In a previous report, a correspondence was found between the representations of solutions of the canonical form of the linear hyperbolic differential equation in 2 independent variables which have been given by S. Bergman and J. Le Roux. This correspondence has the disadvantage that to regular kernel functions, according to Le Roux, there may correspond singular kernel functions in the sense of Bergman. The purpose of this study is to give a second correspondence which avoids this difficulty. (Contractor's abstract)

MDU. 09:044

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE ITERATED WAVE EQUATION, by D. Krahn. May 1956, 29p. (Technical note no. BN-73) (AFOSR-TN-56-239) (AF 18(600)573) AD 88359 Unclassified

Also published in Nederl. Akad. Wetensch. Proc., Indag. Math., Ser. A, v. 60: 492-505, 1957.

A theorem on the decompositions of the general solution of the iterated wave equation is established in terms of solutions of the Euler-Poisson-Darboux equation. A particular decomposition is then chosen to solve a Cauchy problem for the equation $L_o^n(w) = 0$, where $L_o^n \equiv \left(\frac{\partial^2}{\partial n_1^2} + \frac{\partial^2}{\partial n_2^2} + \ldots + \frac{\partial^2}{\partial n_v^2} - \frac{\partial^2}{\partial t^2}\right)^n$ and w is the solution of the equation $L_o^n(w) = 0$, with initial conditions on the boundary $t = 0$. Application of essentially the same techniques is briefly shown for solution of the more general equation $\prod_{i=1}^{n} \left(a_i^2 \frac{\partial^2}{\partial t^2} - \Delta\right) W = 0$. (Contractor's abstract, modified)

MDU. 09:045

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON SUBHARMONIC FUNCTIONS AND DIFFERENTIAL GEOMETRY IN THE LARGE, by A. Huber. May 1956, 92p. refs. (Technical note no. BN-72) (AFOSR-TN-56-261) (AF 18(600)573) AD 88981 Unclassified

Certain problems pertaining to differential geometry in the large are treated by function theoretical methods. Theorems of S. Cohn-Vossen (Compositio Math., v. 2: 69-133, 1935), F. Fiala (Comment. Math. Helv., v. 13: 293-346, 1940-41), and of Ch. Blanc and F. Fiala (Comment. Math. Helv., v. 14: 230-233, 1941-42) are proved in new ways and generalized. Results on analytic functions and differentials are implied. (Contractor's abstract)

MDU. 09:046

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

INEQUALITIES FOR EIGENVALUES OF SUPPORTED AND FREE PLATES, by L. E. Payne. June 1956, 25p. refs. (Technical note no. BN-75) (AFOSR-TN-56-281) (AF 18(600)573) AD 89491 Unclassified

The eigenvalues in the vibration and buckling problems for a supported or free plate were bounded in terms of the eigenvalues in the corresponding fixed or free membrane problems. Eigenvalues of the fixed membrane are monotone with region, while those for the plate problems considered are not. Under certain symmetry conditions, one can obtain a lower bound for the first nonzero eigenvalue in the free membrane problem which involves only the geometry of the region. There are also inequalities which involve the geometry of the plate and the eigenvalues of membranes having the same shape as that of the plate.

MDU. 09:047

Maryland U. Inst. fnr Fluid Dynamics and Applied Mathematics, College Park.

UPPER AND LOWER BOUNDS FOR EIGENVALUES, by J. B. Diaz. June 1956, 47p. refs. (Technical note no. BN-74) ([AF]OSR-TN-56-283) (AF 18(600)-573) AD 89493 Unclassified

Published in Proc. Symposia in Appl. Math. of the Amer. Math. Soc., Chicago, U., Ill. (Apr. 12-13, 1956), New York, McGraw-Hill Book Co., Inc., Vol. VIII, Calculus of Variations and Applications, 1958, p. 53-78.

An account is given of the underlying ideas of the Raleigh-Ritz and the Weinstein methods for the approximation of upper bounds and lower bounds of eigenvalues, respectively. For definiteness, attention has been focussed on a particular differential problem, that of a vibrating clamped plate which was originally utilized by Weinstein (Mémorial des Sciences Mathématiques, v. 88, 1937) in developing his method. In addition, almost all of the relevant differentiability hypotheses required of the "arbitrary" functions occurring in the discussion have been omitted. The eigenvalues are supposed to be defined by means of certain variational problems, and the question of the equivalence between these problems and the corresponding differential problems is not analyzed. The variational problems are used in Section 2 as a basis for all later considerations. In Section 3, the Raleigh-Ritz method is considered, and in Section 4, the Weinstein method is treated.

MDU. 09:048

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON SINGULAR AND REGULAR CAUCHY PROBLEMS, by J. B. Diaz. July 1956, 14p. refs. (Technical note no. BN-79) (AFOSR-TN-56-354) (AF 18(600)573) AD 95440 Unclassified

Presented at Symposium on Partial Differential Equations, California U., Berkeley, June 20-July 1, 1955.

Also published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955), N. Y., Interscience Publishers, Inc., 1955, p. 85-92.

Also published in Cnmmunications on Pure and Appl. Math., v. 9: 383-390, Aug. 1956.

The partial differential equation $\triangle u = u_{tt} + \frac{k}{t}u_{tt}$ with $u = u(x_1, \ldots, x_m, t)$ $\triangle = \frac{\partial^2}{\partial x_1^2}, \ldots \frac{\partial^2}{\partial x_m^2}$ and k = parameter is known as the Euler-Poisson-Darboux equation. The singular and regular Cauchy problems being investigated (initial) conditions or the singular plane $t = 0_w$ and the regular plane $t = t_o > 0$) at Maryland were presented at the Conference in Differential Equations held at the University of California at Berkeley, June 1955. Miss R. M. Davis has shown that, for $k < 0$, the solution of the regular Cauchy problem cannot be expected to approach a solution of a corresponding singular Cauchy problem as t_o approaches zero.

MDU. 09:049

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SUBHARMONIC FUNCTIONS AND GENERALIZED TRICOMI EQUATIONS, by A. Weinstein. Nov. 1956, 22p. refs. (Technical note no. BN-88) (AFOSR-TN-56-574) (AF 18(600)573) AD 110396 Unclassified

The solutinn of a singular Cauchy problem for the hyperbolic Euler-Poisson-Darboux equation with nonnegative index develops the mean value of a sufficiently smooth function. Certain differentiability assumptions are made fnr dealing with hyperbolic partial differential equations. Less smooth functions are not considered. The results are gained by the transformation of the Euler-Poisson-Darboux equation into a generalized Tricomi equation in several variables.

MDU. 09:050

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE GENERALIZED RADIATION PROBLEM OF A. WEINSTEIN, by H. M. Lieberstein. Nov. 1956, 92p. incl. diagrs. refs. (Technical note no. BN-87) (AFOSR-TN-56-594) (AF 18(600)573) AD 115021 Unclassified

MDU. 09:051 - MDU. 09:053

The two-dimensional Euler-Poisson-Darboux equation is studied for solutions $u^{[k]}$ for all $-\infty < k < 1$. The solutions $u_{xx}^{[k]} = u_{yy}^{[k]} + k/y\, u_y^{[k]}$ are constructed so that $u^{[k]}(x,0) = f(x)$, $u^{[k]}(x,x) = g(x)$ where f and g are given functions with a specified number of continuous derivatives on the closed interval $[0, a]$, $a > 0$, and another specified number of vanishing derivatives at the origin, both numbers depending on k. Solutions are constructed with two or more continuous derivatives on the characteristic line $y = x$, and uniqueness does not demand the presence of outer derivatives on the singular line $y = 0$. The necessary techniques and several radiation problem applications are considered and elaborated upon.

MDU. 09:051

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

AN ISOPERIMETRIC INEQUALITY FOR THE N-DIMENSIONAL FREE MEMBRANE PROBLEM, by H. F. Weinberger. [1956] [4]p. [AF 18(600)573] Unclassified

Published in Jour. Rational Mech. and Analysis, v. 5: 633-636, July 1956.

The eigenvalue problem $\Delta u + \mu u = 0$ in R, $\frac{\partial u}{\partial n} = 0$ on R is examined for R, a region in N-dimensional Euclidean space. With eigenvalues arranged in non-decreasing order, $\mu_1 \leq \mu_2 \leq \ldots$, $\mu = 0$ and the corresponding eigenfunction is u = constant. The first eigenvalue of interest, μ_2, is found to attain maximum value on the N-sphere among all N-dimensional domains R of given N-volume.

MDU. 09:052

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

NEW ISOPERIMETRIC INEQUALITIES FOR EIGENVALUES AND OTHER PHYSICAL QUANTITIES, by L. E. Payne. [1956] [12]p. incl. refs. (AF 18(600)-573) Unclassified

Presented at Symposium on Partial Differential Equations, California U., Berkeley, June 20-July 1, 1955.

Published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955), N. Y., Interscience Publishers, Inc., 1955, p. 233-244.

Published in Communications on Pure and Appl. Math., v. 9: 531-542, Aug. 1956.

Isoperimetric inequalities, which include any inequality connecting two or more physical quantities associated with the same region, are derived for the eigenvalues of certain classical plate and membrane problems where the displacement is considered to satisfy a certain differential equation in a plane domain D with boundary C in the x, y-plane. The problem of Stekloff is then considered in an infinite three-dimensional region D* which lies exterior to the closed surface C*; isoperimetric inequalities are obtained for the first and second eigenvalues. Inequalities for certain other physical quantities are derived in order to establish some of the eigenvalue relationships obtained. The eigenvalue problems considered include (1) $\Delta u + \lambda u = 0$ in D, $u = 0$ on C, the classical membrane problem; (2) $\Delta^2 w + \Lambda \Delta w = 0$ in D, $w = \frac{\partial w}{\partial n} = 0$ on C, as well as (3) $\Delta^2 \zeta + \mu \Delta \zeta + b\zeta = 0$ in D, (b= const. > 0), $\zeta = \frac{\partial \zeta}{\partial n} = 0$ on C, buckling problem for a clamped plate; (4) $\Delta^2 \varphi - \Omega \varphi = 0$ in D, $\varphi = \frac{\partial \varphi}{\partial n} = 0$ on C, as well as (5) $\Delta^2 \psi - a\Delta\psi - \Gamma\psi = 0$ in D (a const. > 0), $\psi = \frac{\partial \psi}{\partial n} = 0$ on C, both vibration problems for a clamped plate; and (6) $\Delta \chi = 0$ in D, $\frac{\partial \chi}{\partial n} = k\chi$ on C*, $\chi = 0(R^{-1})$ as $R \to \infty$, the Stekloff problem, Δ denotes the Laplace operator, $\vec{n}$ denotes the outward normal from D (or D*) on C (or C*), $R^2 = x^2 + y^2 + z^2$, and λ, Λ, Ω, Γ, u, and k are constants (eigenvalues) to be determined.

MDU. 09:053

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE RATIO OF CONSECUTIVE EIGENVALUES, by L. E. Payne, G. Pólya, and H. F. Weinberger. [1956] [10]p. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)573] Unclassified

Published in Jour. Math. and Phys., v. 35: 289-398, Oct. 1956.

The eigenvalues considered are those in the three problems for a two-dimensional domain D with boundary C, and

$\Delta u + \lambda u = 0$ in D, $u = 0$ on C,

$\Delta\Delta u - \mu u = 0$ in D, $u = \partial u/\partial n = 0$ on C,

$\Delta\Delta u + \nu\Delta u = 0$ in D, $u = \partial u/\partial n = 0$ on C.

Let λ_n, μ_n, ν_n be the eigenvalues in these problems respectively. It is proved that

$$\lambda_{n+1} \leq \lambda_n + 2(\lambda_1 + \cdots + \lambda_n)/n,$$

$$\mu_{n+1} \leq \mu_n + 8(\mu_1 + \cdots + \mu_n)/n,$$

so that $\lambda_{n+1} \leq 3\lambda_n$, $\mu_{n+1} \leq 9\mu_n$. The method (selection of appropriate trial-functions) is not so successful for (3), in which it is proved only that $\nu_2 < 3\nu_1$. A proof of $\lambda_2 + \lambda_3 \leq 6\lambda_1$ is also sketched. (Math. Rev. abstract)

MDU. 10:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE STRUCTURE OF TURBULENCE, by T. Theodorsen. May 1954, 18p. illus. diagrs. (Technical note no. BN-31) ([AF]OSR-TN-54-131) (AF 18-(600)893) AD 33852 Unclassified

The theory of turbulence is based on the existence of a unique and universal turbulent structure previously introduced. The theory prescribes the existence of an oriented array of bent-vortex formations which are arranged so that work is continually transferred from the main flow to the primary disturbance, and from this primary structure to an external array of secondary structures. The process continues until the smallest existing subdivision is reached. The characteristic structure is referred to as the horseshoe. Each horseshoe is attached to one of the preceding order in such a way as to exert the greatest energy extraction so that a number of horseshoes is created at the expense of the energy contained in the larger order horseshoe. The theory is neither homogeneous nor isotropic because of the oriented structures, and it is considered probable that real turbulence is associated with a shear force and vice versa. The treatment is restricted to shear turbulence in full equilibrium. Experimental verification has been obtained by other researchers on the physical appearance of the proposed turbulent structure.

MDU. 10:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

DISCRETE VORTICES IN THE TRANSITION RANGE OF FLOW IN A PIPE, by J. R. Weske. Feb. 1955, 14p. illus. diagrs. refs. (Technical note no. BN-47) ([AF]OSR-TN-55-37) (AF 18(600)893) AD 54115 Unclassified

Experimental results are presented of the action of 3-dimensional discrete vortices of the Theodorsen-horseshoe-vortex type on the flow in a 6-in. -id, 68-ft long straight tube. The flow, though distorted by the vortices, remained laminar around the vortex filaments and throughout their core up to Re = 4000. The vortex motion itself appeared to be stable and ultimately died down under the effect of viscosity. The travel of vortex centers normal to the direction of mean flow is regarded as being the most significant feature of the motion. Discussions are given of the Magnus effect, momentum drag, effects near the roots of the horseshoe vortices, effects in plan view of the vortex filament, and viscous effects. The observed behavior of horseshoe vortices stretched in a shear flow may be explained by the relative motion between the vortex and the ambient fluid which is caused by the Magnus effect and momentum transfer.

MDU. 10:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE EFFECT OF STRETCHING OF A VORTEX CORE, by J. R. Weske. Aug. 1955 [20]p. incl. illus. diagrs. (Technical note no. BN-57) ([AF]OSR-TN-55-282) (AF 18(600)893) AD 71270 Unclassified

The investigation concerns the core of a straight vortex which is simplified by assuming that it extends to a definite radius within which the rotation is constant. The vortex field surrounding the core is irrotational, and the effects of viscous action and of compressibility between the initial and final states are disregarded. The results show that backflow occurs in the core as the stretching exceeds a certain value. The resulting flow in an annular region close to the center of the core becomes radially unstable. Experimental evidence is presented to show that the backflow actually occurs. (ASTIA abstract)

MDU. 10:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

EXPLANATION OF THE OCCURRENCE OF A LIFT-FORCE ON AN OBJECT PLACED IN VORTEX, by D. F. Gates. [Mar. 31, 1955] 5p. illus. (AF 18(600)893) Unclassified

An experiment was conducted on reproducing a vortex in a cylindrical bottle by means of water jets directed tangentially along the bottle wall. A golf ball of density greater than water is supported near the vortex midpoint of the vortex axis. A guide wire attached to the ball is inserted in a vertical tube allowing the ball to move axially upward but preventing radial motion. From the pressure relationships in the vortex and the axial variation of the core radius, an axial static pressure gradient was established. From the pressure relationships in the vortex and the axial variation of the core radius, the presence of an axial static pressure gradient was established. If a solid body is placed in a region of the vortex in which this axial pressure gradient exists, a pressure force is exerted upon the body in the direction of lower pressure. If the core radius below the object is larger than the above, then there is an upward force or "lift." The existence of a lift force is thus explained. (Contractor's abstract)

MDU. 10:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

A METHOD FOR THE MEASUREMENT OF THE FLOW OF AIR BY MEANS OF SERIES OF ELECTRIC SPARKS, by H. J. Bomelburg. Feb. 1955 [39]p. incl. illus. diagrs. (Technical note no. BN-68) ([AF]OSR-TN-56-38) (AF 18(600)893) AD 80549 Unclassified

MDU. 10:006 - MDU. 11:004

A technique has been developed in which series of electric sparks of low current are used to render visible the flow of air. Sparks traversing the air at very high frequency produce visible successive-displacement profiles, photographic records of which furnish detailed information. The method is applicable to both subsonic and supersonic flow. The technique has been investigated in detail. Its merits and limitations are compared with other methods. Photographs are presented to illustrate possible applications. (Contractor's abstract)

MDU. 10:006

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THE EFFECT OF STRETCHING OF A VORTEX-CORE, by J. M. Burgers. Aug. 1956, 22p. incl. diagr. (Technical note no. BN-80) (AFOSR-TN-56-376) (AF 18(600)893) AD 95812 Unclassified

General relations are established for axially symmetrical nonviscous, rotational flows between converging or diverging meridional streamlines when initially the axial velocity is constant, the radial velocity zero and the radial distribution of peripheral velocity is known. The equations are solved in detail for numerical evaluation for the particular case of a vortex core with solid body rotation, either contained in a duct or surrounded by a potential vortex. A theoretical treatment is given of the problem of stability connected with this type of flow. (Contractor's abstract)

MDU. 11:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

LAMINAR FLOW OF AN ELECTRICALLY CONDUCTING INCOMPRESSIBLE FLUID IN A CIRCULAR PIPE, by S. I. Pai. 1954, 2p. incl. diagrs. ([AF]OSR-TN-54-93) (AF 18(600)993) Unclassified

Published in Jour. Appl. Phys., v. 25: 1205-1207, Sept. 1954.

As an aid in understanding magnetohydrodynamics, the exact solution of the steady laminar flow of an electrically conducting, viscous and incompressible fluid in a circular pipe under an external radial magnetic is presented. Three typical velocity distributions for laminar steady flow in a circular pipe under the influence of different strength magnetic fields are plotted.

MDU. 11:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

HYPERSONIC VISCOUS FLOW OVER AN INSULATED WEDGE AT AN ANGLE OF ATTACK, by S. I. Pai. Oct. 1954, 21p. diagrs. (Technical note no. BN-42) ([AF]OSR-TN-54-321) (AF 18(600)993) AD 47552 Unclassified

Previous work by Pai (Jour. Aeronaut. Sciences, v. 20: 502-504, July 1953) is extended by a detailed calculation of the hypersonic viscous flow over an insulated wedge at an angle of attack by a generalized von Kármán integral method for the boundary-layer equations of a compressible fluid. Both the interactions of the shock wave and of the expansion wave with boundary-layer flow over the wedge are investigated in the strong interaction region. The results are combined to give the over-all effects on the skin friction and the pressure distribution of the wedge. Consideration is given only to those cases where the shock is attached to the wedge. The analysis shows that the interaction phenomenon increases both the pressure on the surface of the wedge and the skin friction of the wedge.

MDU. 11:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

MAGNETOHYDRODYNAMICS AND MAGNETOGASDYNAMICS, by S. I. Pai. Sept. 1955, 33p. refs. (Technical note no. BN-59) ([AF]OSR-TN-55-347) (AF 18(600)993) AD 74432 Unclassified

The fundamental equations of magnetofluiddynamics are derived. For incompressible fluid magnetohydrodynamics, the important parameters are the Reynolds number R_e, the magnetic pressure number R_H, which is the ratio of magnetic pressure to dynamic pressure, and the velocity number R_v, which is the ratio of the fluid velocity to the characteristic velocity of which the magnetic field is moving through a conductor. Some exact solutions and properties of the equations of magnetohydrodynamics are given. Stability of laminar flow and turbulence in magnetohydrodynamics are briefly reviewed. Finally, some magnetohydrodynamic experiments are described. For compressible fluid, magnetogasdynamics, the important parameters are still R_e, R_H and R_v plus other well known parameters of ordinary gas dynamics such as Mach number, Prandtl number and ratio of specific heats. Both the waves of small amplitude, Alfven's waves in compressible fluid, and shock waves in magnetogasdynamics are discussed. (Contractor's abstract)

MDU. 11:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE SIMILARITY SOLUTION OF LAMINAR BOUNDARY LAYER WITH HYPERSONIC VARIABLE FREE STREAM, by S. F. Shen. Oct. 1955, 18p. incl. refs. (Technical note no. BN-60) ([AF]OSR-TN-55-362) (AF 18(600)993) AD 76253 Unclassified

For arbitrary Prandtl number and the power index of

the viscosity-temperature relation, certain "similar solutions" of the boundary-layer equations are shown to exist, provided that errors of the order $O(M_1^{-2})$ may be tolerated, M_1 being the Mach number at the outer edge of the boundary layer. The admissible pressure gradients are of the same types as those for the "similar solutions" of incompressible boundary layers. Application to the "strong-interaction" problem of a flat plate in a hypersonic stream is discussed. (Contractor's abstract)

MDU. 11:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

LAMINAR JET MIXING OF TWO COMPRESSIBLE FLUIDS, by S. I. Pai. Oct. 1955 [30]p. incl. illus. diagrs. (Technical note no. BN-63) ([AF]OSR-TN-55-406) (AF 18(600)993) AD 79701 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 1012-1018, Nov. 1956.

This study is concerned with a steady 2-dimensional laminar flow of a jet of a combustible gas mixture which is injected into and mixed with a uniform stream of another gas which is the combustion product of the combustible mixture. The problem involves 5 unknowns (temperature, density, concentration, and 2 velocity components) which are related through 5 equations: the equations of state, continuity, diffusion, motion, and energy. Detailed discussions are given of the following special cases: (1) jet mixing of a compressible fluid in which the concentration is a constant; (2) isothermal jet mixing of 2 compressible fluids in which 2 gases mix at a low Mach number without a chemical reaction; and (3) isovel jet mixing in which 2 streams of different gases of the same velocity but different temperature mix.

MDU. 11:006

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

INSTRUMENT TO STUDY RELAXATION RATES BEHIND SHOCK WAVES, by E. L. Resler, Jr. and M. Scheibe. [1955] [7]p. incl. illus. diagrs. [AF 18(600)993] Unclassified

Published in Jour. Acoust. Soc. Amer., v. 27: 932-938, Sept. 1955.

An instrument is described which combines the schlieren technique, a photomultiplier tube and an oscilloscope in a manner that enables one to measure the density distribution behind shock waves (in gases) produced in a shock tube. From these measured distributions one can determine the way in which the gas or gases relax to equilibrium and the time it takes to reach equilibrium after the gas's enthalpy is increased suddenly a calculable amount in passing through the shock wave. The theory of the instrument is discussed and its predicted performance verified experimentally by measuring vibrational heat capacity relaxation times behind shock waves in CO_2 containing water vapor. The instrument in the reported tests demonstrated a sensitivity sufficient to record a change in atmospheric density of 1/2% over 1-mm distance and a space resolution of the density in the shock tube of 1/10 mm corresponding to times of the order of 1/10 μsec. (Contractor's abstract)

MDU. 11:007

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON RELAXATION EFFECTS IN SHOCK WAVES IN GASES, by P. E. Stepanov, tr. by B. [B.] Cary. July 1956 [19]p. incl. diagrs. (Technical note no. BN-76) (AFOSR-TN-56-309) (Trans. of Zhur. Eksper. Teoreticheskoi Fiziki, v. 17: 377-385, 1947) (AF 18-(600)993) AD 94843 Unclassified

The possibility of using a shock wave for the investigation of the rate of the redistribution of energy between translational and rotational degrees of freedom is analyzed in the instance of a shock wave in H_2 where the usual ultracoustic method becomes impracticable owing to the slowness of the corresponding relaxation time, 10^{-7} sec, and the necessity of resorting to very high frequencies. The shock wave is composed of 2 regions, one of a width corresponding to the gas-kinetic time of free path, being the seat of redistribution of energy among the translational degrees of freedom, the other, being the scene of passage of energy from translational to rotational degrees of freedom, of a width corresponding to the time lag of that passage. Formulas are derived for the structure of a shock wave with relaxation permitting calculation of the translational-rotational relaxation time from the width of the 2nd region and the pressure increase therein. These determinations will give the heat capacity of the rotational degrees of freedom.

MDU. 11:008

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SHOCK WAVES IN A RELAXING MEDIUM, by S. P. D'iakov, tr. by B. [B.] Cary. July 1956 [15]p. incl. diagrs. (Technical note no. BN-77) (AFOSR-TN-56-378) (Trans. of Zhur. Eksper. Teoreticheskoi Fiziki, v. 27: 728, Dec. 1954) (AF 18(600)993) AD 95814 Unclassified

The possibility of the existence of shock waves in a relaxing medium in which the process of relaxation is accompanied by a decrease in pressure was presented. A concrete example was given of a medium in which shock waves of such a type are possible. An analytical examination was made of weak shocks in a relaxing medium.

MDU. 11:009 - MDU. 11:012

MDU. 11:009

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

CONCERNING THE STABILITY OF SHOCK WAVES, by S. P. D'iakov, tr. by B. [B.] Cary. Aug. 1956 [14]p. incl. diagrs. table. (Rept. no. BN-68) (AFOSR-TN-56-406) (Trans. of Zhur. Eksper. Teoreticheskoi Fiziki, v. 27: 288-295, 1954) (AF 18-(600)993) AD 96214 Unclassified

In this translation, the problem of the stability of shock waves in an arbitrary medium has been examined. Conditions for the instability of shock waves are found, which if satisfied, result in an exponential growth of the disturbances with time. The original phenomenon discovered is the spontaneous radiation of sound by the shock wave; conditions which determine the possibility of its occurrence are considered. Examples are given of the shapes of Hugoniot adiabatics in which it is possible for the conditions of instability and spontaneous radiation of sound to be fulfilled. It is shown in which media the fulfillment of these conditions is to be expected.

MDU. 11:010

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON EXACT SOLUTIONS OF ONE DIMENSIONAL FLOW EQUATIONS OF MAGNETOGASDYNAMICS, by S. I. Pai. Sept. 1956 [14]p. incl. diagrs. (Technical note no. BN-82) (AFOSR-TN-56-486) (AF 18(600)993) AD 97370 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 834-840, Oct. 1957.

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 3: 17-25, 1957.

The magnetogasdynamic equations describing the steady, one-dimensional flow of a viscous, heat conducting, electrically conducting and compressible gas under planar magnetic field perpendicular to the velocity vector are treated. The generalized Rankine-Hugoniot relations are discussed. A formula for the effective sound speed is obtained. The transition regions connecting the two uniform states of the generalized Rankine-Hugoniot relations are discussed.

MDU. 11:011

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

SELECTED TOPICS FROM THE THEORY OF GAS FLOW AT HIGH TEMPERATURES, by J. M. Burgers. Sept. 1956, 63p. incl. diagrs. (Technical note no. BN-83) (AFOSR-TN-56-509) (AF 18(600)993) AD 110324 Unclassified

The following topics are discussed: cases of one-dimensional gas flow mainly involving exchange of translation energy; quantities depending on molecular properties, which introduce various scale factors into the field; gas flow in one dimension; refinements necessary in order to take account of adjustments in the distribution of molecular velocities; equations for steady flow; states of uniform flow; numerical example; the transition region; application of the molecular picture to the transition in a shock wave; more refined picture; provisional considerations concerning the viscous stress and the heat flow; Boltzmann's equation for the distribution function of the molecular velocities; application of Boltzmann's equation to obtain the equation of continuity, momentum and energy; application of Boltzmann's equation to the investigation of the mean values c_x^2, c_y^2, c_z^2; application of Boltzmann's equation to the investigation of the mean values c_x^3, $c_x c_y^2$, $c_x c_z^2$; introduction of approximations; integrals of the right hand side of Boltzmann's equation; final form of the equations for τ and q; alternative expressions for the right hand side of Boltzmann's equation; considerations concerning the function $\bar{\Phi}$; application of the

$$\frac{\partial F}{\partial t} + \xi \frac{\partial F}{\partial x} = n\varkappa F + n^2 K \bar{\Phi}$$

to the problem is considered; and formal solution of the $\frac{\partial F}{\partial t} + \xi \frac{\partial F}{\partial x} = -n\varkappa F + n^2 \bar{\Phi}$ and application to a shock wave.

MDU. 11:012

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ONE-DIMENSIONAL UNSTEADY FLOW OF MAGNETOGASDYNAMICS, by S. I. Pai. Nov. 1956, 14p. (Technical rept. no. BN-86) (AFOSR-TN-56-537) (AF 18-(600)993) AD 110356 Unclassified

Also published in Proc. Fifth Midwestern Conference on Fluid Mechanics, Michigan U., Ann Arbor (Apr. 1-2, 1957), Ann Arbor, Univ. Mich. Press, 1957, p. 251-261.

The one-dimensional unsteady flow of a viscous, heat conducting, electrically conducting and compressible gas under planar magnetic field perpendicular to the velocity vector is investigated. First the special case of an ideal gas which is inviscid nonheat-conducting and infinite electrically conducting is considered in detail. An exact solution of this case has been found which shows the shock wave formation in magnetogasdynamics. Next the characteristics of these one-dimensional magnetogasdynamics flow equations are discussed in detail. (Contractor's abstract)

MDU. 11:013

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park. .

SELECTED TOPICS FROM THE THEORY OF GAS FLOW AT HIGH TEMPERATURES (II), by J. M. Burgers. Oct. 1956, 51p. incl. diagr. (Technical note no. BN-84) (AFOSR-TN-56-538) (AF 18(600)993) AD 110357 Unclassifted

The following toptcs are brtefly discussed: cases of one-dimenstonal gas flow accompanied by chemical reactions or by storage of energy tn tnternal degrees of freedom — general deftnitions and equations; equations of motion; example of a steady slate problem; dissoctation; considerations on reaction rates; additional observations; resulting formula for the change of the degree of dissoctation with the distance x; case of several reactions taking place simultaneously; formulas for the reaction rates; approximations to be used for the flow behind a shock wave, when the reactions do nol influence the composition to more than a few percent; equilibrtum relations tn systems tn which chemical reactions can take place; observations on the characteristics of the equations; equations for low flow speeds.

MDU. 11:014

Maryland U. Insl. for Fluid Dynamics and Applied Mathematics, College Park.

DISSOCIATION OF AIR BEHIND STRONG SHOCK WAVES, by E. L. Resler, Jr. and B. B. Cary. [1956] 8p. tllus. tables. [AF 18(600)993] Unclassified

Published tn Proc. Conference on Chemical Aeronomy, Cambrtdge, Mass., Sept. 1956.

An tnstrument combtning the tnterferometer and drum camera has been utilized to study the approach to equilibrtum behind strong shock waves tn air. It is found experimentally that the density distribution behind the shock wave goes through a maximum while approaching equilibrium. This represents a departure from what has been predicted previously and indicates that the air tends to over-dissociate in approaching equilibrium. A theoretical examtnation of the processes tnvolved shows that this sort of relaxation effect is possible under the experimental conditions. (Contractor's abstract)

MDU. 11:015

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON THE BOUNDARY-LAYER EQUATIONS OF A VERY SLENDER BODY OF REVOLUTION, by S. 1. Pai. Apr. 6, 1956, 1p. (AF 18(600)993) AD 109842 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 795, Aug. 1956.

A discussion ts presented of the boundary-layer equations over a body of revolution of a very small radius, and their transformation to an equivalent two-dimensional problem. Probstetn and Elliot (The Transverse Curvature Effecl tn Compressible Axially Symmelrtc Laminar Boundary-Layer Flow, Jour. Aeronaul. Sctences, v. 23: 208-222, 1956) used the same lransform to study this problem. It is demonstraled tn the present study that the fundamenlal equations can be lransformed tnlo exactly the same form of the two-dimensional equations. Thetr application to hypersonic guided missile work ts mentioned.

MDU. 12:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

PHASE RELATIONS IN ISOTROPIC TURBULENCE, by R. Betchov. Aug. 1954, 36p. tncl. table, refs. (Technical ncte no. BN-40) ([AF]OSR-TN-54-254) (AF 18(600)1014) AD 42070 Unclassifted

Certain relations between the spectrum of a turbulent function, and that of the square of the function depend upon phase correlations between the vartous Fourier components. The case of uncorrelated phases can be treated with a suitable hypothesis, and studied experimentally with electronic noises. Experiments with tsotroptc turbulence show that phase correlations affect only the high frequency end of the spectrum. Phase correlations tn tsotropic turbulence are associated with a certain type of pulse, easily observed tn a phase space. Comparisons between turbulence and electronic notse tndicate that energy transfer and vorticity production are highly tntermittent processes. These results suggest some hypothesis on the mechantsm of energy transfer and vorticity production. (Contractor's abstract)

MDU. 12:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ELECTRONIC INSTRUMENTS FOR SQUARING CUBING AND MULTIPLYING, by R. Betchov. May 1954, 22p. illus. diagrs. (Technical note no. BN-30) ([AF]OSR-TN-54-302) (AF 18(600)1014) AD 46465 Unclassified

Theoretical and experimental information ts presented on tnstruments which square, cube, or multiply electric signals by the use of chains of diodes. Upper limits and estimates of error are discussed for finite chains of tubes.

MDU. 12:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

ON TRANSITION FROM LAMINAR TO TURBULENT FLOW, by F. R. Hama, J. D. Long, and J. C. Hegarty.

MDU. 12:004 - MDU. 13:001

Aug. 1956 [52]p. incl. illus. diagrs. refs. (Technical note no. BN-81) (AFOSR-TN-56-381) (AF 18(600)1014) AD 95817 Unclassified

Also published in Jour. Appl. Phys., v. 28: 388-394, Apr. 1957.

Water-tank observation of the flow phenomena associated with boundary-layer transition has confirmed that a 2-dimensional discrete vortex line, which is considered to be the consequence of an amplified perturbation wave, has a strong tendency in shear flows to form a 3-dimensional vortex loop with a marked transverse wave length. The formation and development of the vortex loop are found to be the essential features preceding the origination of a turbulence spot, which takes place near the top of the vortex loop and near the outer edge of the boundary layer, and the guiding principle of laminar-to-turbulent transition not only in boundary layers but in wakes and in jet boundaries as well. As an application, an efficient turbulence-stimulation device is proposed. (Contractor's abstract)

MDU. 12:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

AN EFFICIENT TRIPPING DEVICE, by F. R. Hama. Oct. 15, 1956, 2p. illus. (AF 18(600)1014) Unclassified

Published in Jour. Aeronaut. Sciences, v. 24: 236-237, Mar. 1957.

Investigations on transition from laminar to turbulent flow have revealed that the formation and development of a 3-dimensional vortex loop are the essential features preceding the genesis of a turbulent spot. As an application of this confirmation, a proposed turbulence-stimulation or "tripping" device, for use in wind-tunnel or towing-tank model tests, is described. A sketch of the device shows a row of thin triangular patches pasted on a flat plate. Streamlines near the triangle are diagrammed, indicating that a spiral motion inherent to a 3-dimensional vortex loop will be produced. In addition, because of converging stream lines near the bottom corner of 2 adjacent triangles, the fluid velocity close to the surface will be increased, giving an efficient vortex which sheds even better than a 2-dimensional trip. This arrangement generates 3-dimensional vortex loops directly with more efficiency in shedding, and for this reason appears to give a simple yet better way of tripping laminar boundary layers than any other known stimulation device. An experimental test indicated that the triangular-patch device is far superior to a 2-dimensional trip. Comparative flow pattern photographs of the test results are presented.

MDU. 12:005

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THREE-DIMENSIONAL VORTEX PATTERN BEHIND A CIRCULAR CYLINDER, by F. R. Hama. Oct. 15, 1956, 2p. illus. (AF 18(600)1014) Unclassified

Published in Jour. Aeronaut. Sciences, v. 24: 156-157, Feb. 1957.

A study was made of the 3-dimensional vortex pattern behind a circular cylinder in a towing tank, 2-ft wide, 2-ft deep and 12-ft long. The circular cylinder, a .25-in. outside diameter brass tube 20-in. long, is submerged horizontally at the mid-depth of the water. Red dye is leaked slowly through a row of small holes in the cylinder. The row of holes is located approximately 120°, measured from the foward stagnation point so that only one side of the vortex sheets is observed from above the plane of the vortex sheet. Results of the observations are presented in photographs taken at Reynolds numbers of 117, 190, and 313. At the lowest Reynolds number (stable range), the vortices are shed regularly without showing much 3-dimensionality except for a slight long-range deformation which is rather attributable to persistent large-scale disturbance in still water. Reasonably good 2-dimensionality was obtained consistently. When the Reynolds number is increased to about 200 (transition range), the 3-dimensionality is seen to appear violently. Flow phenomena in the irregular range in which the Reynolds number exceeds approximately 300, look much the same as those behind a trip wire on a flat plate; the vortex line being shed by the circular cylinder becomes wavy almost immediately, develops further apparently in the shear layer, and then breaks down into turbulent motion. The appearance of the 3-dimensionality, and its importance in creating the local transition into turbulent motion are therefore confirmed in the wake behind a circular cylinder. These processes, thus, are considered to be the guiding principle of transition phenomena not only in jet boundaries and boundary layers, but also in wakes.

MDU. 13:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

STUDIES IN NON-EQUILIBRIUM CHEMICAL KINETICS. I. THE RELAXATION OF A SYSTEM OF HARMONIC OSCILLATORS, by E. W. Montroll and K. E. Shuler. Mar. 1956 [38]p. incl. diagrs. refs. (Technical note no. BN-70) (AFOSR-TN-56-108) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600) 1315 and Atomic Energy Commission) AD 82504 Unclassified

Also published in Jour. Chem. Phys., v. 26: 454-464, Mar. 1957.

As part of an investigation of non-equilibrium phenomena in chemical kinetics, a theoretical study has been made

of the collisional and radiative relaxation of a system of harmonic oscillators contained in a constant temperature heat bath and prepared initially in a vibrational non-equilibrium distribution. An exact solution has been obtained for the general relaxation equation applicable to this system; expressions have been derived for the relaxation of initial Boltzmann, Poisson, and σ-function distributions, and for the relaxation of the moments of the distributions. Using the latter result, explicit expressions are given for the relaxation of the internal energy of the system of oscillators and for the time dependence of the dispersion of the distributions. (Contractor's abstract)

MDU. 13:002

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

THEORY OF THE VIBRATIONAL RELAXATION OF DIATOMIC MOLECULES, by E. W. Montroll. Nov. 1956 [12]p. (Technical note no. BN-85) (AFOSR-TN-56-507) (AF 18(600)1315) AD 110322 Unclassified

This report discusses the manner in which systems of polyatomic molecules initially in a non-equilibrium vibrational state relax to their stationary states. Initial non-equilibrium distributions arise during the formulation of molecules and upon passage of shock waves through a gas composed of polyatomic molecules. The theory of dissociation of polyatomic molecules is discussed as a type of random walk process. (Contractor's abstract)

MDU. 13:003

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

NOTE ON THE RELATION OF ISOTOPIC SPINSPACE TO SPACETIME, by R. L. Ingraham. Nov. 1956 [10]p. (Rept. no. BN-89) ([AF]OSR-TN-56-570) (AF 18(600)1315) AD 110391 Unclassified

Also published in Phys. Rev., v. 106: 595-597, May 1, 1957.

The customary form of physical space as the direct product of space-time and isotopic spin space can be replaced by a certain fusion of these 2 spaces into 1 space if the group from the Lorentz group is widened to the conformal space-time group which endows particles with an intrinsic finite size. It is shown that the familiar space-time transformations continue to induce their familiar Dirac spinor transformations, while the new space-time transformations in general induce isotopic spin transformations as well. The detailed correspondence is worked out for a theory of T = 1 bosons coupled to T = ½ fermions. (Contractor's abstract)

MDU. 13:004

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

CROSSLINKING OF POLYETHYLENE-TYPE POLYMERS BY HIGH-ENERGY IRRADIATION, by H. Okamoto and A. Isihara. [1956] [8]p. [AF 18(600) 1315] Unclassified

Published in Jour. Polymer Science, v. 20: 115-122, Apr. 1956.

Effects of high-energy radiation on polyethylene-type polymers are considered. At the initial stage of irradiation, crosslinking, double bond formation, and hydrogen evolution are proportional to the radiation dose. The efficiency of irradiation in forming an infinite network is estimated. It depends on the mobility of decomposed atoms or radicals in the solid polymers. (Contractor's summary)

MDU. 13:005

[Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.]

ON THE THEORY OF REPLACEMENT OF MACHINERY WITH A RANDOM FAILURE TIME, by G. H. Weiss. [1956] [15]p. incl. diagrs. [AF 18(600)1315] Unclassified

Published in Naval Research Logistics Quart., v. 3: 279-293, Dec. 1956.

Study is made of the reliability function and moments thereof, of a machine which is periodically replaced in order to increase the mean time to failure. Two cases are considered: strictly periodic replacement and randomly periodic replacement.

MDU. 13:006

Maryland U. [Inst. for Fluid Dynamics and Applied Mathematics, College Park.]

RANDOM WALKS IN MULTIDIMENSIONAL SPACES, ESPECIALLY ON PERIODIC LATTICES, by E. W. Montroll. [Dec. 1956] [20]p. incl. diagrs. refs. [AF 18(600)1315] Unclassified

Published in Jour. Soc. Indus. Appl. Math., v. 4: 241-260, Dec. 1956.

The author forms the generating function of a random walk on a k-dimensional lattice, with steps between nearest neighbor points, subject to periodic boundary conditions. Generalizing a method used by Watson, the probabilities of return to the starting point for k = 1, 2, 3 are expressed in terms of the complete elliptic integral of the second kind; an asymptotic formula is given for k large. The results are extended to body centered and face centered lattices. Various remarks are made

MDU. 14:001 - MIT. 02:001

about Pearson's walk, mean motions, and physical applications.

MDU. 14:001

Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park.

PROCEEDINGS OF THE CONFERENCE ON DIFFERENTIAL EQUATIONS HELD AT THE UNIVERSITY OF MARYLAND MARCH 17, 18 AND 19, 1955, by J. B. Diaz and L. E. Payne. Sept. 20, 1956, 294p. incl. illus. diagrs. tables, refs. (AFOSR-TR-56-51) (AF 18(600)1380) AD 110314 Unclassified

The papers presented consider both the historical developmenis as well as recent advances in various fields of differential equations. The topics covered illustrate the wide and diverse uses of differential equations in both mathematics and in the physical and engineering sciences. The papers by title include: Differential Systems With Boundary Conditions at More Than Two Points, by W. M. Whyburn; Sturm-Liouville and Heat Equations Whose Eigenfunctions are Ultraspherical Polynomials or Associated Bessel Functions, by S. Bochner; Repeated Branching Through Loss of Stability, an Example, by E. Hopf; Problems Related to Characteristic Surfaces, by M. Riesz; On the Euler-Poisson-Darboux Equation, Integral Operators, and the Method of Descent, by J. B. Diaz and G. S. S. Ludford; On Partial Differential Equations of Mixed Type, by M. H. Protter; Some Applications of Riesz's Method, by E. T. Copson; Discontinuity and Representations of Minimal Surface Solutions, by Y. W. Chen; Relations Between Different Capacity Concepts, by G. Szego; Some Results on Generalized Axially Symmetric Potentials, by A. Huber; On the Numerical Solution of the Dirichlet Problem, by Z. Nehari; Bounded or Almost Periodic Solutions of Non-linear Differential Systems, by L. Amerio; The Extension of the Riemann Mapping Theorem to Elliptic Equations, by F. G. Dressel and J. J. Gergen; On the Eigenfunctions of the Membrane Equation in a Singular Case, by A. Pleijel; An Abstract Formulation of the Method of Separation of Variables, by B. Fiedman; The Heat Equation and the Weierstrass Transform, by D. V. Widder; Extensions of Operational Mathematics, by R. V. Churchill; On Generalized Sturm-Liouville Operators, by W. Feller; Heat Transfer to Hagen-Poiseuille Flows, by K. Millsaps and K. Pohlhausen.

MDU. 15:001

Maryland U. Inst. of Molecular Physics, College Park.

SCATTERING OF LOW VELOCITY MOLECULAR BEAMS IN GASES, by E. A. Mason. May 12, 1956, 35p. incl. diagrs. tables, refs. (Rept. no. IMP-OSR-1; AFOSR-TN-56-208) (AF 18(600)1562) AD 87522 Unclassified

Also published in Jour. Chem. Phys., v. 26: 667-677, Mar. 1957.

A large number of partial and total molecular scattering cross sections have been calculated numerically for molecules obeying an exp-six potential, consisting of an exponential repulsion term and an inverse sixth power attraction term. The tabulations cover a wide range of scattering angles, energies, and potential parameters, and can be used to obtain information about intermolecular forces from the results of experiments on the scattering of low velocity molecular beams in gases. The calculations are classical throughout, and quantum effects are ignored, but an approximate formula is given for estimating where the classical calculations break down in any particular case. The use of the tables is illustrated by a comparison with Knauer's results on the scattering of beams of H_2 in Hg vapor. (Naturwissenschaften, v. 21: 366, 1933; Zeitschr. Physik, v. 90: 599, 1934). (Contractor's abstract)

MIT. 01:001

Massachusetts Inst. of Tech., Cambridge.

RESEARCH IN DIFFERENTIAL GEOMETRY, by W. Ambrose. Final rept. [1955] 1p. (AFOSR-TR-54-17) (AF 18(600)764) Unclassified

Progress is reported of a study of the mapping of the tangent space of a Riemannian manifold both into the manifold and into the bundle of frames.

MIT. 01:002

Massachusetts Inst. of Tech., Cambridge.

PARALLEL TRANSLATION OF RIEMANNIAN CURVATURE, by W. Ambrose. [1956] [27]p. (AF 18(600)764) Unclassified

Published in Ann. Math., v. 64: 337-363, Sept. 1956.

The object of this paper is to characterize complete simply connected C^∞ Riemannian manifolds by their Riemannian curvature and its behavior under parallel translation. The main theorem asserts that if the Riemannian curvature parallel iranslates in the same way along correspondingly singly broken geodesics then the manifolds are isometric. (Contractor's abstract, modified)

MIT. 02:001

Massachusetts Inst. of Tech., Cambridge.

A THEOREM OF MYERS, by W. Ambrose. Nov. 9, 1956 [4]p. [AFOSR-TN-56-552] (AF 18(603)91) AD 110371 Unclassified

Also published in Duke Math. Jour., v. 24: 345-348, Sept. 1957.

Myers theorem has been approved which states that if the mean curvature of a complete Riemannian manifold M is bounded below by a positive number, the M is compact. A variant with a weaker assumption that the integral of the mean curvature of the tangential direction is infinite along all geodesic rays emanating from fixed point of M is proved. M is a completely connected C^{∞} Riemannian manifold of dimensions $d \geq 2$.

Massachusetts Inst. of Tech., Cambridge.

N6ori-10503 and N5ori-07855, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:097 - PRI. 11:109.

MIT. 03:001

Massachusetts Inst. of Tech. [Aeroelastic and Structures Research Lab.] Cambridge.

A STUDY OF GUST ENTRY OF SWEPTBACK WINGS, by T. H. H. Pian and H. Ashley. May 1954 [31]p. incl. diagrs. refs. [AFOSR-TN-54-116] (AF 33(038)-7267 and AF 33(600)961) AD 42902 Unclassified

The lift and moment growths on a swept wing upon entering a sharp-edged gust are determined by strip theory and by a "semi-three-dimensional" theory. The latter is based on the calculation of lift distribution of an infinite swept wing penetrating a gust front. This unsteady-flow problem is shown to be equivalent to a steady-flow problem involving an infinite swept wing with an angle-of-attack discontinuity at a spanwise station. Results indicate that, according to the improved theory, the airloads build up faster than what is shown by strip theory. (Contractor's abstract)

MIT. 04:001

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

THE STATISTICAL THEORY OF SIZE AND SHAPE EFFECTS IN FATIGUE, by F. A. McClintock. Nov. 4, 1954, 15p. diagrs. ([AF]OSR-TN-54-351) (AF 18-(600)895) AD 51990 Unclassified

Also published in Jour. Appl. Mech., v. 22: 421-426, Sept. 1955.

Fatigue specimens are considered in which the stress amplitude is constant with respect to time but falls off parabolically along the length of the specimen from the point of maximum stress. From assumptions regarding the local variability in the strength of the material, equations are derived relating the scatter in cycles to failure to the scatter in position of failure. The effect of specimen size is determined for these two types of scatter, as well as for the average life. It is found that the shape of the distribution function does not seriously affect the relation between scatter in cycles to failure and scatter in position of failure. The size effect, however, is markedly influenced by the shape of the distribution function. A modification is suggested to make the results applicable to tests to determine the endurance limit, where the stress amplitude is a variable. (Contractor's abstract)

MIT. 04:002

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

A CRITERION FOR MINIMUM SCATTER IN FATIGUE TESTING, by F. A. McClintock. Nov. 29, 1954 [17]p. incl. diagrs. tables. ([AF]OSR-TN-55-1) (AF 18(600)-895) AD 68081 Unclassified

Also published in Jour. Appl. Mech., v. 22: 427-431, Sept. 1955.

When a number of fatigue tests are run on specimens with a longitudinal radius of curvature, there results a scatter in both the number of cycles to failure and the position of failure. A previous statistical analysis showed that if the variations in life are due solely to local inhomogeneities in the specimen, then there is a definite relation between the scatter in position of failure and the scatter in the number of cycles to failure. If the scatter in life significantly exceeds that corresponding to the scatter in position of failure, then there is some factor other than local inhomogeneities contributing to the scatter in life. Such other factors can be eliminated by improving the experimental technique. The usefulness of this criterion is illustrated by its application to crack detection tests on polycrystalline ingot iron. (Contractor's abstract)

MIT. 04:003

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

VARIABILITY IN FATIGUE TESTING: SOURCES AND EFFECT ON NOTCH SENSITIVITY, by F. A. McClintock. May 25, 1955 [15]p. incl. tables, refs. ([AF]OSR-TN-55-186) (AF 18(600)895) AD 71738 PB 120014 Unclassified

Presented at International Union of Theoretical and Appl. Mech. Colloquium on Fatigue, Stockholm (Sweden), May 1955

Rough limits are obtained for the effect of various testing variables on fatigue life. Experimental data support the theoretical relation between scatter in position of failure and scatter in life due to local variations in strength: $K_{\log N}/2.3S_m a)_z^2 = 1$. From a statistical analysis taking into account the stress gradient normal to the surface, an estimate of notch insensitivity is obtained. Data from 75ST6 aluminum alloy indicate that it is unlikely that notch insensitivity results from statistical effects alone. (Contractor's abstract)

MIT. 04:004 - MIT. 06:001

MIT. 04:004

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

RESEARCH ON MINIMUM SCATTER IN FATIGUE TESTING, by F. A. McClintock. Final research rept. Dec. 28, 1955, 3p. (AFOSR-TR-56-3) (AF 18(600)895; continued by AF 18(600)957) AD 83283 Unclassified

The research project results show that for fatigue specimens in which the stress is assumed to vary with longitudinal distance z and depth y according to $S = S_m(1 - az^2 - gy)$, the mean and standard duration of the life and position of failure have been calculated for a class of distribution functions representing the strength of the differential elements comprising the specimen. These theoretical results provide a method for checking whether the variability in life at constant stress, or the variability of the rupture stress in the case of Prot testing, arises solely from that due to local inhomogeneities within the material or also arises in part from extraneous factors associated with specimen preparation and testing technique. These theoretical results provide a framework for estimating how much of the size effect arises from statistical causes. An approximate application of the results to notched specimens is suggested. (Contractor's abstract)

MIT. 05:001

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

THE GROWTH OF FATIGUE CRACKS UNDER PLASTIC TORSION, by F. A. McClintock. Feb. 17, 1956 [25] p. incl. illus. diagrs. tables, refs. (AFOSR-TN-56-277) (AF 18(600)957) AD 89487 Unclassified

Also published in Proc. International Conference on Fatigue of Metals, London (England), Sept. 1956, p. 538-542.

Theoretical and experimental studies were made of the growth of cracks in bars subjected to fully plastic cycles of torsion. Rules were postulated which state: (a) cracks always tend to grow toward the center of the remaining section, which is that point most distant from all present boundaries; and (b) a branch crack grows as above, but more slowly. Crack propagation and fracture are essentially dependent on the size of the specimen as opposed to yielding where size effects are of secondary importance. In the case of 2 geometrically similar specimens subject to the same nominal (large) strain amplitude, cracks progress across the larger one in fewer cycles. Rectangular specimens (7/32 in. x 7/16 in.) of precipitation hardening 7075 T6 Al alloy were subjected to reversed shear strains of constant amplitude and sectioned for examination of crack patterns. The development of fatigue cracks under fully plastic torsion, which is predicted from a knowledge of the strain distribution around the crack, was in general accord with experimental results. (ASTIA abstract)

MIT. 05:002

Massachusetts Inst. of Tech. Dept. of Mechanical Engineering, Cambridge.

ELASTIC-PLASTIC STRESS AND STRAIN DISTRIBUTIONS AROUND SHARP NOTCHES UNDER REPEATED SHEAR, by F. A. McClintock and J. A. H. Hult. Apr. 12, 1956, 11p. incl. diagrs. (AFOSR-TN-56-278) (AF 18(600)957) AD 89488 Unclassified

The elastic-plastic stress and strain distributions around sharp notches were obtained for pure shear, which is the limiting case of a very shallow notch in a specimen subjected to torsion. A small region at the tip of a fatigue crack is sujected to plastic flow caused by the intensity of the stress. Plasticity equations are solved for a material with a shear modulus G and yield stress in shear of k. The shear strain γ is formulated for a distance r beyond the end of a sharp notch, with zero flank angle and depth c in a region subjected to a nominal shear stress very much smaller than the yield stress, by the equation $\gamma = C\tau_\infty^2/r\,kG$. The analysis analysis shows that: (1) the strain at a sharp, zero-angle notch under plastic flow is greater than that for a purely elastic material by the factor $(\tau_\infty^2/k)\sqrt{2c/r}$ at relatively low stresses, and is still greater at higher stresses; (2) the angle subtended by the region of infinite strain becomes smaller as the notch angle increases; (3) the strain amplitude under repeated loading depends on the stress range but not on the mean stress; and (4) the strain concentration becomes insensitive to the notch angle at high stresses.

MIT. 06:001

Massachusetts Inst. of Tech. [Fluid Dynamics Research Group] Cambridge.

APPLICABILITY OF PISTON THEORY TO THE FLOW AROUND WINGS IN UNSTEADY MOTION, by E. L. Mollo-Christensen and H. Ashley. June 6, 1954, 3p. incl. illus. table. [AF 18(600)961] Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 779-781, Nov. 1954.

It has been observed that the pressures on a body which suddenly starts moving in a compressible fluid depend, at the first instant, only upon the local normal velocities of the surface (Two-dimensional Unsteady Lift Problems in Supersonic Flight, by M. A. Heaslet and H. Lomax, NACA rept. no. 945, 1949). This information can be applied to rapidly oscillating bodies, considering the frequency of oscillation as the primary variable, rather than the time-constant of the motion. It is shown that such a simplification of the problem of finding the pressures on oscillating wings can be deduced directly from small disturbance considerations, and criteria for the applicability of the simplified theory can be obtained in the process. The general expression for the pressures

on an oscillating wing is developed, and the results of sample calculations for "piston theory" are compared to results of more exact theory. Piston theory proves to be more accurate, the higher the Mach number, but the order of accuracy persists down to $M_1 = 10/7$ for $k > 2$, where k = reduced frequency.

MIT. 06:002

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

AN APPROXIMATE AERODYNAMIC THEORY FOR GUST ENTRY OF SWEPT WINGS, by H. Ashley. Dec. 1954, 63p. incl. diagrs. tables, refs. (MIT Fluid Dynamics Research Group rept. no. 54-1) ([AF]OSR-TN-55-32) (AF 18(600)961) AD 55743 Unclassified

The lift and moment growths on a swept wing entering a sharp-edged gust are determined by a "semi-3-dimensional" theory, based on calculating the lift distribution of an infinite swept wing penetrating a gust front. This unsteady flow problem is shown to be equivalent to steady flow over an infinite swept wing with discontinuous angle of attack. Results indicate that the new theory predicts a more rapid buildup of gust loading than conventional strip theory at subsonic speeds. Details of lift and moment are given for subsonic flight, and for supersonic flight with both supersonic and subsonic leading and trailing edges. (Contractor's abstract)

MIT. 06:003

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

ON THERMALLY INDUCED SOUND FIELDS, by L. Trilling. Dec. 1954, 15p. refs. (MIT Fluid Dynamics Research Group repl. no. 54-2) ([AF]OSR-TN-55-47) (AF 18(600)961) AD 59955 Unclassified

Also published in Jour. Acoust. Soc. Am., v. 27: 425-431, May 1955.

The sound pulse induced in a gas at rest in a semi-infinite pipe by a sudden temperature change at the origin and the boundary layer induced along a wall by a progressing shock front are investigated by examining the superposition of pressure, temperature, and vorticity modes needed to satisfy the boundary conditions. (Contractor's abstract)

MIT. 06:004

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

UNSTEADY FLOW AROUND THIN WINGS AT HIGH MACH NUMBERS, by M. T. Landahl. June 1955, 20p. incl. diagrs. (MIT Fluid Dynamics Research Group rept. no. 55-3) ([AF]OSR-TN-55-245) (AF 18(600)961) AD 71949 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 24: 33-38, Jan. 1957.

The perturbation velocity potential for unsteady flow around thin wings is expanded in a series of M^{-2}, taking into account linear and second-order terms in perturbation velocities. The first terms for the pressure are seen to be in agreement with those predicted by the Hayes-Lighthill piston theory. The additional terms provide an accuracy sufficient for engineering purposes down to $M \approx 2$. This solution cannot be used in the hypersonic region, and is also restricted to low reduced frequencies.

MIT. 06:005

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

UNSTEADY LAMINAR BOUNDARY LAYERS, by M. Finston. June 1955, 19p. incl. diagrs. refs. (MIT Fluid Dynamics Research Group rept. no. 55-4) ([AF]OSR-TN-55-466) (AF 18(600)961) AD 84887 Unclassified

Equations are presented describing motion of a viscous fluid. The unsteady boundary-layer equations are compared with the linearized flows. The high-frequency perturbations on an existing boundary layer are shown to be independent of the main flow and relatively insensitive to curvature of adjacent surfaces. An explanation is advanced for these phenomena by using exact solutions to Rayleigh's problem and related classical examples.

MIT. 06:006

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

PARAMETRIC STUDIES OF VISCOUS AND NON-VISCOUS UNSTEADY FLOWS, by M. T. Landahl, E. L. Mollo-Christensen, and H. Ashley. Apr. 1955, 94p. incl. diagrs. tables, refs. (MIT Fluid Dynamics Research Group repl. no. 55-1) ([AF]OSR-TR-55-13) (AF 18(600)961) AD 64033 Unclassified

A systematic study is made of the circumstances under which the differential equations governing motion of viscous and nonviscous gases can be simplified by eliminating or linearizing various terms. In the nonviscous case, a complete classification of small disturbance potential flow problems is constructed by means of series expansions involving all important dimensionless parameters. Parametric ranges are found within which mathematical reductions are permissible, and the order of magnitude of the numerical error made in each of these is estimated. The multiplicity of parameters prevents exhaustive classification of viscous flows, but several interesting simplifications are presented.

MIT. 06:007 - MIT. 06:011

including linearized cases with differential equations of diffusion type. Solutions are derived for 2 of the simpler problems identified in the parametric analysis. The first concerns the emission of sound from a wire heated by alternating current, and qualitative comparisons are made with the data from an elementary experiment. The second is "piston theory" for wings moving at high frequencies or Mach numbers. Certain relatively easy computations are shown to compare favorably with more exact 2- and 3-dimensional results, and the application to flutter prediction is discussed. (Contractor's abstract)

MIT. 06:007

Massachusetts Inst. of Tech. [Fluid Dynamics Research Group] Cambridge.

ON APPROXIMATE SOLUTIONS FOR THE COMPRESSIBLE FLOW AROUND OSCILLATING THIN WINGS, by M. T. Landhal, H. Ashley, and E. L. Mollo-Christensen. Mar. 14, 1955, 2p. incl. illus. [AF 18-(600)961] Unclassified

Published in Jour. Aeronaut. Sciences, v. 22: 581-582, Aug. 1955.

A thin wing with root semichord b = 1 oscillating in a free stream of velocity U = 1 with reduced frequency of $k = \omega b/U$, ω being the circular velocity, is considered. An equation is given for which exact solutions can be obtained only in special cases, e.g., the 2-dimensional supersonic case. By neglecting one or several terms, however, simple solutions can be procured. Three approximations are discussed which are applicable for different ranges of k and M.

MIT. 06:008

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

FORCES AND MOMENTS ON OSCILLATING SLENDER WING-BODY COMBINATIONS AT SONIC SPEED, by M. T. Landahl. Feb. 1956, 42p. incl. diagrs. (MIT Fluid Dynamics Research Group rept. no. 56-1) ([AF]OSR-TN-56-109) (AF 18(600)961) AD 82505 Unclassified

It is shown that, under certain conditions, the linearized equations of motion are valid for treating the lifting, unsteady, transonic flow around slender configurations of finite thickness. On this basis, a method of solution is proposed which is valid for low combinations of aspect ratio and reduced frequency of oscillation. The method is an extension of the iterative method of Adams and Sears (Jour. Aeronaut. Sciences, v. 20: Feb. 1953), and is applied in detail to a wing-body configuration. The stability derivatives are calculated and simple formulas are given for the influence of the body. It is found that, except for very slender configurations ($A < 1$), the slender-body theory alone is inadequate for calculation of damping derivatives. The effect of the body is to decrease the damping moment in pitch and this effect is important in case of a delta wing. (Contractor's abstract)

MIT. 06:009

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

A STRIP THEORY FOR OSCILLATING THIN WINGS WITH SUBSONIC LEADING AND SUPERSONIC TRAILING EDGES, by M. T. Landahl. Mar. 1956, 19p. incl. illus. tables, refs. (MIT Fluid Dynamics Research Group rept. no. 56-2) (AFOSR-TN-56-155) (AF 18-(600)961) AD 86315 Unclassified

A strip theory is presented for calculation of forces and moments on an oscillating wing having subsonic leading and supersonic trailing edges. The theory is valid when the reduced frequency, based on the wing semi-span and the velocity of sound, is large. Tables for forces and moments on a streamwise strip are given. (Contractor's abstract)

MIT. 06:010

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

STRONG SHOCK WAVES IN POLYATOMIC GASES, by I. Greber. May 1956, 22p. incl. diagrs. refs. (MIT Fluid Dynamics Research Group rept. no. 56-3) ([AF]OSR-TN-56-310) (AF 18(600)961) AD 94845 Unclassified

A summary is presented of a brief survey concerning the literature of strong shock waves. Of the 23 published- and report-literature references treated, which range in time from 1922 to 1955, 22 are in English and 1 is in German. Primary attention is placed on the structure of strong shock waves in a polyatomic gas, particularly air, and the generation of strong shock waves in shock tubes. The increase of shock strengths obtainable from simple configurational modifications of the basic shock tube are shown. (Contractor's abstract)

MIT. 06:011

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

THE FLOW AROUND OSCILLATING LOW-ASPECT RATIO WINGS AND WING-BODY COMBINATIONS AT TRANSONIC SPEEDS, by M. T. Landahl. [1956] 6p. diagrs. refs. (AFOSR-TN-56-445) (AF 18(600)961) AD 96970 Unclassified

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 3: 103-112, 1957.

Theoretical results on the unsteady transonic flow

around thin, low-aspect-ratio wings and wing-body combinations are presented. First the problem of linearization of the equations of motion is considered. It is shown that linearization is possible provided the reduced frequency of oscillation is large compared to a certain parameter involving the thickness ratio and aspect ratio of the wing. This requirement automatically makes any upstream influence vanish, even when the free stream is slightly subsonic and thus considerably simplifies the analysis. The linearized solution for the perturbation velocity potential is obtained through expansion in terms of aspect ratio or reduced frequency. Two different methods are used, one which is valid for wings of delta type and the other for rectangular wings. The methods are applicable both for rigid and elastic oscillations of the wings, so that they can be used for three-dimensional flutter calculations. In the case of a wing-body combination the different terms in the expansion of the solution are found by use of the theory of conformal transformation. Some numerical results are given and compared with those of earlier, simpler theories. It is found that three-dimensional flow effects are very important. Dynamic stability derivatives are also calculated, and it is shown that the damping in pitch can vanish for certain wings and wing-body combinations. The interference effect of the body is to decrease the damping. Means are suggested for modifying the planform so as to provide a substantial increase in the damping. (Contractor's abstract)

MIT. 06:012

Massachusetts Inst. of Tech. [Fluid Dynamics Research Group] Cambridge.

THE FLUTTER OF LOW-ASPECT-RATIO WINGS, by R. L. Halfman. [1956] 20p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)961 and Bureau of Aeronautics under NOa(s)-53-712-C) Unclassified

Published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 3: 113-123, 1957.

A brief description is given of recent progress made in the theory of unsteady airloads and the construction of dynamic models.

MIT. 07:001

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

MEASUREMENTS OF THREE-DIMENSIONAL BOUNDARY LAYERS ON WINGS, by P. H. Winter. Mar. 1955, 30p. incl. illus. diagrs. (MIT Fluid Dynamics Research Group rept. no. 55-2) ([AF]OSR-TN-55-133) (AF 18(600)1306) AD 64034 Unclassified

A description is given of a preliminary experimental investigation of 3-dimensional boundary layer flow on a 45° sweptback, infinite, flat-plate wing. A probe mounting with 3° of freedom in translation and 1° of freedom in rotation in a plane parallel to the wing surface controlled from outside the tunnel was designed and built. Measurements of profiles were taken at a Reynolds number of 3.3×10^5. At zero incidence, the profiles satisfied approximately the 7th power law, but the boundary-layer thickness was appreciably greater than for the equivalent 2-dimensional boundary layer. At incidence, the free stream was nearly parallel, the flow in the core of the boundary layer appeared to turn upstream near the leading edge, and to sweep outward further downstream. (Contractor's abstract)

MIT. 07:002

Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge.

VISCOUS FLOWS NEAR SIDE EDGES AND LEADING EDGES, by L. Trilling. June 1955, 64p. incl. diagr. refs. (MIT Fluid Dynamics Research Group rept. no. 55-4) ([AF]OSR-TN-55-220) (AF 18(600)1306) AD 70112 Unclassified

The solution is given of the Navier Stokes equations for the unsteady motion of a viscous incompressible fluid past a parabolic cylinder parallel to its generatrices, and of the linearized Oseen equations for the steady flow past a quarter infinite thin flat plate whose edges are respectively parallel and perpendicular to the direction of undisturbed motion. In the second problem, the convection velocity is the constant free stream velocity; the no-slip conditions are applied on the plate surface, and the vorticity vanishes in the plane of symmetry off the plate surface. The pressure and skin friction on the plate are computed; the pressure vanishes and the skin friction has an inverse square root singularity along both edges; its strength remains constant along the leading edge, decreases as an inverse quarter power of distance downstream from the leading edge along the side edge, and depends on the direction of approach in the neighborhood of the corner. (Contractor's abstract)

MIT. 08:001

Massachusetts Inst. of Tech. [Lab. for Insulation Research] Cambridge.

PIEZOELECTRICITY, FERROELECTRICITY, AND CRYSTAL STRUCTURE (Abstract), by A. von Hippel. [1952] [1]p. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N50ri-07801]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Published in Phys. Rev., v. 87: 200-201, July 1, 1952.

MIT. 08:002 - MIT. 08:005

By visualizing polar crystals as a network of permanent dipole moments, the piezo- and ferroelectric properties of dielectrics may be derived from the standpoint of molecular symmetry. This approach is used to clarify the relation between the sphalerite and wurtzite structures, the ferroelectric feedback effect in barium titanate, aspects of domain formation, and the interrelationship between ferro- and piezoelectricity.

MIT. 08:002

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PHOTOEMISSION FROM SILVER INTO AgCl, KBr, NaCl AND NEW BANDS OF PHOTOSENSITIVITY IN AgCl, by M. A. Gilleo. Oct. 1952, 40p. incl. diagrs. refs. (Technical rept. no. 54) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) U24896 Unclassified

Also published in Phys. Rev., v. 91: 534-542, Aug. 1, 1953.

The work required to move an electron from a metal into an insulator has been investigated photoelectrically. The work function thus found was about 4.3 ev for Ag evaporated in vacuo on KBr (Fowler plot) as well as on NaCl (threshold wavelength). The photoelectrons become trapped in these crystals at vacant anion sites and may be released by F-band illumination. For Ag on AgCl a work function of 1.1 ev is measured at the low temperatures used to freeze out ionic conductivity. In AgCl seven new bands of photoconductive response were found; the optical absorption was too small to be measured directly. These bands have a half width of ca 0.2 ev at 90°K and are bleached by irradiation. The 4400, 5000, 5700, 6600, and 7500A bands increase in intensity with an increasing supply of electrons provided by photoelecIric emission and behave analogously to the F bands of the alkali halides. The 4800 and 9200A bands are favored by a scarcity of electrons and may correspond to trapped holes. Photosensitivity in all these bands can be created by irradiation in the intrinsic optical-absorption edge of AgCl at low temperature. They may not be characteristic of a perfect crystal. The intrinsic band-like photoconductive response of AgCl and the absorption edge on which it occurs shift toward shorter wavelengths with decreasing temperature. The maximum of response which appears with decreasing wavelength may arise from a bimolecular recombination of charge carriers released by light. The absorption edge steepens as it shifts toward shorter wavelengths with decreasing temperature. (Contractor's abstract)

MIT. 08:003

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

ELECTRICAL AND OPTICAL PROPERTIES OF RUTILE SINGLE CRYSTALS, by D. C. Cronemeyer. [1952] [11]p. incl. diagrs. table, refs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) Unclassified

Published in Phys. Rev., v. 87: 876-886, Sept. 1, 1952.

Clear, synthetic rutile (TiO_2) single crystals have been investigated by electrical and optical methods. It seems possible to correlate the high temperature conductivity (E_G = 3.05 ev) with the threshold of optical absorption at low temperatures (3.03 ev) and with the maximum of the photoconductivity (3.00 - 3.03 ev). This evidence indicates an energy gap ca 3.05 ev for rutile as an insulator. Semiconducting rutile, prepared by hydrogen reduction at temperatures $\leq$ 800°C, shows a blue color arising from an optical absorption maximum at ca 1.7μ (0.73 ev). Conductivity-temperature plots for slightly reduced specimens indicate an optical activation energy of 0.68 ev. A theoretical calculation for the ionization of the first electron from an oxygen vacancy indicates 0.74 ev as the expected value, in good agreement with the experimental results. At room temperature the mobility of electrons in slightly reduced single crystals is ca 10^{-4} m^2/v-sec. Strongly reduced rutile is opaque; a comparison of electron concentrations calculated from weight loss and Hall coefficient data shows that for samples in which the electron concentration is $10^{26}/m^3$, all contribute to conduction at room temperature. (Contractor's abstract)

MIT. 08:004

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

BEHAVIOR OF SLOW ELECTRONS IN POLAR CRYSTALS, by E. P. Gross. Dec. 1952, 40p. incl. diagrs. refs. (Technical rept. no. 55) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6048 Unclassified

The effective mass of slow electrons in polar crystals is investigated using the continuum model of Pekar and Frölich, Plezer and Zienau. The Hamiltonian is studied in a Fock representation so that effects of several quanta can be assessed. The calculations show that the effective mass is larger than that predicted by the one quantum solution, but that the effective mass is still small for weakly polar crystals. For excess electrons in strongly polar crystals many quantum contributions must be included and the present method is inappropriate. It is uncertain whether the effective mass is small in this case. Holes in polar crystals appear to satisfy the conditions for the validity of the theory of Landau and Pekar which predicts a high effective mass. (Contractor's abstract)

MIT. 08:005

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge

THE GROWING OF LEAD TITANATE CRYSTALS

AND SOME OF THEIR PROPERTIES, by H. H. Rogers. Dec. 1952, 17p. incl. illus. diagrs. refs. (Technical rept. no. 56) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 4803 Unclassified

Small, high-purity, single crystals of lead titanate were grown from a melt consisting of TiO_2 and an excess of PbO. The preparation of a large single crystal by the Bridgman-Stockbarger method is described. Its subsequent fracturing on cooling is interpreted by visual observation and by x-ray measurements. The chemical reactivity of $PbTiO_3$ is discussed and data on the thermal dissociation into PBO vapor and by x-ray measurements. $PbTiO_3$ appears to be the only stable compound in the system PbO-TiO_2. The chemical reactivity of $PbTiO_3$ is discussed on data on the thermal dissociation into PbO vapor and solid TiO_2 are given. $PbTiO_3$, as expected, is piezoelectric at room temperature, has the domains characteristic of a ferroelectric substance, and, in addition, undergoes a reversible color change from red to yellow when cooled through the Curie point (ca 490°C). The density of a cracked crystal, measured at 25°C, proved to be 7.96 g/ml, or 99.2% of x-ray density. The birefringence at 25°C has been measured as a function of wavelength (at 5800A, $^{n}max^{-n}min = 0.011$). (Contractor's abstract)

MIT. 08:006

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

TABLES OF DIELECTRIC MATERIALS, VOLUME IV, by [A. von Hippel]. Jan. 1953, 138p. incl. diagrs. tables. (Technical rept. no. 57) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 5843 Unclassified

This work in its present form summarizes the measurements of the Laboratory for Insulation Research at M. I. T. on the complex permittivity (dielectric constant and loss tangent) and the complex permeability of important dielectrics made in this country. They are intended to aid government agencies, engineers and manufacturers in the proper application of dielectrics and in the development of better products. Volume IV reports on about 250 new materials; simultaneously, it has taken over and amplified the measurements given in the previous volumes as far as they still are of special interest. A number of materials now not in production have been retained for this reason but are indicated as "discontinued." The total number of materials included amounts to over 600. (Contractor's abstract)

MIT. 08:007

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

AN X RAY DIFFRACTION STUDY OF BARIUM TITANATE, by H. T. Evans, Jr. Jan. 1953, 35p. incl. illus. diagrs. tables, refs. (Technical rept. no. 58) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 4273 Unclassified

An x-ray diffraction investigation was carried out in an attempt to determine in detail the atomic positions and temperature motions in the crystal structure of the tetragonal ferroelectric form of barium titanate. The basic experimental data used in the analysis consisted of the integrated intensities of 99 Bragg reflections of the type (hk0). The intensities were carefully measured by means of a scanning technique using a Geiger counter assembly especially designed for this study, a small (0.1 mm) untwinned single crystal, and MoKα radiation. The intensities were corrected for absorption and secondary extinction effects determined by special techniques worked out for this particular crystal. The search for a structure which will adequately account for these data was carried out by the methods of trial and error and least-squares analysis. A model was finally defined in terms of 3 structure and 9 anisotropic temperature parameters. It was found that in the general intensity function for all reflections there is an interaction between the structure parameter of an atom (displacement along the tetragonal axis) and the temperature motion of the atom in this direction. Therefore, in order to determine the value of one from the observed intensity data, it is necessary to assume a fixed value for the other. Consequently, within a rather wide range, it is not possible to determine uniquely the structure of tetragonal barium titanate. Certain temperature parameters do not interact with other parameters, and these are uniquely determined. From these, reasonable values have been assigned to the other temperature motions, and the structure consistent with these assumptions determined. The reliability factor R for this structure is 0.0367. These results are compared with those published by other workers. (Contractor's abstract)

MIT. 08:008

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PHOTOCURRENT SPACE CHARGE BUILDUP, AND FIELD EMISSION IN ALKALI HALIDE CRYSTALS, by A. von Hippel, E. P. Gross and others. Feb. 1953, 38p. incl. diagrs. tables, refs. (Technical rept. no. 59) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6049 Unclassified

Also published in Phys. Rev., v. 91: 568-579, Aug. 1, 1953.

Additively colored alkali halide crystals represent, in a first approximation, a transparent solid with frozen-in electrons which can be mobilized by light absorption. When moving towards the anode, these electrons leave

MIT. 08:009 - MIT. 08:013

a positive space charge behind, and an adjustable cathode fall results which can be steepened until electrons are released by field emission. The steady-state and transient solutions for the charging and discharging cycle are calculated, the effects of light intensity, wavelength, field emission discussed, and KBr crystals investigated experimentally as function of time, voltage, light intensity, and colorcenter density. Field emission has been produced with voltages as low as 1 v, and a field-emission photocell has been realized. (Contractor's abstract)

MIT. 08:009

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

ON THE DISORDER IN CRYSTALLINE 2, 2-DINITROPROPANE AT ROOM TEMPERATURE, by S. C. Abrahams. Feb. 1953, 4p. incl. diagr. table, refs. (Technical rept. no. 60) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force] Office of Scientific Research under N5ori-07801 and N5ori-07858) AD 6191 Unclassified

Also published in Jour. Chem. Phys., v. 21: 1218-1219, July 1953.

2-2-Dinitropropane formed face-centered cubic crystals at room temperature, with a_o = 8.73 ± 0.05 A, and 4 molecules/unit cell. For the models considered, the agreement between observed and calculated factors was uniformly better for the centrosymmetric case than for the noncentrosymmetric case. It was suggested that although the disorder is complete at long range, there is a high degree of order at short range.

MIT. 08:010

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE LOW-TEMPERATURE TRANSITION IN MAGNETITE, by S. C. Abrahams and B. A. Calhoun. Feb. 1953, 4p. incl. tables. (Technical repl. no. 61) (Bound with its Technical repl. nos. 60-63; AD 6191-AD 6094) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6192 Unclassified

Also published in Acta Crystallographica, v. 6: 105-106, Jan. 10, 1953.

Magnetite was shown to transform from the cubic to the orthorhombic system at temperatures below 119°K. The thermal expansion coefficient of the c axis became negative below 119°K, and at about 95°K there was no appreciable difference in the spacing of (440) and (008). The dimensions of the magnetite unit cell were measured at 295°, 128°, and 78°K and the resulting volumes were 591.4, 589.1, and 589.6 A^3, respectively. From these data and the c axis length at 108°K, the coefficients of thermal expansion above and below the transition were calculated.

MIT. 08:011

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A LOW-TEMPERATURE ADAPTOR FOR THE NORELCO HIGH-ANGLE SPECTROMETER, by B. A. Calhoun and S. C. Abrahams. Feb. 1953, 3p. incl. illus. (Technical rept. no. 62) (Bound with its Technical rept. nos. 60-63; AD 6191-AD6194) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6193 Unclassified

Also published in Rev. Scient. Instruments, v. 24: 397, May 1953.

A description is given of a simple adapter which was developed for use with the Norelco high-angle spectrometer with samples cooled to 78°K. The cryostat consists of a sample holder, an insulated open chamber for liquid N, and an insulated cover to prevent ice formation near the sample. The device was successfully used to investiage the transition in magnetite down to 78°K.

MIT. 08:012

Massachusells Inst. of Tech. Lab. for Insulation Research, Cambridge.

A SHIELDING DEVICE FOR X-RAY DIFFRACTION CAMERAS, by S. C. Abrahams and W. R. Blackmore. Feb. 1953, 2p. incl. illus. (Technical rept. no. 63) (Bound with its Technical rept. nos. 60-63; AD 6191-AD 6194) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6194 Unclassified

Also published in Rev. Scient. Instruments, v. 24: 885, Sept. 1953.

A description is given of a simple device of durable construction which was developed to prevent the scattering of x-rays between the window of an x-ray tube and the collimator of the camera. The shield was designed for Machlett x-ray tubes and Supper collimators and cameras, but it may easily be modified for most types of tubes and cameras.

MIT. 08:013

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A MOVING-STRIP FOURIER ANALYZER, by P. J. Grenville Wells. Feb. 1953, 18p. incl. illus. tables. (Technical rept. no. 64) (Bound with its Technical rept. nos. 64-66; AD 6195-AD 6197) (Sponsored

jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6195 Unclassified

Also published in Rev. Scient. Instruments, v. 25: 1156-1161, Dec. 1954.

An analyzer is described which performs directly 2-dimensional Fourier summations of the type $\Sigma\Sigma_{HK} F(hk)\cos 2\pi(hX + kY)$. The analyzer also evaluates sine summations and some 3-dimensional summations. The device accommodates values of F(hk) = ± (1 - .99), h = -15 to 15, k = 0 to 15 for X and Y = 1/36 of the repeat distance. The operation of the analyzer is illustrated by an example.

MIT. 08:014

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A GRAPHICAL METHOD OF EVALUATING CERTAIN CRYSTALLOGRAPHIC STRUCTURE FACTORS, by H. J. Grenville-Wells. Feb. 1953, 14p. incl. illus. table. (Technical repl. no. 65) (Bound with its Technical rept. nos. 64-66; AD 6195-AD 6197) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 6196 Unclassified

Also published in Jour. Appl. Phys., v. 25: 485-490, Apr. 1954.

A graphical method is described for evaluating structure factors of the form

$$F(hk) = \sum_{0}^{n} f_r(hk)\cos 2\pi(hx_r + ky_r)$$ and electron density

expressions of the form $\rho(X, Y) = \Sigma_H \Sigma_K F(hk)\cos 2\pi(hX + kY)$. The method depends upon the fact that if in a 2-dimensional [001] projection of a unit cell the normal to the planes (hk0) is graduated with the appropriate cosine function giving the phases of points along the normal, then a circle, having its center at (X/2, Y/2) and passing through the origin will cut the normal to F(hk0) at the value of cos 2π(hx + ky). The practical limitations and general utility of the construction are discussed. (ASTIA abstract)

MIT. 08:015

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

UPPER-LEVEL PRECESSION PHOTOGRAPHY AND THE LORENTZ POLARIZATION CORRECTION, by H. J. Grenville-Wells and S. C. Abrahams. Feb. 1953, 6p. incl. illus. (Technical rept. no. 66) (Bound with its Technical rept. nos. 64-66; AD 6195-AD 1197) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-07801 and N5ort-07858) AD 6197 Unclassified

Also published in Rev. Scient. Instruments, v. 23: 328-331, July 1952.

A set of charts is presented for the Lorentz-polarization correction for upper-level precession photographs obtained with a 30° precession angle. The charts cover 7 levels in reciprocal space, 0.05 rlu apart, and correspond to a 5.5-cm magnification factor. By superimposing x-ray films on the charts, the corrections can be read off at the positions at which diffraction spectra occur.

MIT. 08:016

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

INHOMOGENEITY OF THALLIUM HALIDE MIXED CRYSTALS AND ITS ELIMINATION, by A. Smakula, J. Kalnajs, and V. Sils. Mar. 1953, 20p. incl. illus. tables, refs. (Technical rept. no. 67) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 8948 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 43: 698-701, Aug. 1953.

A study was made of the optical inhomogeneity of prisms used in IR spectroscopy, which are cut from mixed crystals of thallium halides. The cause of the defect was determined to be the use of incorrect minimum melting points of the compositions from which the crystals were grown. The freezing points of thallium halides and the minimum freezing points of the binary systems (TlCl with TlBr and TlI) were determined by cooling the melted samples and measuring the temperature with an Fe-Constantan thermocouple. The freezing points were higher than those of Moenkemeyer (Neves Jahrb. Mineral. Geol. Pal. 22, Beilage-Band, 1906). Crystals of binary systems were grown on the basis of the new data, and the greatest deviation of the lattice constant along the crystal length was determined to be more than 5×10^{-5}. These results show that the optical inhomogeneity was caused by the incorrect composition of the melt. The refractive index variation in the new crystals was less than 1×10^{-5}.

MIT. 08:017

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

ELECTRICAL CONDUCTIVITY OF MAGNETITE AT LOW TEMPERATURES (Abstract), by B. A. Calhoun. [1953] [1]p. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N5ori-07801]) Unclassified

MIT. 08:018 - MIT. 08:020

Presented at meeting of the Amer. Phys. Soc., Cambridge, Mass., Jan. 22-24, 1953.

Published in Phys. Rev., v. 90: 374, Apr. 15, 1953.

The electrical conductivity of synthetic magnetite single crystals, has been measured from room temperature to 40°K. Below the transition at 119°K, the activation energy decreases from 0.11 ev (90-78°K) to 0.061 ev (52-40°K). The conductivity below the transition is isotropic when the samples are cooled in a demagnetized state. Samples cooled through the transition in a magnetic field sufficient to saturate and then demagnetized show an anisotropic conductivity. The conductivity depends on the orientation of both the sample and the magnetic field. Verwey and his co-workers (Jour. Chem. Phys., v. 15: 181, 1947) suggested that the transition resulted from an ordering of the ferrous and ferric ions in the octahedral sites and proposed an ordered structure of orthorhombic symmetry. The observed anisotropy of the conductivity agrees with this model. (Contractor's abstract)

MIT. 08:018

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A HIGH-TEMPERATURE LABORATORY CATENARY KILN, by G. Economos and F. E. Vinal. [1953] [3]p. incl. illus. diagrs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801)
Unclassified

Published in Jour. Amer. Ceramic Soc., v. 36: 204-206, June 1953.

The catenary curve was analyzed to find the dimensions at which a self-supporting arch can be obtained. For kiln construction, a height-to-base ratio of 1 to 1 was found to be advisable. Detailed construction data was given for a kiln with a 0.5-cu ft chamber. A parallel heating element system with a low-voltage, high-ampere power circuit is described, and the advantages of the arrangement are noted. Excellent temperature uniformity is reported, and 1400°C can be attained at a rate of 65°C per hour with 3-kw power input. An atemized cost of construction is also given. (Contractor's abstract)

MIT. 08:019

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

MAGNETIC AND ELECTRIC PROPERTIES OF MAGNETITE AT LOW TEMPERATURES, by B. A. Calhoun. July 1953. 49p. incl. diagrs. tables, refs. (Technical rept. no. 68) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-07801 and N5ori-07858) AD 15523 Unclassified

Also published in Phys. Rev., v. 94: 1577-1585, June 15, 1954.

The low-temperature transition in magnetite, according to Verwey, is due to the ordering of the ferrous and ferric ions in the octahedral interstices of the spinel lattice. This arrangement would require a symmetry change from cubic to orthorhombic. X-ray diffraction indicates and electric conductivity and magnetization measurements confirm that the transition leads to an orthorhombic structure. An external magnetic field applied while cooling through the transition establishes a preferred orientation for the c axis throughout the whole crystal. Below the transition this c axis can be switched to a new direction by a strong magnetic field, a process involving a cooperative rearrangement of the ferrous ions in new sites and relatively large changes in dimensions. In stoichiometric, synthetic, single crystals the transition occurs at 119.4°K and is marked by an abrupt decrease in the conductivity by a factor of 90 in a temperature interval of 1°. No thermal hysteresis is observed. The conductivity of a crystal cooled in a strong magnetic field is anisotropic below the transition as given by the relation $\sigma = A + B(1 + \cos^2\theta)$, where θ is the angle between the c axis and the direction of measurement. The ratio $B/(A + B)$ increases rapidly as the crystal is cooled to 90°K, indicating a progressive increase in the long-range order. The c axis is the direction of easy magnetization below the transition, and the anisotropy energy is very much larger below than above; the anisotropy constants have been determined at 85°K. (Contractor's abstract)

MIT. 08:020

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A NOMOGRAM FOR EVALUATING THE TEMPERATURE FACTOR, by H. J. Greenville-Wells. [1953] [2]p. incl. diagr. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) Unclassified

Published in Acta Crystallographica, v. 6: 665-666, July 10, 1953.

The nomogram evaluates the expression

$$\exp[(-2B \sin^2\theta)/\lambda^2] = f_t/f_o,$$

where the symbols have the usual significance. It has four scales, A, B, C, and D. A and D are logarithmic scales with 1 cycle = 10 in.; they are equidistant from C, which is the logarithmic scale having 2 cycles = 10 in. required for multiplication. The B scale, which is a linear inch scale, is antilogarithmic against the A scale. An example of the use of the nomogram for evaluating f_t/f_o for particular values of B and $\sin^2\theta/\lambda^2$ would be: if $\sin^2\theta/\lambda^2 = 0.04$ and B = 3, the $f_t/f_o = 0.79$.

MIT. 08:021

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A KINETIC APPROACH TO COLLISION PROCESSES IN GASES. I. SMALL AMPLITUDE PROCESSES IN CHARGED AND NEUTRAL ONE-COMPONENT SYSTEMS, by P. L. Bhatnager, E. P. Gross, and M. Krook. Sept. 1953, 41p. incl. illus. refs. (Technical rept. no. 69) (In cooperation with Harvard Coll. Observatory, Cambridge, Mass. under AF 19(604)146) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 17744 Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 27-28, 1953.

Abstract published in Phys. Rev., v. 93: 936, Feb. 15, 1954.

Also published in Phys. Rev., v. 94: 511-525, May 1, 1954.

This approach appears adequate for the unified treatment of the dynamic properties of gasss over a continuous range of pressures from the Knudsen limit to the high-pressure limit where the aerodynamic equations are valid. Alterations are made in the collision terms of the Boltzmann equation; each collision conserves particle number, momentum, and energy; persistence of velocities and angular dependence may be included. The approach illustrates a technique for a simple model involving the assumption of a collision time independent of velocity; this model is applied to the study of small amplitude oscillations of 1-component ionized and neutral gases. The initial value problem for unbounded space is solved by performing a Fourier transformation on the space variable and a Laplace transformation on the time variable. For uncharged gases there results the correct adiabatic limiting law for sound-wave propagation at high pressures. For ionized gases the difference in the nature of the organization in the low-pressure plasma oscillations and in high-pressure sound-type oscillations is studied. Two important cases are distinguished. If the wave length of the oscillations is long compared to either the Debye length or the mean free path, a small change in frequency is obtained as the collision frequency varies from zero to infinity. The accompanying absorption is small and reaches its maximum value when the collision frequency equals the plasma frequency. The other case refers to waves shorter than both the Debye length and the mean free path; these waves are characterized by a very heavy absorption. (For part II of this report see item no. SYit. 03:002) (ASTIA abstract)

MIT. 08:022

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF BARIUM TETRASULFIDE MONOHYDRATE, by S. C. Abrahams. Sept. 1953, 25p. incl. illus. tables, refs. (Technical rept. no. 70) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 17743 Unclassified

Also published in Acta Crystallographica, v. 7: 423-429, May 20, 1954.

Barium tetrasulfide monohydrate forms piezoelectric crystals belonging to the orthorhombic system, space group D_2^3 - $P2_12_12$ with 4 molecules in the unit cell of dimensions a = 9.67, b = 7.99, c = 7.81 Å. The crystal structure was completely determined, and the values of the 17 atomic coordinates were refined by double Fourier series and least-square methods, based upon 296 terms derived from visual intensity measurements, in the 3 principal zones. The Ba atom is completely ionized, and is in ionic contact with the S atoms and the O of the H_2O molecule. The tetrasulfide ion possesses C_2 symmetry. Like the anion of Cs_2S_6 the tetrasulfide ion is non-branched and nonplanar, and also exhibits a similar alternation in bond length. Two kinds of S-S bonds are present, of length 2.02 and 2.07 A, allowing a new tentative bond-order vs bond-length curve for S to be established. (Contractor's abstract)

MIT. 08:023

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

DERIVATION OF ATOMIC COORDINATES IN HELICAL STRUCTURES, by H. J. Grenville-Wells. Sept. 1953, 12p. incl. illus. (Technical rept. no. 71) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 19939 Unclassified

A general method is developed for obtaining the coordinates of atoms in helical structures. The helix is treated as the repetition of a structural unit by an n-fold screw axis, where n is continuously variable. The coordinates are needed in complex structures such as proteins for the calculation of bond lengths and bond angles. The specific form in which the derivation is presented was developed for the analysis of polypeptide chain helices. Graphs are given which facilitate the use of the derived expressions.

MIT. 08:024 - MIT. 08:027

MIT. 08:024

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A SINGLE-CRYSTAL ADAPTOR FOR THE NORELCO HIGH-ANGLE DIFFRACTOMETER, by S. C. Abrahams and H. J. Grenville-Wells. Sept. 1953, 4p. incl. illus. (Technical rept. no. 72) (Bound with its Technical rept. no. 71; AD 19939-AD 19940) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ort-07858) AD 19940 Unclassified

Also published in Rev. Scient. Instruments, v. 25: 519-520, May 1954.

The adaptor is based on the principle of completely bathing a small single crystal in a slightly divergent collimated x-ray beam, and slowly rocking the crystal through the Bragg reflection angle while keeping the GM counter stationary at the proper 2θ angle. The normal specimen holder is replaced by a long shaft which closely fits the bronze sleeve of the diffractometer and ends in a screw on which a Supper goniometer head can be fitted. A graduated circle is attached to the other end of the shaft which is connected to a synchronous motor. The whole shaft can be translated along its length to bring the crystal into the x-ray beam. A Bodine motor is used to rotate the crystal at a constant angular velocity of 1/8° θ/min. A backstop is mounted on a sleeve which fits over the collimator shaft, and permits the counter to record spectra with angles as low as 3°2θ.

MIT. 08:025

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A REGULATED CONTROL SYSTEM FOR A LARGE ELECTROMAGNET, by L. E. Johnson. Sept. 1953 [41]p. incl. illus. tables, refs. (Technical rept. no. 73) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 19932 Unclassified

The system is an automatic self-correcting device which maintains the magnet current at any desired level. The design is a servomechanism which functions as a follow-up device for varying input commands. It also compensates for extraneous current fluctuations resulting from variations produced by temperature changes, generator brush noise, generator structural asymmetries, and changes in generator speed caused by variations in line voltage. The design originally incorporated a parallel-connected dual-loop design of which the L.F loop, or current stabilizer, was intended to satisfy the input requirements, while the 2 loops together would give the proper degree of stabilization. The present system however, uses only the L.F loop which compensates for the drift and small shifts in the dc value of the current at any desired level. Slow thermal drift and small dc shifts are held to within 1 part in 10^5. (ASTIA abstract)

MIT. 08:026

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

BLEACHING OF CaF_2 CRYSTALS COLORED BY X-RAYS, by A. Smakula. Sept. 15, 1953 [2]p. incl. diagrs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N5ori-07801]) Unclassified

Published in Phys. Rev., v. 91: 1570-1571, Sept. 15, 1953.

Bleaching by light at room temperature is reported of x-ray colored CaF_2 synthetic crystals, by use of a filtered Hg lamp. Tabulated results show no apparent bleaching of the absorption bands marked 1 to 4 after 3 weeks treatment at room temperature. An exposure to light absorbed only by band 1 does not bleach this band after one hour of exposure. A five-minute exposure to light absorbed by band 2 produced a strong decrease of band 2, the other bands being unaffected; simultaneous with destruction of band 2, a new band peaking at 4850A appears. Band 2 can be restored either by heat or by light absorbed by band 1 which remains unaffected while the new band at 4850A disappears. Use of light simultaneously absorbed by bands 1 and 2 effects bleaching of both bands and formation of a new band at 4850A; both bands can be restored either thermally or by irradiation in band 1. A tentative explanation of the absorption bands is proposed.

MIT. 08:027

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

EFFECT OF A TWO-DIMENSIONAL PRESSURE ON THE CURIE POINT OF BARIUM TITANATE, by P. W. Forsbergh, Jr. Oct. 1953, 20[1]. incl. illus. refs. (Technical rept. no. 74) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 19933 Unclassified

Also published in Phys. Rev., v. 93: 686-692, Feb. 15, 1954.

By hydraulics, a single crystal of $BaTiO_3$ in the shape of a flat circular disk was subjected to a pressure exerted on the edges. After removal of all domains that were not normal to the disk by a slight pressure, the stress system consisted of equal pressures on the 2 a axes and none on the c axis. The transition temperature increased with the square of the 2-dimensional pressure; Merz's hydrostatic pressure produced a linear drop. The free energy for the 2 dimensional and hydrostatic stress systems was obtained by using Devonshire's expansion for energy (Phil. Mag., v. 40: 1040,

1949; v. 42: 1065, 1951) and the appropriate Legendre transformation. The expansion had to be supplemented to obtain a quadratic effect. The evaluation of the effect of pressure on the transition temperature was difficult when higher terms were included, but the effect on Curie-Weiss temperature was easily determined. The linear part of the Curie-Weiss temperature shift depended only on the lower terms in the free energy expansion; it provided 2 independent relations for determining the 2g coefficients. The quadratic shift of the Curie-Weiss temperature depended on the higher terms with which the Devonshire's expansion was supplemented, and an interpretation of these higher terms gave an upward direction to the shift.

MIT. 08:028

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE KINETICS OF THE HETEROGENEOUS PARA-HYDROGEN CONVERSION, by Y. L. Sandler. 1953 [2]p. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N5ori-07801]) Unclassified

Published in Jour. Chem. Phys., v. 21: 2243-2244, Dec. 1953.

Heterogeneous parahydrogen conversion is asserted to follow a strict first order decay law. The observed rate is written as: $r = kN = k_3N_3$, where N is the total number of molecules present in the reaction vessel and N_3 is the number of absorbed molecules. The "true" rate constant k_3 is defined by the aforegiven equation. Like k, it generally will be a function of temperature and pressure (or coverage).

MIT. 08:029

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

SOLUTION OF THE BOLTZMANN EQUATION FOR MAXWELLIAN MOLECULES, by E. P. Gross. [1954] [2]p. [Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force] Office of Scientific Research under [N5ori-07801] Unclassified

Published in Phys. Rev., v. 93: 347-348, Jan. 15, 1954.

The Boltzmann integrodifferential equation for monatomic gases has been studied extensively in two limiting cases, where the mean free path is small compared to the relevant lengths of the problem and where the mean free paths are large compared to a container dimension. Due to present active interest in processes occurring in rarefied gases, a method of solution is required which deals with the entire range of pressures in a unified manner and which can satisfy general microscopic boundary conditions. A method is outlined for the special case of Maxwellian molecules which repel each other with an inverse fifth-power law of force.

MIT. 08:030

Massachusetts Inst. of Tech. [Lab. for Insulation Research] Cambridge.

A KINETIC APPROACH TO COLLISION PROCESSES IN GASES, II (Abstract), by E. P. Gross and M. Krook. [1954] [1]p. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N5ori-07801]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 27-28, 1953.

Published in Phys. Rev., v. 93: 936, Feb. 15, 1954.

A kinetic approach is applied to the study of the small amplitude oscillations of one-component ionized and neutral gases. The initial-value problem in unbounded space is solved in detail for a simple collision model involving the assumption of a collision time independent of velocity. For uncharged gases, there results the corrected adiabatic limiting law for sound-wave propagation at high pressures. In addition, one obtains a theory of the absorption and dispersion of sound for arbitrary pressures. For ionized gases the difference in the nature of the organization in the low-pressure plasma oscillations and in high-pressure sound-type oscillations can be studied. At high pressures it is not permissible to treat an ionized gas as a one-component system; the electron ion coupling must be studied more carefully. This kinetic approach is therefore generalized to treat many-component systems and is applied to the treatment of the oscillations of ionized gases and to the propagation of sound in mixtures of neutral gases. (Contractor's abstract)

MIT. 08:031

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF DI-p-TOLYL TELLURIDE, by W. R. Blackmore and S. C. Abrahams. May 1954, 15p. incl. illus. tables, refs. (Technical rept. no. 75) (Bound with its Technical rept. nos. 76-77; AD 35327(a) - AD 35327(b)) (Sponsored jointly by Office of Naval Research, Signal Corps and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 35327 Unclassified

Also published in Acta Crystallographica, v. 8: 317-323, June 10, 1955.

Di-p-tolyl telluride forms orthorhombic crystals, space group $P2_12_12_1$, with four molecules in a unit cell of dimensions a = 25.33, b = 8.05, and c = 6.01Å. The crystal structure has been determined, the 45

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positional parameters being refined by double Fourier series and least-squares methods. There were 299 terms used, derived from visual tntensity measurements by two independent observers. The tellurium-carbon bond length was measured as 2.05Å and the carbon-tellurium-carbon bond angle was 101°. The planes of the two aromatic rtngs are tnclined at an angle of 62° to each other. Evidence only for van der Waals forces in the crystal was found. (Contractor's abstract)

MIT. 08:032

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF DI-p-TOLYL SELENIDE, by W. R. Btackmore and S. C. Abrahams. May 1954, 10p. incl. illus. tables, refs. (Technical rept. no. 76) (Bound with its Technicat rept. no. 75; AD 35327) (Sponsored jotntly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientiftc Research] under N5ori-07801 and N5ori-07858) AD 35327(a) Unclassified

Also published tn Acta Crystallographica, v. 8: 323-329, June 10, 1955.

Di-p-toiyl selenide forms orthorhombtc crystals, space group $P2_12_12_1$, with a unit cell of constants a = 25.12, b = 7.99, and c = 5.88Å, containing four molecules. The crystat structure has been determined, and the 45 positional parameters refined by double Fourier sertes and least-square methods, emptoying 401 terms. The tniensities were measured visually by two observers. The selenium-carbon distance ts 1.93Å and the carbon-setenium-carbon valence angle is 106°. The ptanes of the two aromatic rtngs forms an angle of 55° with each other. (Contractor's abstract)

MIT. 08:033

Massachusetts tnsi. of Tech. Lab. for Insutation Research, Cambrtdge.

TltE CRYSTAL STRUCTURE OF DI-p-TOLYL SULFIDE, by W. R. Btackmore and S. C. Abrahams. May 1954. May 1954, t5p. tnct. ittus. tables, refs. (Technical repi. no. 77) (Bound with its Technicat repi. no. 75; AD 35327) (Sponsored joinity by Office of Naval Research, Signat Corps, and [Air Force Office of Scientific Research] under N5ori-0780t and N5ori-07858) AD 35327(b) Unclassified

Also published in Acta Crysialtographica, v. 8: 329-335, June t0, t955.

Di-p-tolyl sulfide betongs to the orthorhombic system and has cell dimensions, a = 25.07, b = 7.92, c = 5.81Å. There are four molecutes per ceit, and the space group is $P2_12_12_1$. The crysial structure has been determined, and 284 terms were used in double Fourier series and leasi squares procedures to refine the atomic coordinates of the 65 positional parameters. The intensities were measured visually by two independent observers. The sulfur-carbon bond length is 1.75Å and the carbon-sulfur-carbon bond angle ts 109°. The normals to the two aromatic rings form an angle of 56° with each other. (Contractor's abstract)

MIT. 08:034

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A STUDY ON MAGNETIC CERAMICS [Parts 1-5], by G. Economos. May 1954, 59p. incl. iltus. tables, refs. (Technical rept. no. 78) (Sponsored jotntly by Offtce of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801, N5ori-07858, and AF 19(604)458) AD 33858 Unclassifted

Also published tn Jour. Amer. Ceramic Soc., Pt. 1, v. 38: 241-244, July 1955; Pt. 2, v. 38: 292-297, Aug. 1955; Pt. 3, v. 38: 335-340, Sept. 1955; Pt. 4, v. 38: 353-357, Oct. 1955; and Pt. 5, v. 38: 408-411, Nov. 1955.

Magnetite, manganese ferrite, and magnesium ferrite together with thirteen compositions within the system Fe_2O_3-MgO-MnO were investigated. A carbonate decomposition method of obtaining a well-dispersed oxide mix of high reactivity was used. The ferrites were also prepared and fired in various controlled atmospheres. Magnesium ferrite and one complex composition (approximate mole percent: 30 Fe_2O_3: 35 MgO: 35 MnO) with a rectangular hysteresis loop characteristic were investigated in detail under a variety of ftring conditions. They showed an increase tn the tnitial permeability (μ_i) and a decrease in the coercitive field (H_c) with tncreasing peak firing temperature and ftring time. The maximum induction (B_m) tncreased, but the remanent induction (B_r) fell off when fired at 1450°C, especially for the complex composition. A similar decrease of B_r was noted by quenching from above 800°C. Oxygen loss or gain over the stoichiometrtc amount produced a loss of magnetic properties in atl the ferrttes tnvestigated (μ_i, B_m, B_r down and H_c up). Changes in the magnetic properties of the complex ferrites in the center of the system Fe_2O_3-MgO-MnO coutd be correlated to the amount and types of tons contributing magnetic momenis. X-ray and microsiructure studies aided in the tnterpretation of ihe experimenial data. (Contractor's abstract)

MIT. 08:035

Massachusetts tnsi. of Tech. [Lab. for Insulation Research] Cambridge.

PROPAGATION OF WAVES IN IONIZED GASES (Absiract), by E. P. Gross and M. Krook. Preliminary rept. [t954] [1]p. [Sponsored jointly by Office of Naval ttesearch, Signal Corps, and Air Force Office of Scientific Research under N5ori-07801] Unctassified

Presented at annual meeting of the Amer. Phys Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 778, May 1, 1954.

A theoretical study is made of the small-amplitude oscillations of a completely ionized gas as a function of pressure. At low pressures there exist two types of waves. The high-frequency electronic plasma waves (Phys. Rev., v. 75: 1851, 1864; 1949), are only slightly modified by the motion of positive ions. In addition, we find the low-frequency "plasma-ion" waves previously studied by Tonks and Langmuir (Phys. Rev., v. 33: 195, 1929). The latter are, however, undamped only when the electron temperature is considerably greater than the ion temperature. To study the effects of collisions we make use of a model for collision processes proposed earlier (Bull. Amer. Phys. Soc., v. 28: 32, 1953). It is found that the low frequency modes are increasingly damped as the pressure is raised. The high-frequency modes are also highly damped at intermediate pressure. However, at higher pressures this mode changes its nature continuously and becomes a sound wave with a propagation velocity characteristic of a mixture of gases. (Contractor's abstract)

MIT. 08:036

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

SHAPE OF COLLISION-BROADENED SPECTRAL LINES, by E. P. Gross. May 1954, 24p. incl. diagrs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] as technical rept. no. 79 under N5ori-07801 and N5ori-07858, and technical note no. P-5; AFOSR-TN-54-84 under Syracuse U. Inst. for Industrial Research AF 18(600)459) AD 33884 Unclassified

Also published in Phys. Rev., v. 97: 395-403, Jan. 15, 1955.

Van Vleck and Weisskopf and Fröhlich have derived a microwave line shape by studying the interruption by collisions of the motion of a classical oscillator. They assume that after the instantaneous impact the oscillator variables are distributed according to a Boltzmann distribution appropriate to the value of the applied field at collision. In contrast to the earlier theory of Lorentz, they obtain the correct static polarization. The procedure involves an assumption of very large velocity during collision. This is criticized on the grounds that the duration of collision is short compared to the resonant period and energy exchanges are of the order of kT. We have derived a line-shape formula assuming that the positions are unchanged after impact. Two extreme models are studied. In one, the oscillators have a Maxwellian distribution of velocities after impact; the second is a Brownian motion treatment. The resulting line shape in both cases is that of a friction-damped oscillator. For collision frequency much less than the resonant frequency, the polarization postulated by the above authors is reached as a result of kinematic motion between collisions, and the line shapes agree with ours. However, to obtain equal line widths and peak absorptions, the collision frequency is twice as large for the present theory. For collision frequency comparable to resonant frequency a less distorted line shape results. For testing the theories, experiments on foreign-gas broadening in the microwave region at pressures of the order of an atmosphere are required. Differences between the theories are small for conditions accessible experimentally at present. (See also item no. SYR. 04:007) (Contractor's abstract)

MIT. 08:037

Massachusetts Inst. of Tech Lab. for Insulation Research, Cambridge.

THE LATTICE CONSTANTS OF THE ALKALI BOROHYDRIDES AND THE LOW-TEMPERATURE PHASE OF SODIUM BOROHYDRIDE, by S. C. Abrahams and J. Kalnajs. July 1954, 8p. incl. diagrs. tables. (Technical rept. no. 80) (Bound with its Technical rept. nos. 81-82; AD 37227(b)) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 37227 Unclassified

Also published in Jour. Chem. Phys., v. 22: 434-436, Mar. 1954.

The lattice constants of sodium, potassium, rubidium, and cesium borohydrides have been measured at 25.0°C as 6.1635 ± 0.0005, 6.7272 ± 0.0005, 7.029 ± 0.001, and 7.419 ± 0.001A, respectively. All four crystals are face-centered cubic and have the sodium chloride structure. Below the transition point (-83°C) sodium borohydride becomes tetragonal with lattice constants of a = 4.354 ± 0.005 and c = 5.907 ± 0.005A at -195°C. (Contractor's abstract)

MIT. 08:038

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF BARIUM PEROXIDE, by S. C. Abrahams and J. Kalnajs. July 1954, 14p. incl. illus. tables, refs. (Technical rept. no. 81) (Bound with its Technical rept. no. 80; AD 37227) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 37227(a) Unclassified

Also published in Acta Crystallographica, v. 7: 838-842, Dec. 10, 1954.

The lattice constants of barium peroxide have been remeasured, and at 25.0°C, the tetragonal unit cell has a = 5.634 ± 0.010 and c = 6.841 ± 0.005A. The crystal structure has been redetermined, using a

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complete least-squares method, as well as triple Fourier series, based upon powder-derived intensities, measured with a Geiger counter. The oxygen-oxygen bond lengths is 1.49 ± 0.04A, and there are two kinds of barium-oxygen contacts of 2.66 and 2.78A. The final agreement factor R_1 has the value 0.0381. (Contractor's abstract)

MIT. 08:039

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A MAGNETO-X-RAY STUDY OF MAGNETITE AT 78°K, by S. C. Abrahams and B. A. Calhoun. July 1954, 10p. incl. illus. refs. (Technical rept. no. 82) (Bound with its Technical rept. no. 80; AD 37277) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and N5ori-07858) AD 37227(b) Unclassified

Also published in Acta Crystallographica, v. 8: 257-260, May 10, 1955.

The x-ray diffraction pattern produced by a small single crystal of magnetite after cooling through the transition at 119°K, has been examined. It is demonstrated by using orientated magnetic fields during the cooling process that up to six different domain orientations are present in the crystal at 78°K. This number of domain orientations can be produced only if the symmetry of the low-temperature phase of magnetite is orthorhombic, or lower. (Contractor's abstract)

MIT. 08:040

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL AND MOLECULAR STRUCTURE OF ORTHORHOMBIC SULFUR, by S. C. Abrahams. Sept. 1954, 27p. incl. illus. tables, refs. (Technical rept. no. 83) (Bound with its Technical repts. nos. 84-85; AD 45684(a)-AD 45684(b)) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 45684 Unclassified

Also published in Acta Crystallographica, v. 8: 661-671, Nov. 10, 1955.

The lattice constants of orthorhombic sulfur have been determined as a = 10.437 ± 0.020, b = 12.845 ± 0.010, and c = 24.369 ± 0.010 A. Using Mokα radiation, and both Weissenberg and precession cameras, 669 out of a possible 1049 structure factors have been measured. Warren and Burwell's approximation to the structure was refined first by double Fourier series, and then by repeated least-squares analyses using all the measured structure factors. The coordinates thus obtained, after the least-squares method had completely converged, were used in evaluating a triple Fourier series. The arithmetic mean of the coordinates obtained by the triple Fourier series and the final least-squares analysis correspond to an S_8 molecule in which the average sulfur-sulfur bond length is 2.039 ± 0.007A, the average sulfur-sulfur-sulfur bond angle is 107°41 ± 39' and the average dihedral angle is 99°44' ± 48'. There are no unusual intermolecular contacts. The dimensions in the S_8 molecule are briefly discussed in terms of other recent determinations of sulfur compounds. (Contractor's abstract)

MIT. 08:041

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF α-POTASSIUM SUPEROXIDE, by S. C. Abrahams and J. Kalnajs. Sept. 1954, 10p. incl. diagrs. table, refs. (Technical rept. no. 84) (Bound with its Technical rept. no. 83, AD 45684) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 45684(a) Unclassified

Also published in Acta Crystallographica, v. 8: 503-506, Aug. 10, 1955.

The lattice constants of α-potassium superoxide have been measured, and the tetragonal unit cell found to be a = 5.704 ± 0.005 and c = 6.699 ± 0.005A at 25°C. The coordinates have been refined by use of the method of least squares and by triple Fourier series. Geiger-counter methods were used to measure the intensities diffracted by a powder specimen. The oxygen-oxygen bond length is 1.28 ± 0.02A, and there are two kinds of closest potassium-oxygen contact, of 2.71 and 2.92A. (Contractor's abstract)

MIT. 08:042

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

CRYSTALLOGRAPHY OF THE TELLURIUM-IODINE SYSTEM, by W. R. Blackmore, S. C. Abrahams, and J. Kalnajs. Sept. 1954, 8p. incl. illus. diagrs. table. (Technical rept. no. 85) (Bound with its Technical rept. nos. 83, AD 45684) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 45684(b) Unclassified

Also published in Acta Crystallographica, v. 9: 295-296, Mar. 10, 1956.

Tellurium tetraiodide is shown to be dimorphous: the tetragonal modification has a = 16.12 ± 0.02A and c = 11.20 ± 0.020A; space group, $I4_1/amd$. The orthorhombic modification has a = 13.54 ± 0.02, b = 16.73 ± 0.02, and c = 14.48 ± 0.02A; space group Pnma. Evidence for the formation of a crystal with composition TeI is presented. (Contractor's abstract)

MIT. 08:043

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

COLOR CENTERS IN CALCIUM FLUORIDE CRYSTALS, by A. Smakula. Sept. 1954, 18p. incl. illus. tables, refs. (Technical rept. no. 86) (Sponsored jointly by Office of Naval Research, Signal Corps, [Air Force Office of Scientific Research] under N5ori-07801 and Watertown Arsenal. Ordnance Material Research Office under DA 19-020-ord-3429) AD 42473 Unclassified

Also published in Zeitschr. f. Physik, v. 138: 276-283, 1954.

Synthetic CaF_2 crystals were colored by 2.5-mev electrons, Ca vapor, and low-energy electrons. Impurities and imperfections of the crystals were compared by the measurements of UV light transmission, density, and ionic conductivity and by spectroanalysis. The best crystals showed good transmission in the near and far UV, high density, and low ionic conductivity; they had a low yield of color centers. Four absorption bands located at 2.16, 3.14, 3.70, and 5.50 ev were observed. The coloration rate was higher and the absorption bands varied somewhat in spectral position and intensity. The 4 bands observed in the best crystals were caused by electrons and/or holes trapped in lattice imperfections and not by chemical impurities as was suggested by Luty (Zeitschr. Physik. v. 34: 596, 1956). (ASTIA abstract)

MIT. 08:044

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE DYNAMIC BEHAVIOR OF DOMAIN WALLS IN BARIUM TITANATE, by E. A. Little. Oct. 1954, 44p. incl. illus. refs. (Technical rept. no. 87) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 45689 Unclassified

Also published in Phys. Rev., v. 98: 978-984, May 15, 1955.

The nucleation and growth of 180° and 90° domains in $BaTiO_3$ single crystals were measured with optical techniques. The creation of 180° domains proceeds by the nucleation of long thin spikes with an initial velocity along the polar axis of about 10^4 cm/sec for E=5 kv/cm. The limiting field for 180° domain growth is nearly identical with the limiting field for nucleation of a domain. The growth of 90° domains in an electric field begins by the nucleation of long thin wedges. Direct measurements of the nucleation rate as a function of time and field strength show that this rate traverses a maximum as a function of time. The maximum growth rate of a single wedge approaches asymptotically about 10^6 cm/sec with increasing field strength. The interaction of 90° and 180° domains were also investigated. Observations showed that 90° walls may form head-to-head or tail-to-tail configurations which can only be switched by the intermediate formation of 180° domains. The free energy for rotation of the polar axis through 90° was calculated, and an approximate value for the energy of a 90° wall was derived. (ASTIA abstract)

MIT. 08:045

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

LINE BROADENING AND DIELECTRIC RELAXATION IN COMPRESSED GASES, by C. S. E. Phillips. Oct. 1954, 23p. incl. diagrs. refs. (Technical rept. no. 88) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 45688 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2388-2394, Dec. 1955.

An attempt was made to investigate the transition from resonance to relaxation spectrum by high-pressure research in the microwave region. Equipment was developed for studying the dielectric constant and loss of gases and liquids in the K-band region up to 1000 atm at temperatures up to 300°C. Measurements on a nearly spherical molecule of strong dipole moment ($CHClF_2$), on a linear molecule of weak dipole moment (N_2O), and on mixtures of $CHClF_2$ with nitrogen are reported, and a preliminary discussion of the results is given. (Contractor's abstract)

MIT. 08:046

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE SYNTHESIS OF FERRITES AND PREPARATION OF COBALT-FERRITE CRYSTALS, by D. G. Wickham. Oct. 1954, 51p. incl. diagrs. tables, refs. (Technical rept. no. 89) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801, and [Wright Air Development Center. Electronic Components Lab.] under AF 33(616)2191) AD 47112 Unclassified

A new method is developed for the preparation of magnesium, manganese, cobalt, nickel, and zinc ferrites, based on the thermal decomposition of the mixed precipitates of ferrous oxalate dihydrate with the analogous compounds of magnesium, manganese, cobalt, nickel, and zinc. Evidence is presented to show that ferrous oxalate dihydrate forms mixed crystals (solid solutions) with the other oxalates of the series. The ferrites are prepared from these mixed crystals at relatively low temperatures and with greater convenience in comparison with methods previously used. The purity of the ferrite products is established by x-ray and chemical analysis. An x-ray diffraction

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study of the oxalate dihydrates shows that the compounds of manganese, cobalt, nickel, and zinc possess crystal structures very similar to that of ferrous oxalate dihydrate, which is found to be orthorhombic (space group, Fmm2). Lattice parameters for ferrous oxalate are directly measured, those for the other oxalates and mixed crystals are computed. A high temperature furnace, utilizing a molybdenum wire heating element, is designed and constructed for the purpose of growing single crystals of the ferrites from the melt by the Bridgman method. The operation of the furnace is tested in attempts to prepare single crystals of cobalt ferrite. The results of these experiments show that single crystals can be obtained by the method used, but in order to prepare crystals of the composition given by the formula, $CoFe_2O_4$, an oxygen pressure surrounding the melt considerably higher than one atmosphere will be required, and some provision to prevent the loss of cobalt oxide by evaporation will be necessary. (Contractor's abstract)

MIT. 08:047

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE ORIENTATION OF ELECTRIC-BREAKDOWN PATHS IN ALKALI HALIDE SINGLE CRYSTALS, by M. E. Caspari. Nov. 1954, 55p. incl. diagrs. tables, refs. (Technical rept. no. 90) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 49542 Unclassified

Also published in Phys. Rev., v. 98: 1679-1691, June 15, 1955.

Experiments were conducted to establish the breakdown-path directions in some alkali haldie crystals over a wide temperature range under controlled field conditions prior to breakdown. Independence of the dc breakdown strength of NaCl in homogeneous fields on the direction of the applied field was confirmed for liquid N temperature. Experiments on the orientation of the breakdown paths in NaCl at room temperature with various electrode shapes and immersion media revealed the existence of 3 different types of breakdown paths: anodic, cathodic, and homogeneous field paths. Breakdown leading to anodic paths is initiated by prebreakdown discharges at the anode and is produced by highly inhomogeneous starting fields. The paths are precisely orientated with respect to the crystallographic axes of the crystal. Cathodic breakdown paths are initiated directly at the cathode in point-plane electrode systems with the point as cathode; their direction difference differs from those of anodic paths. Breakdown paths produced in homogeneous fields follow the direction of the applied field. Experiments on NaCl, NaBr, KBr, RbCl, and RbI from -160° to 325°C under reproducible field conditions confirm the findings of Davisson (Phys. Rev. v. 70: 685, 1946; v. 73: 1194, 1948) that the anodic path directions follow the sequence: random → '100' → 'ttt' → 'tt0' with increasing temperature. While the random → 't00' transition takes place gradually over a range of more than 100°C, the [100] → [110] transition in K and Rb salts is sharp. Mechanical deformation has little effect on the path directions. (ASTIA abstract)

MIT. 08:048

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PREBREAKDOWN CURRENT AND NOISE IN INSULATORS, by D. A. Powers and T. Suita. Jan. 1955, 12p. incl. diagrs. refs. (Technical rept. no. 91) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 54505 Unclassified

Also published in Jour. Appl. Phys., v. 26: 1244-1247, Oct. 1955.

Haworth and Bozorth (Physics, v. 5: 15, 1934), as well as von Hippel (Phys. Rev., v. 54: 1096, 1938), many years ago observed that the prebreakdown current in dielectrics may be accompanied by characteristic noise phenomena of a not clearly established origin. Lately, several scientists have ascribed this noise to impact ionization in the dielectric and deduced the number and height of these avalanches from it. This interpretation appears very doubtful, because the onset of impact ionization in the presence of field emission should normally lead to breakdown. To clarify the situation, the present authors have investigated the origin of the noise and its frequency spectrum in some detail. The finding is that most of the noise is due to surface discharges and can be eliminated by special types of electrodes and careful experimentation. The remaining noise has a frequency spectrum with the highest amplitudes at very low frequencies; it falls rapidly to the Johnson noise level in the measuring resistor at about 10^4 cps. This noise apparently originates from fluctuations in the field emission current. (Contractor's abstract)

MIT. 08:049

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PRECISION DETERMINATION OF LATTICE CONSTANTS WITH A GEIGER-COUNTER X-RAY DIFFRACTOMETER, by A. Smakula and J. Kalnajs. Feb. 1955, 28p. incl. diagrs. tables, refs. (Technical rept. no. 92) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-07801 and Watertown Arsenal Ordnance Material Research Office under DA 19-020-ord-3429) AD 56364 Unclassified

Also published in Phys. Rev. v. 99: 1737-1743, Sept. 15, 1955.

It is shown that the Geiger-counter x-ray diffractometer can be used for precision determination of lattice

constants. The zero point of the goniometer (determined by two methods) and the position of the diffraction lines (2θ) have been obtained with an accuracy of ± 0.001°. The temperature was kept constant by a special unit within 0.05°C. An investigation of the systematic errors has been made, which shows that the extrapolation of lattice constants vs $\cos^2\theta$, according to Wilson's equation, is permissible and the vertical divergence error, as computed by Eastabrook, lies up to 2θ = 165°, within the limits of error, and may be neglected. The lattice constants of Al, Ag, Ge, Si, CaF_2, CsI, TlCl, and TlBr, determined by extrapolation, are in good agreement with published data. The limiting factor in the accuracy of the lattice constants determination is not in the error of the diffractometer, but in the x-ray wavelength. (Contractor's abstract)

MIT. 08:050

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

CONDUCTION AND BREAKDOWN IN HEXANE, by W. B. Green. Mar. 1955, 38p. incl. diagrs. refs. (Technical rept. no. 93) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 57124 Unclassified

Also published in Jour. Appl. Phys., v. 26: 1254-1264, Oct. 1955.

Conduction currents in hexane were studied as a function of spacing, metal, and heat-treatment of the electrodes over the field-strength range from 0 to 250 kv/cm. Exposure to γ rays increases the current in a way that indicates a decrease of the effective work function. The most important factor determining the currents appears to be the surface layer on the cathode. As the voltage increases from zero, positive ions accumulate in front of the cathode and set up an intense local field which induces field emission. The size of the local field depends on the number of ions arriving per second and on the thickness, homogeneity, and conductivity of the surface layer. For some electrodes, the current increases with gap width for constant field, but change of current with gap width is an electrode property. In one case the current was measured up to breakdown (1060 kv/cm).

MIT. 08:051

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

INFRARED SPECTRA OF FERRITES, by R. D. Waldron. Mar. 1955, 22p. incl. diagrs. tables, refs. (Technical rept. no. 94) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 59713 Unclassified

Also published in Phys. Rev., v. 99: 1727-1735, Sept. 15, 1955.

The infrared spectra of 7 ferrites of the formula MFe_2O_4, where M designates a divalent metal, are presented and analyzed. Electronic absorption was observed in the visible and near-infrared regions. Two absorption bonds arising from interatomic vibrations were measured and force constants calculated for the stretching of bonds between octahedral or tetrahedral metal ions and oxide ions. These force constants are in agreement with the elastic and thermodynamic properties of these compounds and are sensitive to the distribution of metal ions between the alternate sites. The integrated vibrational bond intensities were measured; they are compatible with predominantly ionic bonding for these structures. (Contractor's abstract)

MIT. 08:052

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PRECISION DENSITY DETERMINATION OF LARGE SINGLE CRYSTALS BY HYDROSTATIC WEIGHING, by A. Smakula and V. Sils. May 1955, 9p. incl. diagrs. tables, refs. (Technical rept. no. 95) (Bound with its Technical rept. no. 96; AD 64148) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ort-07801 and Watertown Arsenal. Ordnance Materials Research Office under DA 19-020-ord-3429) AD 64148 Unclassified

Also published in Phys. Rev., v. 99: 1744-1746, Sept. 15, 1955.

In connection with a study of crystal imperfections, precision determination of density (better than 1×10^{-4} g/cm^3) have been made on large single crystals of Si, quartz, CaF_2, CsI, Ge, TlCl and TlBr. In addition, polycrystalline Al was measured. (Contractor's abstract)

MIT. 08:053

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

DENSITIES AND IMPERFECTIONS OF SINGLE CRYSTALS, by A. Smakula, J. Kalnajs, and V. Sils. May 1955, 14p. incl. diagrs. tables, refs. (Technical rept. no. 96) (Bound with its Technical rept. no. 95; AD 64148) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and Watertown Arsenal. Ordnance Materials Research Office under DA 19-020-ord-3429) AD 64148(a) Unclassified

Also published in Phys. Rev., v. 99: 1747-1750, Sept. 15, 1955.

The densities of Si, Al, CaF_2, CsI, Ge, TlCl, TlBr,

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and SiO_2 (quartz) have been computed from lattice constants and molecular weights obtained from International Atomic Weights, and compared with the densities as determined by hydrostatic weighing of large crystals. The hydrostatic density of Ge proves too large by 0.0019 0.00193. This discrepancy disappears when the mass-spectroscopic atomic weight is used for the density calculations. Also for Si, Al, and CaF_2 a better agreement results with mass-spectroscopic atomic weights. From this series of measurements it is concluded that the mass-spectroscopic atomic weights are more reliable than the officially accepted ones. From measured densities and lattice constants of Si, Al, CaF_2, and Ge, Avogadro's number is obtained 6.02368×10^{23} $mole^{-1}$. The relative density defects for these samples of Si, Al, CaF_2, and Ge proves to be negligible within the limit of the measurements ($< 5 \times 10^{-6}$). These crystals are considered the most perfect that we have obtained up to the present time. A somewhat higher relative density defect in quartz (11×10^{-6}) may be caused by uncertainty of the data used for the computation of the density and that for CsI (13×10^{-6}) by Rb contamination. TlCl and TlBr show the greatest relative density defects, 43×10^{-6} and 40×10^{-6}, respectively. These crystals may contain vacancies or dislocations in the order of $\sim 5 \times 10^{18}$/cc, as is known also for the silver halides. (Contractor's abstract)

MIT. 08:054

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

DIELECTRIC SPECTROSCOPY OF FERROMAGNETIC SEMICONDUCTORS, by A. von Hippel, W. B. Westphal, and P. A. Miles. July 1955, 117p. incl. diagrs. refs. (Technical rept. no. 97) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and Wright Air Development Center. Electronics Components Lab. under AF 33(616)2191) AD 68767 Unclassified

Also published in Rev. Modern Phys., v. 29: 279-307, July 1957.

A broad-band dielectric spectroscopy of the ferrites is attempted. The objective of such a research is defined, the language of dielectric spectroscopy is formulated and the experimental techniques from dc to the ultraviolet are described. Sections 3-11 discuss the physics of the situation, outlining the existing information on the frequency dependence of ferromagnetic response, and reformulating in our language the gyroscopic effects in magnetization phenomena, the behavior of domain walls, and the possible resonance and relaxation-type responses that may be expected in polarization and magnetization processes. The criteria for distinguishing between these responses are considered. Measurements in the optical and infrared ranges show the contributions to the low-frequency dielectric constant of the electronic and atomic polarizabilities, the latter showing sensitivity to cation distribution in ferrites. Conductivity measurements at microwave frequencies indicate a loss mechanism differing from the normal semiconducting behavior observed at lower frequencies. Boundary-layer effects predominate in the kilocycle range. The magnetization, in contrast, varies with frequency only in the electrical range. Two main dispersion regions can be distinguished and the uncertainty of their interpretation as domain-wall or spin-orientation processes is partly resolved by evidence from the nickel-zinc ferrite system and from temperature and time effects. Dielectric spectroscopy, as a mode of thinking, can obviously contribute much to the perception of ferromagnetic effects and of their appraisal in proper perspective. (Contractor's abstract)

MIT. 08:055

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

PULSE-VOLTAGE STUDIES ON THE CONDUCTIVITY OF ELECTROLYTES AND SEMICONDUCTORS, by F. R. Kotter. July 1955, 45p. incl. illus. diagrs. refs. (Technical rept. no. 98) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 67868 Unclassified

Equipment was developed for the study of conductivities and of deviations from Ohm's law in highly conducting systems. A differential pulse transformer bridge similar to that of Gledhill and Patterson (Jour. Phys. Chem., v. 56: 999, 1952) was built for Wien-effect measurements. Preliminary measurements at field strengths up to 10^5 v/cm with 3-μsec rectangular-voltage pulses on aqueous $MgSO_4$ solutions (0.0002 to 0.004M) showed departures from ohmic behavior about 50% larger than predicted by the Onsager-Wilson Theory (H. S. Harned and B. B. Owen, The Physical Chemistry of Electrolytic Solutions, N. Y., Reinhold, 1950, p. 95-114). Contrary to the predictions of the Onsager theory for weak electrolytes, measurements on acetic acid (0.0006 to 0.3N) showed a dependence on concentration. Four-terminal equipment was used with 10-μsec voltage pulses in preliminary studies on solids (magnetite, Se, and Ag_2HgI_4). Significant departures from ohmic behavior were observed with field strengths of the order of 10^3v/cm.

MIT. 08:056

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

FERROMAGNETIC AND FERROELECTRICS, by A. von Hippel. Aug. 1955, 43p. incl. diagrs. refs. (Technical rept. no. 99) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 71382 Unclassified

A comparison between ferromagnetics and ferroelectrics is given that intends to place these states of spontaneous order into clearer perspective by emphasizing their analogies and differences. Magnetization and

polarization by uncoupled moments leads to the Curie law. The introduction of a long-range feedback coupling produces the Curie-Weiss law; and the concept of an "inherent" ordering temperature sets both laws in a mutual relation. However, it becomes apparent that the long-range dipole forces of permanent moments cannot account for the creation of the observed long-range order. They have to be replaced by a short-range ordering forces, because the magnetic moments are too weak and the electric moments too strong. The formation of the ordered state is followed in more detail in the examples of nickel, barium titanate and magnetite. The domain status of the ordered state and its response to "effective" fields requires an analysis of the domain walls and of the distortion caused by walls in the crystal lattice. On the basis of domain rotation and the domain-wall nucleation and motion, the dynamics of the ordered state is considered as shaped by anisotropy, resonance and relaxation effects, fabrication parameters, and the short-range order of the material. (Contractor's abstract)

MIT. 08:057

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

FIELD EMISSION FROM METALS INTO ALKALI HALIDE CRYSTALS, by M. Geller. Oct. 1955, 31p. incl. diagrs. tables, refs. (Technical rept. no. 100) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 76994 Unclassified

Also published in Phys. Rev., v. 101: 1685-1693, Mar. 15, 1956.

Experimentation on (1) the transient photocurrents associated with the movement of photoelectrons in additively colored alkali halide crystals and (2) the accompanying growth of positive space charge at the cathode with subsequent field emission was extended from room temperature to low temperatures, and the theory was expanded to include the final photocurrents produced by the space-charge-enhanced field. The field strength at the cathode was derived and correlated to the final current density by means of measurements of the initial current, its time constant, and the final current. Fowler-Nordheim plots yielded a straight line, but the order of magnitude of the calculated field and the apparent work function were too small to be reasonable. The work function exhibited a dependence on light intensity. The decrease of the photocurrent from room temperature to -130°C by a factor of only 2 was attributed to the lowered mobility of the electrons in the crystal. An analysis of final photocurrent-vs-voltage curves for various metals and composite surfaces indicated that the photocurrent was controlled by the ionized F centers in a thin surface layer of the crystal, and that the image forces of these centers created the high fields which were required for the emission.

MIT. 08:058

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

MOLECULAR ENGINEERING, by A. von Hippel. Oct. 1955, 22p. incl. refs. (Technical rept. no. 101) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 76993 Unclassified

Also published in Science, v. 123: 315-317, Feb. 24, 1956.

A discussion is presented on the concept of molecular engineering and the necessity of a transition from the phenomenological approach to matter to such a concept. In cases of great complexity, empirical experimentation may be more suitable than scientific analysis and synthesis, but the shift will be to molecular engineering as knowledge and experience increase. The concept is applied to the problem of developing aircraft materials capable of withstanding temperatures of 1000°F caused by friction. An academic environment incorporating areas for fundamental research, discussion of practical implications and long-range applications, and prototype development is recommended.

MIT. 08:059

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

DEVELOPMENT OF THE VIBRATING-COIL MAGNETOMETER AND ITS APPLICATION TO MAGNETITE, by D. O. Smith. Nov. 1955, 77p. incl. diagrs. refs. (Technical rept. no. 102) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 80347 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 261-268, May 1956.

Also published in Phys. Rev., v. 102: 959-963, May 15, 1956.

A vibrating-coil magnetometer was used to measure the isothermal M-H curves of magnetite at atmospheric pressure in the principal crystallographic directions from room temperature to the Curie point. Near the Curie point, the magnetizing field required to create a single domain was less than 100 amp/m which provides an unambiguous experimental determination of the spontaneous magnetization in this critical region. In the neighborhood of the Curie point, the M-H curves are very nonlinear; replotting the data in the form of H-T curves at constant magnetization shows that in this region the magnetic energy can be expressed as $U_M = -\mu_o WM^2/2$ where W is a constant, H is the applied field, and M is the volume magnetization. These results suggest that the classical work of Weiss and Forrer (Ann. Phys., v. 5: 153, 1926) on nickel

should be repeated with the use of a single crystal to eliminate domain effects.

MIT. 08:060

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge,

CONTROLLED FIELD EMISSION IN HEXANE, by W. B. Green. Nov. 1955, 16p. incl. diagrs. refs. (Technical rept. no. 103) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801 and Army Ordnance. Diamond Ordnance Fuze Labs. under DAI-49-186-502-ord(P)-334) AD 80348 Unclassified

Also published in Jour. Appl. Phys., v. 27: 921-925, Aug. 1956.

The current-voltage relationship for dielectric liquids consists of two portions, usually in superposition; at lower voltages a current of ions flows; at higher voltages, field emission sets in. The field emission current depends on the material of the cathode, but not simply on its work function. The current may be altered by changing the thickness of the cathode surface layer or the gas adsorbed upon the surface. When the ion content of the liquid is raised, not only the ionic current, but also the field-emission portion of the current increases. Controlled field-emission currents have been produced. (Contractor's abstract)

MIT. 08:061

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE STEREOCHEMISTRY OF SUBGROUP VI_b OF THE PERIODIC TABLE, by S. C. Abrahams. Apr. 1956, 71p. incl. diagrs. tables, refs. (Technical rept. no. 104) (Sponsored jointly by [Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research] under N5ori-07801) AD 92639 Unclassified

Also published in Quarterly Rev., v. 10: 407-436, 1956.

In the last decade, a great increase in both theoretical and, particularly, experimental knowledge regarding the nature of the vartous kinds of chemical bond formed by the atoms of subgroup VI_b has become available. The present review is an attempt to bring together the most important information, at present scattered throughout the literature, concerning the geometrical and electronic configuratton of these atoms in thetr different bonded states. (Contractor's abstract, modified)

MIT. 08:062

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambrtdge.

PREBREAKDOWN CURRENT STUDIES IN COMPRESSED NITROGEN, by N. L. Allen. Apr. 1956, 24p. incl. diagrs. tables, refs. (Technical rept. no. 107) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 99321 Unclassified

A description is given of a vessel containing an electrode system for measurement of prebreakdown currents in compressed gases. Auxiliary equipment includes a pressure intensifier and a manganin-wire pressure gauge. A highly stablized high-voltage supply allows measurements to be made very close to breakdown. Values of the ionization coefficient η and regeneration coefficient Υ are given for pressures between one and four atmospheres and the variation of Υ in this region is discussed in detail. Difficulties encountered at higher pressures and suggestions for future experiments are outlined. (Contractor's abstract)

MIT. 08:063

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE CRYSTAL STRUCTURE OF DIPHENYL SULFOXIDE, by S. C. Abrahams and H. J. Grenville-Wells. May 1956, 20p. incl. diagrs. tables, refs. (Technical rept. no. 105) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 95350 Unclassified

Also published in Acta Crystallographica, v. 10: 417-422, June 10, 1957.

Diphenyl sulfoxide forms monoclinic crystals, space group $P2_1/n$, in a cell with lattice constants a = 8.90 ± 0.02, b = 14.08 ± 0.03 and c = 8.32 ± 0.02A, and β = 101°7' ± 10', containing four molecules. The crystal structure has been solved by a combination of isomorphous replacement and trial and error methods. Refinement of the atomic parameters was effected by the use of double Fourier series, followed by least-squares analysis of a set of 664 independent structure factors. This partially complete set of three-dimensional structure factors was derived by visual intensity measurement. The final coordinates lead to bond lengths of 1.47 ± 0.016A for sulfur-oxygen, 1.76 ± 0.015A for sulfur-carbon and 1.40 ± 0.008A for carbon-carbon, and bond angles of 106°10' ± 40' for carbon-sulfur-oxygen, 97°19' ± 58' for carbon-sulfur-carbon and 119°27' for sulfur-carbon-carbon. The dihedral angle between the normals to the planes of the aromatic rings is 75°50' ± 58', and between the plane of each ring and the common carbon-sulfur-carbon plane is 81°54' ± 40'. An intermolecular contact of 3.36A satisfying the formal requirements of a C - H ...O bond occurs in this crystal. In considering the stereochemistry of subgroup VI_b of the periodic table, there is a special importance in a study of these atoms when chemically linked to three other atoms. The early debates on the possibility of planarity in the three sulfur bonds in the sulfoxide group were largely ended by the optical resolution of unsymmetrical sulfoxides by Harrison, Kenyon

and Phillips (1926). This work clearly demonstrated that the three bonds could not be coplanar, but left the precise arrangement undetermined. Recent studies of the molecular constants of several simple sulfoxides has entirely confirmed the pyramidal form of these bonds. The present study of the simplest aromatic sulfoxide was undertaken in order to throw further light on the stereochemistry of the sulfoxide group, and also for comparison with similar molecules lacking the oxygen atom.

MIT. 08:064

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

INFRARED-ABSORPTION STUDIES ON BARIUM TITANATE AND RELATED MATERIALS, by J. T. Lasi. May 1956, 38p. incl. diagrs. tables, refs. (Technical rept. no. 106) (Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research under N5ori-07801) AD 96171 Unclassified

Presented at meeting of the Amer. Phys. Soc., Eugene, Ore., June 21-23, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 255, June 21, 1956.

Also published in Phys. Rev., v. 105: 1740-1750, Mar. 15, 1957.

The infrared-absorption spectrum of $BaTiO_3$ has been measured for thin single crystals and for powder samples dispersed in pressed KBr disks. Absorption bands for single-crystal samples occur at 495 cm^{-1} and at ca 340 cm^{-1}, arising from normal vibrations of the TiO_3 group. A third vibration, a motion of Ba against the TiO_3 group, occurs below the experimentally accessible range. A frequency of about 225 cm^{-1} is expected for this vibration on the basis of a comparison of the specific heat contributions of the observed bands with the measured low-temperature specific heat. Measurements were made on the 495 cm^{-1} band over a wide temperature range. As the crystal changes from the cubic to the tetragonal, orthorhombic, and rhombohedral structures, there occurs band splitting which can be related to the change of crystal symmetry. The spectra of the perovskite titanates, $SrTiO_3$, $PbTiO_3$, and $CaTiO_3$, and the perovskite niobates, $KNbO_3$ and $NaNbO_3$, have been found to be similar, in general features, to that of $BaTiO_3$. The slight differences in band frequency and structure can be related to differences in unit-cell size and symmetry. Integrated band intensities have been found to be in reasonable agreement with measurements on other oxide systems that have vibrations in this spectral region. (Contractor's abstract)

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Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

THE INFRARED SPECTRA OF HDO IN WATER AND IONIC SOLUTIONS, by R. D. Waldron. May 1956, 18p. incl. diagrs. tables, refs. (Technical rept. no. 108) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 100917 Unclassified

Also published in Jour. Chem. Phys., v. 26: 809-814, Apr. 1957.

The IR spectra of HDO in H_2O and saturated metal-halide solutions were investigated for studying the interactions between ions and solvent molecules and the nature of H bonding in aqueous systems. The fundamental and overtone bands of the OH and OD streiching vibrations are shifted to lower frequencies and the bending vibration is shifted to higher frequencies in passing from the gaseous to the liquid state. Similar shifts occur for the metal-halide solutions; the magnitudes of these are sensitive to the anion species but relatively independent of the cations. The frequency shifts for ionic solutions increase in the order I^-, Cl^-, and F^-, with the shift in ion-free H_2O about equal to that for Cl^-. The vibrational anharmonicity of the OH stretching vibration in solution was almost independent of the frequency shift and only slightly larger than the gas value. The dependence of frequency shift on the shortening of H bonds (volume contraction) and H-bond energy gave qualitative agreement with other systems previously investigated.

MIT. 08:066

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

SINGULAR POTENTIALS IN QUANTUM MECHANICS, by F. L. Scarf. June 1956, 48p. incl. diagrs. refs. (Technical rept. no. 109) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N5ori-07801) AD 100919 Unclassified

Many physical systems are characterized by attractive potential energies which become infinite in such a way that $\lim_{r \to 0} r^2 V(r) < 0$. For example, magnetic, spin-orbit, polarization and many exchange forces are all approximately described (at large distances) by these so-called singular potentials for which ordinary methods of solving Schrödinger's equation are insufficient. In this paper the general problem of solving the quantum-mechanical wave equations for singular potentials is reinvestigated. It is shown that a set of orthogonal states states with complex energy eigenvalues $(E_n = W_n + \frac{1}{2} i \Gamma_n)$ is obtained. In general, this is interpreted in the following way: W_n is the most probable position of the energy level for various kinds of

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potential cut-offs and Γ_n is a measure of the probable error. The virial theorem and the W. K. B. method are used to explain the physical basis of these results. (Contractor's abstract)

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Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

WIDE-BAND HIGH-PRESSURE DIELECTRIC CELL, by M. G. Vallauri and P. W. Forsbergh, Jr. Oct. 1956, 8p. incl. diagrs. (Technical rept. no. 110) (Sponsored jointly by Office of Naval Research, Signal Corps, [Air Force Office of Scientific Research] and Ordnance Materials Research Office under [N5ori-07801] AD 114705 Unclassified

Also published in Rev. Scient. Instrument, v. 28: 198-199, Mar. 1957.

A quartz and metal seal capable of holding compressed gases at 1500 atm forms the tapered, coaxial transition leading from a standing-wave detector or from a bridge, into a coaxial condenser. The continuity of characteristic impedance through the seal is sufficiently good to allow accurate measurement of dielectric constant and loss in compressed gases and liquids from low frequencies to 3000 mc (λ_0 = 10 cm) in a single cell. The performance is illustrated with isotherms of the dielectric constant of N_2O through the critical point. Organic sealing materials are not used. The unit promises to be satisfactory for a wider temperature range than is reported here.

MIT. 08:068

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

A SYSTEM FOR ELECTRICAL MEASUREMENTS ON SMALL CRYSTALS UNDER HIGH PRESSURES, by P. W. Forsbergh, Jr. and G. J. Wolga. Oct. 1956, 4p. incl. diagr. (Technical rept. no. 111) (Bound with its Technical rept. no. 110; AD 114705) (Sponsored jointly by Office of Naval Research, Signal Corps, [Air Force Office of Scientific Research] and Ordnance Materials Research Office under [N5ori-07801]) AD 114705(a) Unclassified

A high-pressure system for electrical measurements is described, which uses a new type of seal. The pressure vessel is simple in construction and can be considered readily expendable, thereby allowing a greater range of useful pressures. The seal is effective for work at the highest pressures at which a vessel without external support can be used (15,000 atm or higher, depending on the material and treatment of the vessel). (Contractor's abstract)

MIT. 08:069

Massachusetts Inst. of Tech. Lab. for Insulation Research, Cambridge.

ELECTRIC BREAKDOWN AND CONDUCTION THROUGH MYLAR FILMS, by Y. Inuishi and D. A. Powers. Dec. 1956, 19p. incl. illus. (Technical rept. no. 112) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N5ori-07801] and DAI-49-186-502-ord(P)-334) AD 120218 Unclassified

Also published in Jour. Appl. Phys., v. 28: 1017-1022, Sept. 1957

Studies of dc breakdown on Mylar film show that defects cause a decrease in dielectric strength with decreasing film thickness at room temperature but not at -180°C. The breakdown at defects is associated with moisture content. Using self-healing electrodes to eliminate weak areas, a dc electric strength of 6 mv/cm is found, independent of film thickness. Prebreakdown current measurements indicate ionic currents which are fairly uniform throughout a sample, and field emission currents localized at incipient breakdown points. Breakdown probably occurs as a result of local heating due to the field emission currents. (Contractor's abstract)

MIT. 09:001

Massachusetts Inst. of Tech. Naval Supersonic Lab., Cambridge.

MACH NUMBER MEASUREMENTS IN HIGH-SPEED WIND TUNNELS, by J. A. F. Hill, J. R. Baron, and L. H. Schindel. Jan. 1956, 121p. incl. diagrs. tables, refs. (Technical rept. no. 145) (AFOSR-TR-56-7) (AF 18(603)4) AD 81540 Unclassified

Presented at Eighth meeting of the Wind Tunnel and Model-Testing Panel of AGARD, Rome (Italy), Feb. 1956.

The report discusses the measurement of subsonic and supersonic Mach numbers in air from the point of view of calibration measurements of an empty wind tunnel, of measurements of local Mach numbers at points in the flow field around a model, and of simulating free flight Mach numbers in the presence of wind-tunnel wall interference. The sensitivity of various parameters to change in Mach number is evaluated and instruments and techniques are discussed. The Mach number is related to various measurable properties by assuming certain properties. Errors are due to departures from the assumed properties (perfect gas, etc.) and the interference of the probe.

MIT. 10:001

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON A CLASS OF TRANSFER FUNCTIONS SUITABLE FOR VIDEO NETWORKS, by R. M. Fano. Apr. 13, 1950, 14p. incl. diagrs. refs. (Technical rept. no. 155) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U12315; ATI-84985 Unclassified

This report deals with a new class of transfer functions suitable for video networks. The resulting unit-step response has a very small amount of overshoot which is almost independent of the algebraic degree of the corresponding transfer function. The applications of such functions to the design of video filters and amplifiers is discussed in some detail. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON THE EVALUATION OF INTEGRALS OF THE TYPE $f(\tau_1, \tau_2, \ldots, \tau_n) = \frac{1}{2\pi i} \int F(s) e^{W(s, \tau_1, \tau_2, \ldots, \tau_n)} ds$ AND THE MECHANISM OF FORMATION OF TRANSIENT PHENOMENA. PART 2a. AN ELEMENTARY INTRODUCTION TO THE THEORY OF THE SADDLE-POINT METHOD OF INTEGRATION, by M. V. Cerrillo. May 3, 1950, 74p. incl. diagrs. (Technical rept. no. 55:2a) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) AD 47792 Unclassified

This report is concerned with the ideas that serve as a foundation for the "Saddlepoint Method of Integration." This method is also known by other names; particularly, as the "Method of Steepest Descent" and the "Method of the Points of Stagnation." The method and ideas presented here will serve as an introductory presentation to a more complete theory of integration which will be discussed in subsequent reports of this series. The material covers the following condensed description: (a) definition and properties of saddlepoints of different orders; (b) basic procedure of integration through saddlepoints of the second order; (c) definition of the family of integral approximations of the resonant type. The pole, zero, and dipole solutions; (d) integration in the case of composite behavior; (e) introduction to the idea of "Generating Function" associated with second-order saddlepoints. The Fresnel solid; (f) the case of saddlepoints of higher order and the theory of transition for saddlepoints of the third order; (g) zero, pole, and dipole types of integral; (h) the Airey-Hardy type of "Generating Function." The corresponding generating solid; (i) the mixed type of integral and composition of solutions; and (j) a few comparative typical solutions for transitions of higher order corresponding to the pole, zero, and dipole cases. The manuscript was originally written for use in certain applications in circuit theory. Because of this objective some specific terminology was used: "resonant transients," "transitional transients," etc. This nomenclature is, of course, not quite suitable for other applications of the method of integration. It is therefore advised that the reader disregard the terms "resonant and transitional transients" and use instead the terms "second-order, third-order solutions. (Contractor's abstract)

MIT. 10:003

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PERIODIC SAMPLING OF STATIONARY TIME SERIES, by J. P. Costas. May 16, 1950, 7p. incl. diagrs. (Technical rept. no. 156) [Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U11612; ATI-83682 Unclassified

When measuring the mean or average value of a random time function by periodic sampling some error is to be expected since only a finite number of samples are taken. An expression for the mean-square error of a sample mean is derived. The variation of error with changes in total sampling time and spacing between samples is discussed. An expression for the error involved in determining the mean by continuous integration is derived and the concept of sampling efficiency is introduced. A brief discussion of the probability of error is presented. (Contractor's abstract)

MIT. 10:004

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE DETERMINATIONS OF AVERAGE ELECTRON ENERGIES AND THE FIRST TOWNSEND COEFFICIENT IN HYDROGEN, by L. J. Varnerin, Jr. and S. C. Brown. May 24, 1950, 14p. incl. diagrs. refs. (Technical rept. no. 158) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U13444; ATI-83681 Unclassified

A microwave method of measuring the average energy of electrons in a gas in the presence of a dc field has been developed through a measurement of the ratio between the electron diffusion and mobility. By solving for ac and dc distribution functions it is found possible to compare quantitatively the effective ac ionization coefficient and the first Townsend coefficient in hydrogen. It is then possible to calculate the first Townsend coefficient from ac breakdown data in hydrogen and these values are compared with previously determined values. Measurements of average energy have been made and values calculated from theory compared with previous measurements of average energy. All measurements are in substantial agreement with each other

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and with the theoretically determined values. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE INFLUENCE OF A TRANSVERSE FIELD ON THE CONDUCTIVITY OF THIN METALLIC FILMS, by E. H. Sondheimer. May 31, 1950, 11p. incl. diagrs. (Technical rept. no. 161) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U12103; ATI-84982 Unclassified

The influence of a transverse magnetic field on the conduction properties of thin metallic films, of thickness comparable with the free path of the conduction electrons, is investigated. It is shown that, owing to scattering of electrons at the boundaries of the film, the Hall coefficient is increased and the electrical resistance oscillates with the strength of the applied magnetic field. (Contractor's abstract)

MIT. 10:006

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SHORT-TIME AUTOCORRELATION FUNCTIONS AND POWER SPECTRA, by R. M. Fano. June 6, 1950 [5]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100 and W36-039-sc-32037]) U13567; ATI-198559 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 22: 546-550, Sept. 1950.

The reciprocal relations between autocorrelation functions and power spectra, known as Wiener's Theorem, are extended in a modified form to the case of experimental results obtained by means of filters with finite time constants. If the short-time autocorrelation function $\varphi_t(\tau)$ and power spectrum $G_t(\omega)$ are properly defined, it is found that

$$\varphi_t(\tau) = \frac{e^{a|\tau|}}{2\pi} \int_{-\infty}^{\infty} G_t(\omega) \cos\omega\tau \, d\omega$$

$$G_t(\omega) = \int_{-\infty}^{\infty} e^{-a|\tau|} \varphi_t(\tau) \cos\omega\tau \, d\tau$$

where $1/a$ is a time constant. These equations may be used to relate the autocorrelation-function representation of a speech wave to the corresponding spectrographic representation. (Contractor's abstract)

MIT. 10:007

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ANALOG DEVICE FOR SOLVING THE APPROXIMATION PROBLEM OF NETWORK SYNTHESIS, by R. E. Scott. June 8, 1950, 47p. incl. illus. diagrs. refs. (Technical rept. no. 137) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] U14032; ATI-92381 Unclassified

An analog device has been developed which can solve the approximation problem of network synthesis with sufficient accuracy for most network problems. The complex frequency plane is represented by a conducting sheet of Teledeltos paper. The zeros and poles of the rational function are represented by positive and negative currents introduced into the plane. The voltage along the $j\omega$ axis in the plane represents the logarithm of the magnitude of the rational function. This voltage is scanned by a commutator at 10 cps and displayed upon the face of a CRT. The locations of the poles and zeros for a desired function are obtained by a cut and try process. A comparison of calculated and observed results shows that the accuracy of the device is 1-5% for the logarithm of the magnitude of the network function, and 3-15% for the phase, depending upon the particular function which is being solved. This accuracy is adequate for most network problems. A complete analysis is included of the errors introduced by the finite size of the plane, the finite size of the current and voltage probes, and the finite series impedance of the current sources. (Contractor's abstract)

MIT. 10:008

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE EFFECT OF MAGNETIC FIELD ON THE BREAKDOWN OF GASES AT MICROWAVE FREQUENCIES, by B. Lax, W. P. Allis, and S. C. Brown. June 30, 1950, 16p. incl. diagrs. refs. (Technical rept. no. 165) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U12599; ATI-84981 Unclassified

The effect of magnetic field on the HF breakdown of gases has been studied. The presence of energy resonance and the modification of diffusion are shown experimentally and explained theoretically. An application is made of both the average electron theory and the Boltzmann theory, and the correspondence between these two theories is discussed. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AMPLIFIERS WITH PRESCRIBED FREQUENCY

CHARACTERISTICS AND ARBITRARY BANDWIDTH, by J. G. Linvill. July 7, 1950, 61p. incl. diagrs. refs. (Technical rept. no. 163) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] U15596 Unclassified

The amplifier chain, a cascade connection of amplifier tubes connected by 2-terminal or 2-terminal-pair interstages, is the basic component of the amplifiers designed. Shunt capacitance in the interstages imposes a limit on the amplification per stage over a prescribed band of frequencies. The limit of amplification per stage is inversely proportional to the bandwidth. The method of design of amplifier chains presented leads to simple interstages which are economically close to the maximum in performance for the shunt capacitance present. The interstages used are simple-tuned circuits or double-tuned circuits. The technique of design of the amplifier chains is related to the stagger-tuning technique invented by Wallman. The characteristics of individual stages are nonuniform but the stages in a chain complement each other to provide an acceptably uniform characteristic. In the design procedure one chooses the amplification function for the chain being designed, according to a flexible technique presented in technical report no. 145 (TIP U11490), such that prescribed frequency characteristics are approximated. The amplification functions so chosen are suitable to be identified with realizable networks. This step is the key of the whole design process. Single amplifier chains become ineffective as amplifiers when the bandwidth becomes so broad that the amplification per stage approaches 1. When amplifiers are to amplify such broad bands of frequencies that this situation arises, more than 1 amplifier chain is used. The chains amplify different subbands and are connected in parallel at the input and output. The amplification functions of the individual chains are also chosen that the chains, when connected in parallel, give a desired characteristic. A summary of the pertinent characteristics of the distributed amplifier (invented by Percival), which is capable of amplifying over bands greater than those for which single amplifier chains are useful, permits a comparison with the parallel-chain amplifier. The parallel-chain amplifier is more economical in tubes and the design is more flexible. The frequency selectivity of the parallel-chain amplifier is affected by nonuniform changes in the tube characteristics; a properly designed distributed amplifier has a frequency selectivity not altered by changing transconductances of the tubes. (Contractor's abstract)

MIT. 10:010

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DETERIORATION OF OXIDE-COATED CATHODES UNDER LOW DUTY-FACTOR OPERATION, by J. F. Waymouth, Jr. July 20, 1950, 15p. incl. diagrs. tables. (Technical rept. no. 159) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U12316; ATI-85018 Unclassified

The behavior of oxide cathodes coated on a Ni alloy containing about 0.1% Si has been investigated under 100% and zero duty-factor operation. The operation of these cathodes at zero duty-factor was found to be highly favorable to the development of a high resistance in a layer of Ba_2SiO_4 located at the interface between the oxide and the core. The layer itself was present not only in cathodes that had aged without electron emission and had developed interface resistance, but also in cathodes that had aged with electron emission and had not developed interface resistance. A model is presented to account for the experimental observations. Evidence is also presented which shows that there may exist an "active" Ni alloy that does not lead to undue interface resistance formation. (Contractor's abstract)

MIT. 10:011

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AMPLITUDE MODULATION OF SYNCHRONIZED MICROWAVE OSCILLATORS, by W. P. Schneider and E. E. David, Jr. July 25, 1950, 23p. incl. illus. diagrs. refs. (Technical rept. no. 166) (Sponsored jointly by Signal Corps, Office of Naval Research, [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17066; ATI-103041 Unclassified

It can be shown that 2 push-pull frequency-modulated oscillators, both synchronized by the same RF signal, can be arranged so that their combined output contains the side bands of ordinary amplitude modulation. Linearity of the scheme is excellent even for high modulation indices. The bandwidth is somewhat less than the AM bandwidth of the oscillators themselves; it is about 3 mc at X-band. Experimental work with the system indicates that it has characteristics suitable for microwave relay and possibly low-power broadcast applications. (Contractor's abstract)

MIT. 10:012

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE SPECTRUM OF PHOSPHINE, ARSINE AND STIBINE, by C. C. Loomis and M. W. P. Strandberg. July 31, 1950, 20p. incl. tables, refs. (Technical rept. no. 167) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U12314; ATI-84984 Unclassified

The microwave spectrum of the mono-deuterated phosphine (PH_2D), arsine (AsH_2D), and stibine (SbH_2D) has been measured. Although a supposedly pure sample of stibine was prepared, phosphine and arsine proved to be major impurities. They were separated from the sample; the microwave spectrometer was used to

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monitor the distillation process. The quadrupole fine structure associated with the absorption transitions for AsH_2D is used to illustrate the special assumptions which may be made with these molecules having an axis of charge symmetry. These assumptions allow one to rotate the coordinate system from the charge-symmetry axes to the inertial axes without thereby adding unknown cross derivatives to the descriptions of the dyadic ∇E_{zz}. Interpretation of the spectrum of SbH_2D is more complicated. It is not found possible to fit the theory to the observed lines without making use of the second-order order perturbations due to a nearby level of different symmetry but of the same J. This perturbation involves the cross derivatives which had previously been assumed to be zero. With the assumption of cross derivatives approximately 1% of the diagonal terms, the theory fitted experiment within the experimental error. In order to measure the electric dipole moment of arsine and stibine a slight extension is made to the theory of asymmetric tops in a uniform electric field. The ground-state inversion splitting is determined to be less than 0.5 mc/sec for all three molecules. (Contractor's abstract)

MIT. 10:013

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LIMITS FOR THE DIFFUSION THEORY OF HIGH-FREQUENCY GAS DISCHARGE BREAKDOWN, by S. C. Brown and A. D. MacDonald. Aug. 3, 1950, 10p. incl. diagrs. refs. (Technical repl. no. 132) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U10088; ATI-71878 Unclassified

A study is made of the limits within which diffusion phenomena control the breakdown of a HF discharge. The discussion is based on proper variables for dimensional analysis, using the parameters $p\Lambda$, $p\lambda$, and $E\Lambda$, where p is the pressure, Λ the characteristic diffusion length, λ the wave length of the excitation, and E the breakdown electric field. The limits of applicability of the diffusion theory are found to be a uniform field limit, a mean free path limit, and an oscillation amplitude limit. Within these limits, a single function for the effective breakdown voltage, $E\Lambda$, and the energy per mean free path, E/p, correlated the breakdown voltages for all published data tested, covering a wave-length range from 10 to 17,000 cm. (Contractor's abstract)

MIT. 10:014

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF NONLINEAR TRANSDUCERS, by H. E. Singleton. Aug. 12, 1950, 47p. incl. diagrs. tables, refs. (Technical repl. no. 186) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U16903; ATI-96271 Unclassified

Transducers are classified according to the manner in which they make use of storage to control their output. The state of a transducer is specified by the position of a point in multidimensional space. The system function of the transducer is then determined by attaching to each state point a set of numbers or probabilities characteristic of the output for the corresponding state. The technique of synthesizing nonlinear transducers is considered, and standard forms for synthesizing the various kinds of transducers are obtained. It is shown that a necessary and sufficient condition for an invariant finite-state transducer to be capable of synthesis in terms of a finite number of linear elements and rectifiers is that the state-defining regions be bounded by hyperfine surfaces. It is found that any nonlinear system function is determined by certain higher-order autocorrelation functions of the input and cross correlations between the input and output. The problem of optimum design of nonlinear filters is discussed. It is shown that if the probability distributions of noise and signal are Gaussian, the optimum mean-square filter is linear. For finite-state filters, the criterion of minimizing the probability of error is employed. The problem is to specify optimum boundaries for the state-defining regions and to obtain specific design equations. Several examples of filter design are given, including an application to the radar search problem. (Contractor's abstract)

MIT. 10:015

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TRANSIENT STARTING OF A MAGNETRON AS DESCRIBED BY THE INHOMOGENEOUS VAN DER POL EQUATION, by E. E. David, Jr. Aug. 16, 1950, 14p. incl. illus. diagrs. (Technical repl. no. 168) (Sponsored jointly by Signal Corps, Office of Naval Research, [Air Force Office of Scientific Research] under DA-36-039-sc-100 and W36-039-sc-32037) U18525; ATI-111108 Unclassified

The solution to the inhomogeneous Van der Pol equation specifies the operation of a nonlinear oscillator perturbed by an external signal of similar frequency. The steady state behavior of such an oscillator was first quoted by Van der Pol himself and is in agreement with other literature in the field. In this study, approximate and differential analyzer solutions are used to investigate the frequency and phase transients during starting, and distortion of the build-up envelope by the exciting signal. Results are essentially in agreement with results indicated in technical rept. no. 100 (TII' U8967), although details are different because reactive electronic beam-loading is neglected here. (Contractor's abstract)

MIT. 10:016

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NOTE ON THE BEHAVIOR OF MUTUALLY COUPLED OSCILLATORS, by E. E. David, Jr. Aug. 16, 1950, 15p. incl. diagrs. (Technical rept. no. 169) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17791; ATI-109131 Unclassified

The operation of an arbitrary number of oscillators mutually coupled into an arbitrary number of loads is discussed. By utilizing the oscillator Rieke diagrams, the scattering equations of the interconnecting network, and the constraints furnished by passive loads, the behavior of such a system may be predicted. Two simple, but practically important cases are discussed: (1) two oscillators operating into a matched parallel junction, and (2) the dual of this arrangement. The operation of these systems is critically dependent upon the oscillator spacing relative to the interconnecting network, although the tolerances on these spacings are not severe. Dissimilarities between the oscillators are not important. (Contractor's abstract)

MIT. 10:017

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A STUDY OF SPEECH PROBABILITY DISTRIBUTIONS, by W. B. Davenport, Jr. Aug. 25, 1950, 76p. incl. illus. diagrs. refs. (Technical rept. no. 148) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U16015; ATI-101290 Unclassified

The problem of measuring a probability concerning a random time function is shown to reduce generally to that of measuring a time average. A study is made of the error due to averaging over only a finite interval of time. A description is given of apparatus, which, with pulse techniques, can measure certain probabilities concerning the instantaneous amplitude and the zero-crossing periods of any time function whose statistics lie in the range of the voice wave statistics. Measurements of the first probability distribution density of the speech-wave instantaneous amplitude for several speakers indicate that this distribution varies exponentially for large value of amplitude. Small but definite increases in conditional probability were noted for delay times of the order of magnitude of the pitch period. These measurements were of the stationary, or long time, speech statistics. Most of the measurements were made on substantially undistorted speech; some were made to show qualitatively the effect of reflections. (Contractor's abstract)

MIT. 10:018

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SERVOMECHANISM SYNTHESIS THROUGH POLE-ZERO CONFIGURATIONS, by J. G. Truxal. Aug. 25, 1950, 101p. incl. diagrs. refs. (Technical rept. no. 162) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] U15904; ATI-96270 Unclassified

A servomechanism synthesis procedure based on manipulation of pole-zero configurations permits simultaneous control over system response in both the frequency and time domain. In addition, this synthesis procedure is based on several important relationships between pole-zero locations and various criteria of system performance (e.g. error constants or the effect of corrupting signals). The synthesis procedure starts with the selection of an over-all system function meeting performance specifications in both the time and frequency domains and simultaneously resulting in physically realizable compensation networks. From the over-all system function the open-loop transfer function is determined by a simple graphical procedure, and the final step in the design is the determination of compensation networks. (Contractor's abstract)

MIT. 10:019

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AXIALLY SYMMETRIC ELECTRON BEAM AND MAGNETIC FIELD SYSTEMS, by L. A. Harris. Aug. 29, 1950, 77p. incl. illus. diagrs. refs. (Technical rept. no. 170) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17398 Unclassified

The theory of longitudinally uniform and axially symmetric electron beams focused by a uniform axial magnetic field is presented. It is assumed that the axial velocity is common to all electrons and that they do not cross each other radially. The radial electric, magnetic, and centrifugal forces are balanced if the proper relation between the magnetic field at the cathode and that in the uniform beam is satisfied. This balance is due to the rotation of electrons around the axis brought about by their crossing magnetic field lines. A general graphical method is presented for obtaining the potential distribution required for the design of hollow beams. The necessity of bringing the beam through a transition region where electrons acquire their angular velocity restricts the problem to 2 categories in which the cathode is either in a uniform magnetic field or in a magnetically shielded region. Special cases are the solid beam, the hollow beam with uniform radial charge density, the hollow beam between coaxial electrodes at the same potential, and the hollow beam inside an outer electrode only. Of interest is the

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case of a hollow beam focused with a magnetic field in the cathode region only. Explicit design equations are presented for all cases. The possible effects of incidential ionization are briefly considered. Experimental results confirm the theory qualitatively and to a considerable extent quantitatively and indicate the importance of the cathode flux condition and the need for a good method of bringing the beam through the transition region. (Contractor's abstract)

MIT. 10:020

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW METHOD OF ESTIMATING PREOSCILLATION NOISE IN A PULSED OSCILLATOR (MAGNETRON), by E. E. David, Jr. Aug. 30, 1950, 3p. incl. diagr. (Technical rept. no. 173) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100]
U14696; ATI-92489 Unclassified

Starting-time jitter in pulsed magnetrons is throught to be caused principally by a corresponding initial RF amplitude jitter resulting from preoscillation noise. The initial amplitude (Ao) and the nose envelope were assumed to have a Rayleigh distribution, and the built-up was assumed to commence exponentially. Measurements of the time jitter were extrapolated to compute the amplitude variations and subsequently the rms preoscillation noise. Values 100 db above that expected from a temperature-limited diode carrying the same current and about 20 db greater than that found by static measurements were obtained for the QK-61 magnetron. The large value may be attributed to the low magnetic field (1400 gauss) used with this magnetron and the larger plate voltage (1050 v) present during the transient as opposed to the static measurement.

MIT. 10:021

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE QUANTUM THEORY OF ANTIFERROMAGNETISM, by R. J. Harrison. Aug. 31, 1950, 31p. incl. diagrs. refs. (Technical rept. no. 172) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100]
U14693; ATI-92490 Unclassified

Recent neutron diffraction experiments on antiferromagnetic crystals at low temperatures indicate the existence of a long range correlation in direction of the spin magnetic moments. Although the Ising model predicts such a correlation, a consideration of the uncertainty relationships for spin shows that in the correct quantum description of an antiferromagnet, the ordering cannot be the simple type given by this semiclassical model. The problem of determining the lowest quantum state of an antiferromagnet is much the same as the quantum chemical problem of determining the state of a large molecule. The short range correlation of spin moments is measured by a quantity called the "bond order" in molecular problems. This assumes its maximum in the lowest eigenstate. In an attempt to make progress in solving the general quantum mechanical problem, a new method of approximation has been developed and applied to the linear antiferromagnetic chain. The spin eigenfunction is expanded in terms of a set of "valence bond spin functions," grouped according to "degree of excitation." The amplitudes for each excitation are determined by the solution of an infinite set of linear difference equations. (Contractor's abstract)

MIT. 10:022

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

APPLICATION OF STATISTICAL METHODS TO COMMUNICATION PROBLEMS, by Y. W. Lee. Sept 1, 1950, 39p. incl. illus. diagrs. refs. (Technical rept. no. 181) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100)
U16340; ATI-101289 Unclassified

The basic ideas and tools in the statistical theory of communication are discussed. The methods of the theory in the formulation of some important communication problems are outlined. Some techniques which have been developed for application to practical problems, and certain laboratory results in support of the theory are described. To indicate the possibility of practical application, primarily with respect to improvement of S/N ratio, experimental results are presented. (Contractor's abstract)

MIT. 10:023

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LOCKING PHENOMENA IN MICROWAVE OSCILLATORS WITH MISMATCHED LOADS, by J. C. Pitts, W. F. Wicks, and E. E. David, Jr. Sept. 11, 1950, 13p. incl. diagrs. (Technical rept. no. 175) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037)
U17399; ATI-105778 Unclassified

This report is a supplement to technical report no. 63 (TIP U1294). It presents an exact graphical method for predicting the behavior of an oscillator perturbed by an external signal and operating into an arbitrary but passive load impedance. The method is applicable to any oscillator, but is applied here to a reflex klystron. Both theoretical and experimental results are included.

MIT. 10:024

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW "DOUBLE RESONANCE" METHOD FOR THE INVESTIGATION OF ATOMIC AND NUCLEAR MOMENTS. PART I. THEORY OF EFFECTS IN MERCURY VAPOR, by F. Bitter and J. Brossel. Sept. 12, 1950, 24p. incl. diagrs. tables. (Technical rept. no. 176) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] U14030; ATI-92488 Unclassified

In general, if a system is capable of existing in 3 states, A, B and C, the method involves the detection of resonances between any 2 of these, say A and B, by observing changes in transitions from either A or B to C. Of particular interest is the case in which A and B are either Zeeman or hyperfine structure levels, and transitions to C involve frequencies in the optical range. Effects to be expected are analyzed with particular emphasis on Hg vapor. Measurements on both the ground and excited states should be possible. (Contractor's abstract)

MIT. 10:025

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE OFFSET WAVEGUIDE JUNCTION AS A REACTIVE ELEMENT, by L. D. Smullin and W. G. Glass. Sept. 13, 1950, 6p. incl. diagrs. (Technical rept. no. 164) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] U15593; ATI-96267 Unclassified

A new type of wave-guide circuit element is described that has a number of desirable electrical and mechanical properties. These include ease and accuracy of adjustment, and simple analytical expressions for some of the more important properties. The capacitive junction allows the practical construction of capacitively coupled resonant cavities. Such cavities have a relatively constant bandwidth over their tuning range, as compared with the more commonly used inductively coupled cavities. (Contractor's abstract)

MIT. 10:026

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW TYPE OF ELECTROMAGNET. PART I. OPERATION AT 20-kw LEVEL, by F. Bitter and F. E. Reed. Sept 14, 1950 [3]p. incl. illus. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) U16597; ATI-149626 Unclassified

Also published in Rev. Scient. Instruments, v. 22: 171-173, Mar. 1951.

An improved iron core magnet for general laboratory use, weighing two tons, has been designed and several units have been constructed. It incorporates the desirable features of a number of earlier magnets and is engineered to give optimum utility with minimum space and weight and with minimum attention by the operating personnel. A summary of test performance at 20 kw is given.

MIT. 10:027

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A SIMPLIFICATION OF THE HARTREE-FOCK METHOD, by J. C. Slater. Sept. 28, 1950 [5]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) U16598; ATI-158493 Unclassified

Also published in Phys. Rev., v. 81: 385-390, Feb. 1, 1951.

It is shown that the Hartree-Fock equations can be regarded as ordinary Schrödinger equations for the motion of electrons, each electron moving in a slightly different potential field, which is computed by electrostatics from all the charges of the system, positive and negative, corrected by the removal of an exchange charge, equal in magnitude to one electron, surrounding the electron whose motion is being investigated. By forming a weighted mean of the exchange charges, weighted and averaged over the various electronic wave functions at a given point of space, we set up an average potential field in which we can consider all of the electrons to move, thus leading to a great simplification of the Hartree-Fock method, and bringing it into agreement with the usual band picture of solids, in which all electrons are assumed to move in the same field. We can further replace the average exchange charge by the corresponding value which we should have in a free-electron gas whose local density of actual charge is at the position in question; this results in a very simple expression for the average potential field, which still behaves qualitatively like that of the Hartree-Fock method. This simplified field is being applied to problems in atomic structure, with satisfactory results, and is adapted as well to problems of molecules and solid. (Contractor's abstract)

MIT. 10:028

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CENTRIFUGAL DISTORTION IN ASYMMETRIC TOP MOLECULES. 1. ORDINARY FORMALDEHYDE, $H_2C^{12}O$, by R. B. Lawrance and M. W. P. Strandberg. Oct. 3, 1950, 16p. incl. diagrs. tables, refs. (Technical rept. no. 177) [Sponsored jointly by Signal

MIT. 10:029 - MIT. 10:032

Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100]
U14660; ATI-92487 Unclassified

A semiclassical approach is used to develop a simple expression for the centrifugal distortion correction in asymmetric top molecules. The general expression for the shift of any given energy level involves 5 experimentally determined distortion coefficients and a knowledge of the dependence of the term value as a function of asymmetry. A useful simplified expression for the frequency correction in $\Delta J = 0$ transitions involves only 2 effective rigid rotor parameters and 4 distortion coefficients. The method is applied to the microwave spectrum of $H_2C^{12}O$; the results show excellent internal consistency. The resulting rigid rotor parameters are: a = 282,106 mc/sec, b = 38,834 mc/sec, and c = 34,004 mc/sec. The electric dipole moment is determined to be 2.31 ± 0.04 debye and the line breadth parameter as 97 ± 10 microns Hg per mc/sec. (Contractor's abstract)

MIT. 10:029

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CENTRIFUGAL DISTORTION IN ASYMMETRIC MOLECULES. II. HDS, by R. E. Hillger and M. W. P. Strandberg. Oct. 5, 1950, 15p. incl. diagr. tables. (Technical rept. no. 180) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100)
U61362; ATI-123918 Unclassified

Also published in Phys. Rev., v. 83: 575-581, Aug. 1, 1951.

A perturbation method for relating the theory of centrifugal distortion in asymmetric top molecules to observed microwave Q branch, a- or c-type transitions, is presented. The formula for the distortion correction is expressed in terms of the total angular momentum, J, the symmetry axis momentum of the nearest symmetric top, K, and five distortion constants. The formula yields a satisfactory fit to the observed spectrum of HDS ($K \simeq -0.5$). The electric dipole moment is determined as 1.02 ± 0.02 debye. The inertia defect and distortion constants are calculated. The effective structure for the HDS molecule so determined is in agreement with infrared determinations. (Contractor's abstract)

MIT. 10:030

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PRESSURE DEPENDENCE OF SECOND SOUND VELOCITY IN LIQUID HELIUM II, by R. D. Maurer and M. A. Herlin. Oct. 13, 1950 [4]p. incl. diagrs. (Technical rept. no. 179) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100 and W36-039-sc-32037]) U16599; ATI-105777

Unclassified

Also published in Phys. Rev., v. 81: 444-447, Feb. 1, 1951.

The velocity of second sound as a function of pressure and temperature has been measured to 0.95°K by a pulse method. The quantitative dependence of the rise in velocity upon pressure is found to support the role of the phonons in contributing to the normal fluid flow alone. (Contractor's abstract)

MIT. 10:031

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AREA DISPLAYS OF THE ELECTRICAL ACTIVITY OF THE HEART, by S. Goldman, W. F. Santelmann, Jr. and others. Nov. 15, 1950, 11p. incl. illus. diagrs. (Technical rept. no. 121) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U15144 Unclassified

The method of electronic mapping or area display was used to obtain information about the movement of electrical potentials in the heart as projected on the surface of the chest. Sixteen electrodes connected to a CRT were placed in an ordered array on the chest, with a small square marked on the screen of the tube corresponding to each electrode. The light intensity of each square was made proportional to the instantaneous voltage of its electrode by electronic means. The subject was placed on a cot inside a wire-mesh grounded cage and had an added ground attached to his arm. Moving pictures were made of the area display on the CRT and were subsequently shown in slow motion. These pictures indicated the location and sequences or paths of activity of the P, QRS, and T waves in normal and abnormal heart functions.

MIT. 10:032

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE MICROWAVE SPECTRA OF THE DEUTERO-AMMONIAS, by M. T. Weiss and M. W. P. Strandberg. Dec. 18, 1950, 16p. incl. tables. (Technical rept. no. 183) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100 and W36-039-sc-32037]) ATI-118355 Unclassified

Also published in Phys. Rev., v. 81: 286, Jan. 15, 1951 (Letter-to-the-editor).

Also published in Phys. Rev., v. 83: 567-575, Aug. 1, 1951.

Measurements of the inversion-rotation spectra of the deutero-ammonias have been made in the 4000 mc/sec

region. Fifty lines of NH_2D and NHD_2 have been measured and identified by means of the Stark effect. As expected, the results show that for these molecules, only simultaneous rotational and inversion transitions could be observed. Thus, corresponding to each $J_\tau - J_\tau$, transition two absorption lines could be observed, separated by either twice the rotational energy separation or twice the inversion splitting of the levels involved. From the observations the inversion splittings of the partially deuterated molecules could be calculated and were found to be in good agreement with the Dennison and Uhlenbeck inversion doubling theory. Thus, the inversion splittings for the ammonia molecules are approximately as follows: 24,000 mc/sec for NH_3; 12,000 mc/sec for NH_2D; 5,000 mc/sec for NHD_2; 2000 mc/sec for ND_3. The results are also in agreement with the structural parameters of ammonia as given by Herzberg. The sign of the nuclear quadrupole coupling constant was also measured and found to be negative, as expected. The centrifugal distortion for both rotation and inversion states has been experimentally determined. (Contractor's abstract)

MIT. 10:033

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ROTATIONAL MAGNETIC MOMENTS OF $^1\Sigma$ MOLECULES, by J. R. Eshbach and M. W. P. Strandberg. Jan. 9, 1951, 20p. incl. diagr. tables, refs. (Technical rept. no. 184) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U19568; ATI-118356 Unclassified

Also published in Phys. Rev., v. 85: 24-34, Jan. 1, 1952.

The molecules considered have zero total orbital and zero total spin angular moments. The magnetic moment due to the free rotation of a $^1\Sigma$ polyatomic molecule is calculated, using the equation for the magnetic moment of a system of particles

$$\vec{m} = \frac{1}{2c} \sum_i e_i(\vec{r}_i \times \vec{v}_i)$$

where c is the particular axis of inertia fixed in the molecule and e_i is the charge, $\vec{r}_i$ the position vector, and $\vec{v}_i$ the velocity vector of the i^{th} particle. The $\vec{v}_i$'s are derived from the rotational problem. The theory of the rotational magnetic moment in $^1\Sigma$ molecules is applied to describe experiments on the Zeeman effect for a linear rotor, OCS, and a symmetric top, NH_3. (TIP abstract)

MIT. 10:034

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE APPROXIMATION WITH RATIONAL FUNCTIONS OF PRESCRIBED MAGNITUDE AND PHASE CHARACTERISTICS, by J. G. Linvill. Jan. 19, 1951, [11]p. incl. diagrs. (In cooperation with Bell Telephone Labs., Inc.) [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U23852 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 40: 711-721, June 1952.

A successive-approximations method is applied to the selection of network functions having desired magnitude and phase variation with frequency. The first approximation, the first set of pole and zero locations, can be selected on the basis of known solutions to similar problems or through use of a set of curves. In succeeding approximations the pole and zero locations are adjusted to decrease the deviation of the earlier approximations from the desired characteristics. The process adjusts the magnitude and phase characteristics simultaneously. Its flexibility permits accommodation of practical constraints not possible with other methods. (Contractor's abstract)

MIT. 10:035

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXPERIMENTAL STUDY OF NONLINEAR DEVICES BY CORRELATION METHODS, by L. Weinberg and L. G. Kraft. Jan. 20, 1951, 29p. incl. illus. diagrs. refs. (Technical rept. no. 178) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20643; ATI-128339 Unclassified

The autocorrelation method was applied in determining the power density spectra for the output of 2 nonlinear devices, the linear 9005 tube and the square-law 1N48 crystal diode. The characteristic-function method is discussed for obtaining the output autocorrelation function of nonlinear circuits. In the experimental setup, a 6D4 gas triode was employed as the primary white noise generator. Monitoring of the rectifier input and the rectifier bias voltages was accomplished by use of thermocouple and dc meters, respectively. The resonant frequency of the band-pass filter was 23 kc. The sine-wave generator was also set to this frequency. Autocorrelation curves of the rectifier input, with and without the sine wave present, were obtained for Q values (60, 25, 8.8) of the resonant circuit. Autocorrelation curves of the rectifier output were also obtained. The results for the autocorrelation functions were compared with the theoretically calculated curves. (TIP abstract)

MIT. 10:036

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SUBCARRIER MODULATION OF A REFLEX

MIT. 10:037 - MIT. 10:040

KLYSTRON, by J. Jensen. Jan. 26, 1951, 15p. incl. diagrs. refs. (Technical rept. no. 187) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U18786; ATI-113039 Unclassified

A method of modulating a reflex klystron is reported whereby the message to be transmitted is modulated on a subcarrier, which in turn modulates the klystron through its repeller. Of the resulting frequency spectrum only a narrow band, which contains the message, is transmitted. The message was found to be contained in a frequency band centered locally about the first microwave side bands, and in certain cases also about the microwave carrier. A theoretical analysis seems to indicate that the distortion introduced by transmitting only one of these local frequency bands can be made as small as desired under proper operating conditions, dependent upon the modulation index of the frequency-modulated klystron output. The power output obtainable by this method is considered, since the possibility of modulating microwave frequencies at high-power levels is the main reason for studying this problem. The power output of a Si crystal modulator may be exceeded under certain conditions. Experimental data confirm the analytical results within the limits of accuracy of the equipment.

MIT. 10:037

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SIGNAL-TO-NOISE RATIO IN CORRELATION DETECTORS, by R. M. Fano. Feb. 19, 1951, 13p. incl. refs. (Technical rept. no. 186) (Sponsored jointly by Signal Corps; Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17068; ATI-103043 Unclassified

A discussion is presented of the operation in the presence of noise of a correlation detector consisting of a multiplier followed by a low-pass filter. It is shown that in the most favorable cases the output S/N power ratio is proportional to the corresponding input ratio and to the ratio of the signal bandwidth to the bandwidth of the low-pass filter. (Contractor's abstract)

MIT. 10:038

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXTENSION OF THE MICROWAVE SPECTRUM OF ND_2H, by K. A. Sawyer and J. D. Kierstead. Feb. 19, 1951, 5p. incl. tables. (Technical rept. no. 188) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U18585; ATI-113038 Unclassified

Extension of the investigation of the deutero-ammonias down to the 4,000 mc/sec region produced many inversion-rotation spectrum lines of ND_2H. Selection rules, molecular constants, and equations employed by Weiss (The Microwave Rotation-Inversion Spectra of the Deutero-Ammonias, Doctoral Thesis, Physics, M.I.T. 1950) were found to be reliable with the exception of the need for a slight modification of the constants developed for the Sheng, Barker, and Dennison (Phys. Rev., v. 60: 786, 1941) type inversion equation. Frequencies in this region may serve other purposes than that of investigating the ND_2H molecule. The lines are of sufficient intensity to provide a good frequency check in this region. Inasmuch as a mixture of the ammonias is easily prepared and the combined spectrum covers the whole microwave region, the deutero-ammonias are exceptionally useful for this purpose. With the use of this energy region for commercial microwave relay systems these frequencies may have value for stabilization purposes. Frequencies in this region are being considered by NBS for use in an atomic clock, a clock controlled by constant absorption frequencies. (Contractor's abstract)

MIT. 10:039

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A SHORT-TIME CORRELATOR FOR SPEECH WAVES, by P. E. A. Cowley, R. M. Fano, and B. L. Basore. Feb. 26, 1951, 21p. incl. illus. diagrs. (Technical rept. no. 174) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U65644; ATI-162764 Unclassified

A short-time correlator for speech waves is described. This equipment is designed to analyze speech of a quality suitable for toll-telephone circuits. The analysis carried out is a thirteen-point approximation to the short-time autocorrection function which is presented as a display on a cathode-ray tube. The design is discussed in some detail and circuit diagrams of the equipment are presented. The equipment is considered suitable for any application where autocorrection or cross correlation functions of audio waveforms are desired to a moderate accuracy. Some experimental results are also included in this report of short-time correlation patterns of speech sounds, sinusoids, noise, and combinations of these waveforms.

MIT. 10:040

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INTERFERENCE FILTERING, by J. P. Costas. Mar. 1, 1951, 45p. incl. diagrs. tables, refs. (Technical rept. no. 185) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20628; ATI-128340 Unclassified

The problem of filtering a number of channels of information for the best recovery of one particular channel message is considered. Each channel is assumed to carry a message and a disturbance function, and correlation is assumed to exist between all possible pairs of message and disturbance functions. Exact solutions are obtained for filtering with long delay, and expressions for the irremovable filtering error are derived. The synthesis of optimum linear filters by approximation methods is considered. A method of approximation which tends to minimize the filtering error for a given allowable network complexity is given and detailed examples in the use of the method for the general solution of the multiple time series problem are presented. Multichannel filtering techniques may be applied to the problem of detection of amplitude-modulated signals. Adjacent channel interference situations are examined in detail for both double- and single-side-band signals. Experimental results verify the theoretical conclusions. (Contractor's abstract)

MIT. 10:041

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CORRELATOR ERRORS DUE TO FINITE OBSERVATION INTERVALS, by W. B. Davenport, Jr. Mar. 8, 1951, 16p. (Technical rept. no. 191) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17067; ATI-103042
Unclassified

A measurement S/N ratio is defined as the reciprocal of a normalized rms measurement error. This ratio is evaluated for the general continuous correlator and for the general sampling correlator. The limiting behavior of the S/N ratio is studied for several specific cases. The continuous correlator cases considered are those where the averaging filter is: (a) a perfect integrator, and (b) an RC low-pass filter. The sampling correlator special case considered is that where the sampling is done periodically. (Contractor's abstract)

MIT. 10:042

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE MICROWAVE SPECTRUM OF KETENE, by H. R. Johnson and M. W. P. Strandberg. Mar. 15, 1951, 20p. incl. illus. diagrs. refs. (Technical rept. no. 192) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20019; ATI-123911
Unclassified

Also published in Jour. Chem. Phys., v. 20: 687-695, Apr. 1952.

The microwave absorption spectra of the $H_2^1C_2^{12}O^{16}$, $H^1D^2C_2^{12}O^{16}$, and $D_2^2C_2^{12}O^{16}$ ketene molecules were studied. The lines were identified by the Stark effect, intensity, and frequency. The reciprocal moments of inertia were calculated for each, and the centrifugal-distortion theory of Hillger and Strandberg (Technical rept. no. 177; item no. MIT. 10:028) was verified for both Q ($\Delta K_{-1} = 0$, $\Delta J = 0$) and R ($\Delta K_{-1} = 0$, $\Delta J = +1$) branches. The equilibrium structure was calculated from the moments of inertia extrapolated to zero centrifugal distortion. Comparison with data from other methods indicated an increased accuracy for the structure as well as the dipole moments which are determined from the Stark effect. Intensities of satellites of the lightest molecule corresponding to the lowest 3 vibrational fundamentals were also measured, and changes in the average reciprocal moments determined. Calculated vibrational frequencies differed from values reported by infrared workers. Further measurement of the D_2C_2O spectrum was recommended for a more complete check on the centrifugal-distortion theory applied to a molecule with both Q and R branch transitions. Actual calculation of the coefficients from the vibrational fundamentals seemed possible for ketene because of its symmetry.

MIT. 10:043

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ELECTRONIC CORRELATOR, by T. P. Cheatman, Jr. Mar. 28, 1951, 87p. incl. illus. diagrs. refs. (Technical rept. no. 122) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U18523; ATI-112708
Unclassified

The role and application of correlation functions in the statistical theory of communication is described in terms of the important basic properties of autocorrelation and crosscorrelation functions. An electronic correlator constructed on the basis of (a) utilizing pulse-sampling techniques and (b) multiplication in time-amplitude coordinates is described in detail. General criticisms and suggestions for improvements, based on experience gained from the application of the correlator to several problems, are given. Some additional methods of computing correlation functions are outlined and discussed. The experimental application of the electronic correlator is illustrated by several studies that are concerned with the detection, analysis, or filtering of a desired signal in noise. (Contractor's abstract)

MIT. 10:044

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HIGH-FREQUENCY GAS DISCHARGE BREAKDOWN, by S. C. Brown. Apr. 12, 1951, 15p. incl. diagrs. refs. (Technical rept. no. 195) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air

MIT. 10:045 - MIT. 10:048

Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17867; ATI-109076
Unclassified

A phenomenological description of HF gas discharge breakdown is given. The effects of superimposing on the ac field, a small dc field, and a magnetic field are also discussed. (Contractor's abstract)

MIT. 10:045

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SIMPLIFIED FM TRANSIENT RESPONSE, by W. L. Hatton. Apr. 23, 1951, 7p. incl. diagrs. (Technical rept. no. 196) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20023; ATI-123916 Unclassified

The response of a single tuned circuit to a driving current having a sudden jump in frequency is calculated. It is found that the rise time and overshoot depend upon the size of the frequency jump and the position of the initial and final frequencies with respect to the center frequency of the tuned circuit. The slowest rise occurs when the jump is very small and near the center frequency. The rise time is then the same as in the case of double-side-band AM. Larger jumps and decentering of the driving frequencies result in shorter rise times and possibly larger overshoots. FM compares favorably with double-side-band AM.

MIT. 10:046

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE FLOW OF SCHEDULED AIR TRAFFIC (I), by R. B. Adler and S. J. Fricker. May 2, 1951, 100p. incl. diagrs. tables, refs. (Technical rept. no. 198) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and Cca-28152) U19569; ATI-118354
Unclassified

IBM punched-card machines were employed in an analysis of the congestion at a single landing strip when aircraft are scheduled to arrive in sequence but fail to meet such schedules according to certain simple deviation statistics assumed to have a finite spread. Numerical results for the distribution of the resulting stack and total delays are presented. The former are compared with those which arise from the more random Poisson arrival distribution. The amounts of congestion and stack delay are considerably smaller under the new conditions, particularly when the traffic is heavy. A significant range of the parameters was covered by the numerical analysis. A quantitative relation is established between the time-keeping errors of the aircraft en route to an airport and the resulting terminal congestion and delay. The results may be applied to problems of en route control. (TIP abstract)

MIT. 10:047

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A SPECTROSCOPIC STUDY OF THE ELECTRONIC STRUCTURE OF METALLIC POTASSIUM AND CALCIUM, by R. H. Kingston. May 10, 1951, 30p. incl. illus. diagrs. refs. (Technical rept. no. 193) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20230; ATI-125041
Unclassified

Also published in Phys. Rev., v. 84: 944-949, Dec. 1, 1955.

The spectrograph used by O'Bryan and Skinner (Phys. Rev., v. 45: 370, 1934) to study the emission bands of metals was modified by replacing the photographic plates with a photomultiplier detector. Samples were prepared by evaporating a pure coat of the metal onto the targets in a high-temperature furnace; the targets were bombarded with electrons of 300 to 500 ev energy at currents of 2 to 6 ma. Transitions of the valence electrons into the ionized 3p state of the atom produced the radiation. A spectrum curve was recorded in 5 min at bombarding power approximately 0.01 as great as that required with the photographic plates. The emission bandwidths for K and Ca, respectively, were 1.9 and 3.0 ev compared with 3.6 and 5.0 ev predicted from theoretical calculations. Sample purity was the limiting factor in emission-band accuracy; emission edges were as sharp as those observed for Al. Reliability of the emission curves was mainly determined by the depth of penetration of the bombarding electrons. A bombarding potential of 300 v or higher was required for K and Ca. Chemical activity did not appear to be a decisive factor in determining resistance to oxide contamination. Results indicated that the present theories give an inadequate picture of the electronic structure of metals of the third period. A bibliography is included relating to the electronic structure of solids, high-vacuum spectroscopy, and experimental techniques.

MIT. 10:048

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

COMMUNICATION AND LEARNING IN TASK ORIENTED GROUPS, by L. S. Christie, R. D. Luce, and J. Macy, Jr. May 13, 1952, 251p. incl. illus. diagrs. tables, refs. (Technical rept. no. 231) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) AD 16785
Unclassified

This study presents an account of the principal theoretical and experimental developments of the

"Group Networks Lab." at M. I. T. during the period of Aug. 1949 to Apr. 1952. The following are presented: Chap. 1. Task-oriented groups are discussed generally and definitions are introduced to isolate variables which were experimentally manipulated. Chap. 2. A general description of the experimental techniques is given. Chap. 3. The statistical behavior of individual message destination choice is coupled with communication network properties to account for the observed statistics of group performance. Emphasis is placed upon the learning which occurs during trials. Chap. 4. Individual decision latency is shown to be approximately exponential. A simple theory relates group latency to individual, and these results are used to explicate other experiments for which less complete data are available. Chap. 5. Attention is turned to noise in the coding-decoding of messages. Group errors are simply explicable in terms of a measure of noise. A mechanism, redundancy, is demonstrated to account for a decrease in noise. In turn, redundancy is related, imperfectly, to several network properties. Chap. 6. Questionnaire attitudinal data are presented and for some questions a high correlation with network properties is demonstrated. A factor analysis yields four orthogonal factors for the questionnaire used. Appendix 1. Detailed descriptions of specific experiments are presented. Appendix 2. An electrical device which controls and records a class of communication experiments is described. Appendix 3. A human group interpretation of the classical electrical network equations is shown to have very limited applicability. Appendix 4. Some mathematical results on network topology and their experimental implications are recounted. (Contractor's abstract)

MIT. 10:049

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXPERIMENTAL STUDY OF OPTIMUM FILTERS, by C. A. Stutt. May 15, 1951, 127p. incl. illus. diagrs. (Technical rept. no. 182) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U17505 Unclassified

A study was made of the use of mean-square-error (mse) criterion in network and communication-theory problems. It concerned the development of a time-domain technique for use in Wiener's theory for the linear system, and the compilation of experimental data on the performance of optimum-mean-square (oms) filters on certain idealized problems. One part of the design technique is a specification of the impulse response of oms filters, and is pointed towards interpreting this response directly in terms of experimental correlation data. The method hinges on a time-domain solution of the Wiener-Hopf integral equation. A second part is devoted to a laboratory scheme of synthesis for this response. A flexible network, based on the convolution integral, is described. The device incorporates a delay line having multiple taps with provision for linearly combining the voltage of each tap into a common output. The transient voltage evoked in this circuit can be shaped by independent adjustment of the taps. The delay-line network is shown to be useful in the evaluation of Fourier transforms and convolution integrals and as an information storage device. Problems, especially adapted to the mse theory, and equipment for their study in the laboratory are described, and experimental results on the performance of oms filters and a Butterworth-type filter are presented. These results include values of the mse, noise-to-signal ratio, and pictures of pertinent wave forms. These experiments indicate that the mse network specifications may be used advantageously as standards in conventional designs, that oms designs are relatively noncritical, and that the theory needs strengthening by the inclusion of some interpretation of what is objectionable in an error function.

MIT. 10:050

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTROMAGNETIC WAVE PROPAGATION ON HELICAL CONDUCTORS, by S. Sensiper. May 16, 1951, 119p. incl. diagrs. refs. (Technical rept. no. 194) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U69327
ATI-194313 Unclassified

The results of a theoretical investigation of the properties of the natural waves or "free modes" which propagate along infinite helical conductors are reported. The sheath model which replaces the helix by an anisotropic cylindrical sheet is considered. The higher modes are investigated, and it is found that several waves per mode can exist. The significance of these waves in terms of inward and outward traveling waves from a source is shown. The manner in which the characteristics of these waves change as the parameters of the system are altered is discussed. A more physically realistic model of the helix than the sheath model is analyzed. The exact formulation shows the existence of bands where free mode waves are not permitted. The cases of a single wire helix wound with a very narrow tape and a very wide tape for which reasonably valid approximations can be made are analyzed, and the solutions are obtained. The usual low frequency behavior predicted by the sheath model and the anomalous behavior of the propagation constant in the region where the circumference of the helix is approximately equal to a wavelength result from these solutions. The problem of multiwire helices is considered, and the manner in which the sheath helix model is obtained as the number of wires becomes infinite is shown. The integral formulation of the small wire helix problem yields results essentially identical to those obtained by means of the methods and approximations indicated above. This formulation allows a solution for the infinite driven helix to be obtained, and although this is not completely evaluated, the free mode portion is extracted. (Contractor's abstract)

MIT. 10:051 - MIT. 10:055

MIT. 10:051

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PRE-EMPHASIZING VIDEO SIGNALS, by W. L. Hatton. May 23, 1951, 16p. incl. illus. diagrs. (Technical rept. no. 202) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20020; ATI-123909 Unclassified

In considering the feasibility of using FM for TV picture transmission, an effort was made to adapt pre- and de-emphasis networks for obtaining all the noise-reduction benefits of FM. The application of pre-emphasis similar to that for audio waves to the video produced overshoot of the order of 300% for a single rapid white-to-black transition. Analysis of the overshoot caused by an input of the Kallman stretch function (Proc. Inst. Radio Engineers, v. 33: 169, Mar. 1945) by graphical convolution indicated that the principal problem exists at the rapid white-black or black-white transitions. A system of clipping after pre-emphasis was proposed, and comparisons were made of a facsimile-system transmission with and without clipping. The clipping produced some degradation of quality in large transitions, but the overall picture was fairly acceptable. A second method was proposed which spread out the overshoot by phase distortion. An approximate method was used to investigate the effect of this method. In a preliminary test, poor results were obtained which were attributed to improper network approximation.

MIT. 10:052

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PARTICLE DYNAMICS IN THE LINEAR ACCELERATOR, by J. R. Terrall and J. C. Slater. May 31, 1951, 4p. incl. diagrs. (Technical rept. no. 204) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20018; ATI-123912 Unclassified

Also published in Jour. Appl. Phys., v. 23: 66-68, Jan. 1952.

Hamilton's equations for the motion of an electron in a linear accelerator are integrated to obtain the final kinetic energy and phase of an electron injected with arbitrary initial kinetic energy and phase. The results are expressed in the form of a map of the final energy and phase of electrons after traversing a section of the accelerator. The actual operation of the accelerator is discussed on the basis of this map. The curves presented are calculated for numerical values appropriate for the M.I.T. accelerator.

MIT. 10:053

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DETERMINATION OF AXIAL FIELD STRENGTH IN A LINEAR ACCELERATOR CAVITY, by L. C. Maier, Jr. and J. C. Slater. May 31, 1951, 5p. incl. diagrs. (Technical rept. no. 205) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U19802; ATI-123914 Unclassified

Two experimental methods are described for finding the accelerating field E in the MIT linear accelerator. These methods were used to check a numerical factor a in Slater's formula for E in terms of input power per unit length, unloaded Q of the accelerator cavity, and wave length (Rev. Mod. Phys., v. 20: 473, 1948). One method is based on measuring the power leaking out of a hole in the cavity wall at the point where the field is to be determined. This method yielded a value of 0.51 for a compared with the theoretical value 0.48. The other method based on the perturbation of the resonant frequency of the cavity by a small conducting sphere located on the axis gave a value of 0.474. (TIP abstract)

MIT. 10:054

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTROMAGNETIC RESONANT BEHAVIOR OF A CONFOCAL SPHEROIDAL CAVITY SYSTEM IN THE MICROWAVE REGION, by J. C. Simons and J. C. Slater. May 31, 1951, 3p. (Technical rept. no. 206) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100 and W36-039-sc-32037) U19803; ATI-123913 Unclassified

The resonance of a small spheroid in a larger confocal spheroidal cavity is investigated. The resonant frequencies and the ratio of contributions to the Q of the inner and outer conductors are computed for different values of the parameters. This problem is used to approximate the case of a thin needle-like antenna in a large cavity. The needle if thin enough shows a greatly enhanced magnetic field on its surface when the cavity is tuned to the resonant frequency defined by the needle. At resonance most of the cavity loss is located at the surface of the needle and depends on the needle material. This property may be used as a means of measuring the surface impedance of the needle material.

MIT. 10:055

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INTERACTION OF MODES IN MAGNETRON

OSCILLATORS, by R. R. Moats. June 25, 1951, 54p. incl. diagrs. tables, refs. (Technical rept. no. 171) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U21245; ATI-134862
Unclassified

The magnetron is discussed in terms of its properties as a feed-back oscillator in order to show that nonlinear circuit theory may be applied in analyzing mode interactions. The problems under study concern mode selection or the establishing of oscillation in the desired mode stability in either pulse or CW magnetrons. The interaction of modes in a nonlinear feed-back oscillator with 2 resonances was examined. The development established that large-amplitude oscillation in one mode tends to suppress oscillation in other modes. This supports the mode-competition theory advanced by Rieke (Microwave Magnetrons, M. I. T. Rad. Lab. Series 6, McGraw-Hill, 1948). These theoretical observations were supported directly by measurement of the loading effect of an oscillating mode in a magnetron upon small-amplitude externally supplied oscillations in another mode; they were also supported indirectly by observation of the performance of several different types of magnetrons.

MIT. 10:056

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A HIGH VACUUM RECORDING SPECTROGRAPH FOR THE STUDY OF RADIATION FROM SOLIDS IN THE 100-800 A RANGE, by E. R. Piore, G. G. Harvey and others. June 29, 1951 [5]p. incl. illus. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office of Scientific Research] under [DA 36-039-sc-190 and W36-039-sc-32037]) U23078; ATI-149627 Unclassified

Also published in Rev. Scient. Instruments, v. 23: 8-12, Jan. 1952.

The two-meter grazing-incidence vacuum spectrograph used by O'Bryan and Skinner for the study of the emission bands of solids has been rebuilt to operate with improved sensitivity and speed. The major modification is the replacement of the photographic plate by a Be - Cu photomultiplier which is designed to traverse the Rowland circle, giving a continuous record of the photon-counting rate as a function of wavelength. With the photomultiplier it is possible to take as many separate curves as desired, subject to x-ray target condition, without opening the spectrograph, which is normally evacuated to better than 10^{-5} mm Hg. In addition, the sensitivity is increased about a thousand-fold, i.e., with a photographic plate, the target current and voltage needed are 10-100 ma and about 3000 v for a one- to three-hour exposure. Using the photomultiplier, however, these values may be reduced to 2-3 ma and 300-500 v respectively, and the complete emission band may be recorded in five minutes. The results for aluminum are in excellent agreement with the results of previous authors. (Contractor's abstract)

MIT. 10:057

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SOLUTIONS OF SOME PARTIAL DIFFERENTIAL EQUATIONS-(WITH TABLES), by L. Weinberg. July 1951 [20]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) ATI-186157 Unclassified

Also published in Jour. Franklin Inst., v. 252: 43-62, July 1951.

A simple method is demonstrated for obtaining some solutions of the principal equations of mathematical physics. Tables of solutions are included in the appendix so that problems in field theory can be solved with a minimum of labor.

MIT. 10:058

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PROPAGATION OF DISTURBANCES IN ACCELERATED ELECTRON STREAMS. I. ONE-DIMENSIONAL ACCELERATED STREAMS, by L. D. Smullin. July 12, 1951, 6p. (Technical rept. no. 207) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20024; ATI-123910 Unclassified

Also published in Jour. Appl. Phys., v. 22: 1496-1498, Dec. 1951.

The propagation of small sinusoidal modulations in the infinite, parallel-plane diode was studied. A second-order differential equation was obtained for the alternating convection current. Solutions were found in closed form for the cases of a drift-stream, space-charge-limited acceleration, and acceleration with an arbitrary current density less than the space-charge-limited value. (Contractor's abstract)

MIT. 10:059

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTRON DENSITY DISTRIBUTION IN A HIGH FREQUENCY DISCHARGE IN THE PRESENCE OF PLASMA RESONANCE, by W. P. Allis, S. C. Brown, and E. Everhart. July 16, 1951, 9p. incl. illus. diagr. (Technical rept. no. 210) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20228; ATI-123919 Unclassified

In a high frequency discharge, plasma resonance

MIT. 10:060 - MIT. 10:063

maximizes the electric field, thus producing a high ionization rate in the regions near resonance. The effect on the distribution of electrons and of ionization in a parallel plane discharge is calculated and compared with the observation that the light from such a discharge often is a minimum at the center. (Contractor's abstract)

MIT. 10:060

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE DETERMINATION OF THE PROBABILITY OF COLLISION FOR SLOW ELECTRONS IN GASES, by A. V. Phelps, O. T. Fundingsland, and S. C. Brown. July 23, 1951, 9p. incl. diagrs. (Technical rept. no. 211) Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) U20227; ATI-123920
Unclassified

A microwave method is outlined for determining the collision probability for momentum transfer for electrons in thermal equilibrium with a gas. An integral equation is developed which gives the ratio of the resistive and reactive components of the microwave conductivity in terms of the collision frequency for electrons with the gas atoms. Two appropriate solutions are given for the collision frequency as a function of electron energy. An experimental procedure is described in which the conductivity ratio is determined from the shift in the resonant frequency and the change in conductance of a resonant cavity. Measurements are made during the decay of a pulsed discharge after the electrons have cooled to the gas temperature. For electrons having a mean energy of 0.039 ev the following results were obtained for P_c at 1 mm Hg pressure in units of cm^2/cm^3: He, 19; Ne, 3.3; A, 2.1; Kr, 54; Xe, 160; H_2, 46; and N_2, 15.

MIT. 10:061

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A DEWAR FOR INTRODUCING LIQUID HELIUM BELOW THE EXPERIMENTAL APPARATUS, by W. Krag. July 27, 1951 [1]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [W36-039-sc-32037 and DA 36-039-sc-100])
AD 205 Unclassified

Also published in Rev. Scient. Instruments, v. 23: 379-380, July 1952.

A description is given of a Dewar flask that was developed for introducing liquid helium below the experimental apparatus. It was found that only about half as much liquid helium was required to cover a charge of one-eighth in. spherical carbon pellets, 2 in. deep, when the helium was injected through the tube into the bottom of the flask as was required when the helium was introduced on top of the carbon pellets.

MIT. 10:062

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DETERMINATION OF FIELD STRENGTH IN A LINEAR ACCELERATOR CAVITY, by L. C. Maier, Jr. and J. C. Slater. Aug. 2, 1951 [6]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-100) ATI-163260
Unclassified

Also published in Jour. Appl. Phys., v. 23: 78-83, Jan. 1952.

One theoretical and two experimental methods are described for finding the accelerating field in the M.I.T. linear accelerator cavity, in terms of the input power. One of the experimental methods is based on measuring the power leaking out through a calibrated hole in an end wall closing the cavity, the hole being located where the field strength is to be determined. The other method is based on the resonant frequency of the cavity by a small conducting sphere located on the axis. All three methods of determination check satisfactorily. In terms of the resulting relations, we discuss the probable field actually existing in the accelerator under operating conditions. (Contractor's abstract)

MIT. 10:063

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE FLOW OF SCHEDULED AIR TRAFFIC (II), by R. B. Adler and S. J. Fricker. Aug. 13, 1951, 50p. incl. diagrs. tables. (Technical rept. no. 199) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100 and Cca-26152) U19805; ATI-123915
Unclassified

IBM punched-card analysis was used in a study of scheduled air traffic problems under the following conditions: (a) a single en-route control point rescheduled the aircraft, and (b) the control point attempted to keep each plane on its original schedule. In both cases, moderate control reduced the frequency of long slack delays for heavy traffic but had little effect on light traffic. In case (a) the total time-keeping error statistics were not greatly altered by the control, since slack delay was traded for added artifical en-route delay. In case (b), however, the en-route-deviation distribution was reduced as well as the slack delay. A less rigid schedule without en-route control was approximately equivalent to en-route-deviation statistics acting upon a rigid schedule. The slacking caused by a sudden terminal shutdown is illustrated in a severely

idealized case. The effect of a delayed feedback which eventually stops the flow of traffic to the terminal was included. Long stack delays, which can not be accounted for in terms of reasonable en-route-deviation distributions, may be caused by the shutdown. The conditions for this latter occurrence were regarded as relatively rare. (See item no. MIT. 10:046 for Part I) (TIP abstract)

MIT. 10:064

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SPECTROSCOPY OF THE SOLID STATE: POTASSIUM AND CALCIUM, by R. H. Kingston. Aug. 27, 1951 [6]p. incl. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) ATI-149239 Unclassified

Also published in Phys. Rev., v. 84: 944-949, Dec. 1, 1951.

Utilizing the techniques by O'Bryan and Skinner for the study of the emission bands of metals, it has been possible to determine the structure of the conduction bands of the metals, potassium and calcium. The spectrograph used utilizes a photomultiplier in place of a photograph plate, thus enabling higher sensitivity and ease of operation. The particular radiation studied is produced by transitions of the conduction electrons into the ionized 3p state of the atom. The limiting factor in the accuracy of the emission band obtained in this way is the purity of the sample studied. The contamination of the surface of an evaporated sample affects the resultant curve mainly as a result of insufficient penetration of the electrons, since the photon absorption is negligible at depths required to produce radiation representative of the pure bulk metal. The results for potassium and calcium at temperatures between 25°C and 100°C are not in good agreement with previous theoretical calculations. The experimental values of band width are 1.9 and 3.0 ev, respectively, compared with the theoretical calculations of 3.6 and 5.0 ev. (Contractor's abstract)

MIT. 10:065

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STATISTICAL ERRORS IN MEASUREMENTS ON RANDOM TIME FUNCTIONS, by W. B. Davenport, Jr., R. A. Johnson, and D. Middleton. Aug. 29, 1951 [12]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) U23524 Unclassified

Published in Jour. Appl. Phys., v. 23: 377-388, Apr. 1952.

The statistical errors in time-average measurements of various properties of (stationary) random time functions are analyzed for their dependence on the averaging interval, the method of averaging, and the statistics of the particular time function under observation. The specific averaging processes considered here are: (1) the continuous time average

$$\left(\frac{1}{T}\int_0^T Z(t)dt\right);$$

(2) the summation (by discrete sampling techniques)

$$\left(\frac{1}{N}\sum_{n=1}^{N}(nT_o)\right);$$ and (3) the smoothing

accomplished by various low-pass filters (for example, a dc meter). Here Z(t) may represent the output of a linear or non-linear device. As a particular example, the measurement of the power in a random noise voltage of bandwidth ω_F is analyzed in detail. The expected root-mean-square error approaches asymptotically the value $(K/\omega_F T)^{1/2}$, where K is some numerical constant, depending on the device in question. For (1) and (2) T is the total observation time, while for (3) it is proportional to a relevant time constant of the low-pass filter. A short discussion of the relative merits of correlators and spectrum analyzers is included, together with a brief treatment of the distribution function of the error in the measurement.

MIT. 10:066

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NEW SYNTHESIS PROCEDURES FOR REALIZING TRANSFER FUNCTIONS OF RLC AND RC NETWORKS, by L. Weinberg. Sept. 15, 1951, 105p. incl. illus. refs. (Technical rept. no. 201) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 2227 Unclassified

Also published in part in Jour. Appl. Phys., v. 24: 776-779, June 1953.

Synthesis procedures that realize practical RLC and RC networks are presented. The RLC networks are practical in that they contain no mutual inductance and no perfect coils (every inductance has an associated series resistance). New techniques employed in the procedures are discussed in detail and applied to various synthesis problems. Included among the procedures for synthesizing RLC networks are those for realizing unbalanced structures and lattices whose arms possess identical poles. Reduction of the lattices to unbalanced forms is considered; if real transformers are allowed (transformers with winding resistance, magnetizing inductance, and a coupling coefficient smaller than one), then the lattice realization for a transfer admittance is always reducible. Unbalanced networks are realized by the RC synthesis procedure. The number of elements required is smaller than that required by the Guillemin method (A Summary of

MIT. 10:067 - MIT. 10:070

Modern Methods of Network Synthesis; Advances in Electronics, vol. III, Academic Press, New York, 1951) of RC synthesis. Two new synthesis procedures ars presented for realizing a Darlington network (Jour. Math. Phys., v. 18: 257-353, 1939) without any ideal or unity-coupled transformers, whsre a Darlington network is considered to be composed of lossless elements plus only one resistanc. In one of the procedures, the single resistance appears not as a termination but within ths network.

MIT. 10:067

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE HYPERFINE STRUCTURE OF $^2P_{1/2}$ STATE OF THE STABLE CHLORINE ISOTOPES, by J. G. King and V. Jaccarino. Sept. 27, 1951, 2p. incl. diagrs. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100 and W36-039-sc-32037]) U24532; ATI 149238 Unclassified

Also published in Phys. Rev., v. 84: 852-854, Nov. 15, 1951.

From observations of the hyperfine structure (hfs) interaction in an external magnetic field, the nuclear magnetic dipole coupling constants ($a_{1/2}$) for $^2p_{1/2}$ metastable state of the stable chlorine isotopes have been obtained. The results of these measurements are in excellent agreemsnt with recent work on the ratio of the nuclear moments of the two isotopes. Use has been made here of the atomic beam magnetic resonance method.

MIT. 10:068

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN FM-AM MULTIPLIER OF HIGH ACCURACY AND WIDE RANGE, by R. Price. Oct. 4, 1951, 15p. incl. diagrs. refs. (Technical rept. no. 213) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U20226; ATI-123921 Unclassified

This multiplier employs combined frequency and amplitude modulation to obtain nearly faithful multiplication with minimum space requirements. With a fixed dc signal on either input, linearity of the output with the other input is within 1 or 2%. The range in output product is 2500:1, the output for maximum input signals of 1.4 v in the FM channel and 3.6 v in the AM channel being 0.07 v. Frequency response is excellent from dc up to 5 kc in either channel. At 10 kc there is about 7° phase shift in the AM channel, with the same performance in the FM channel if the AFC phase-correcting unit is used. Total chassis space is about 1.5 sq ft.

MIT. 10:069

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RESPONSE OF NONLINEAR DEVICES TO A PULSED SIGNAL AND GATED NOISE, by D. B. Armstrong. Oct. 5, 1951, 15p. incl. diagrs. (Tschnical rept. no. 214) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U20879; ATI-13087 Unclassified

The analysis of the performance of nonlinear devices in the presence of signals and noise is extended to the case in which the excitation consists of a pulsed signal and gated noise. The idealized assumption is made that the pulses are rectangular. The general method of analysis (Quart. Appl. Math., v. 5: 445, 1947) involved determining the autocorrelation function of the response of the nonlinear device in terms of the parameters specifying the applied excitation voltage. The magnitude of each line component of the output signal spectrum and the mean power spectrum of the output noise are derived from the output autocorrelation obtained. The general results are applied to a balanced diode phase-detector circuit.

MIT. 10:070

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LINE BREADTHS IN THE 5-MM MICROWAVE ABSORPTION OF OXYGEN, by B. V. Gokhale and M. W. P. Strandberg. [1951] [1]p. incl. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100] and W36-039-sc-32037) U24533 Unclassified

Published in Phys. Rev., v. 84: 844, Nov. 15, 1951.

Measurements of line breadths in the 5-mm microwave absorption of oxygen were made by means of a Zeeman modulation spectrograph using a modulation frequency of 26.5 cps. Half breadths at half intensity of 0.021-0.48 cm^{-1}/atm are reported for 8 lines.

Transition	Frequency, in mc/sec	Half-breadth at half-intensity, in cm^{-1}/atm
K+ = 1	56,265.2 ± 0.5	0.035 ± 0.007
K+ = 3	58,446.3 ± 0.4	0.028 ± 0.003
K+ = 13	62,412.9 ± 0.8	0.025 ± 0.003
K- = 3	62,486.2 ± 0.4	0.037 ± 0.003
K- = 7	59,164.2 ± 0.2	0.028 ± 0.005
K- = 9	58,324.9 ± 0.3	0.021 ± 0.003
K- = 11	57,612.3 ± 0.4	0.034 ± 0.006
K- = 15	56,364.2 ± 0.5	0.048 ± 0.003

MIT. 10:071

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PARAMAGNETIC RESONANCE IN LIQUIDS, by M. Tinkham, R. Weinstein, and A. F. Kip. [1951] [2]p. incl. illus. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100] and W36-039-sc-32037) U24534 Unclassified

Published in Phys. Rev., v. 84: 848-849, Nov. 15, 1951.

Formulas that explain all observable hyperfine structure are given. The absorption spectrum of 0.15 mole $MnCl_2$ at 80° is shown. The line width W is plotted as a function of η/T for solutions 0.2 - 0.6 mole in $MnCl_2$ and 0 - 0.8 mole in $CaCl_2$. When total ionic strength is constant, W is a nearly linear function of Mn^{++} concentration. When Mn^{++} concentration is constant, W is a nearly linear function of total ion concentration.

MIT. 10:072

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PROPERTIES AND TABLES OF THE EXTENDED AIRY-HARDY INTEGRALS, by M. V. Cerrillo and W. H. Kautz. Nov. 15, 1951, 61p. incl. diagrs. tables. (Technical rept. no. 144) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-[100]) AD 126183 Unclassified

There are three basic Airy-Hardy functions. They are denoted by: $Ah_{1,3}$, $Ah_{2,3}$, $Ah_{3,3}$. The first index refers to the particular function; the second index expresses the order of the saddlepoint associated with the function. Definitions, series representations, and properties are given in this report. The connections of these functions with the methods of integration are supplied in Appendices I and II. The functions $Ah_{\nu,3}$, $\nu = 1, 2, 3$, correspond to the so-called pure transitions. The function $Ah_{1,3}(s)$ has been tabulated for complex values of the argument **s**. This function represents a surface over the s-plane. Radial cross sections have been computed for angular arguments in steps from 0° to 180° and for $|s|$ in the range from zero to 4. Twenty-seven tables give $|Ah_{1,3}(s)|$, $\arg\{Ah_{1,3}(s)\}$, $\mathrm{Re}\{Ah_{1,3}(s)\}$, and $\mathrm{Im}\{Ah_{1,3}(s)\}$. Plots of this function are provided in the graph of the cross sections of each of the functions above. Several isometric plots of the corresponding surface are also given. The aim of the computations given in this report is to show an over-all behavior of the functions indicated above, rather than to produce a detailed evaluation of those functions. Only the function $Ah_{1,3}$ was tabulated. There are simple connecting relations between this function and $Ah_{2,3}$ and $Ah_{3,3}$ that permit a rapid computation for $Ah_{2,3}$ and $Ah_{3,3}$ from the tables of $Ah_{1,3}$. Mixed transitions of third order require some other functions, $\Phi_{\nu,p}(B)$ and $\Phi_{\nu,o}(B)$, which appear when the saddle-point of third order runs over or in the vicinity of a pole or a zero of the integrand. These functions can be expressed as the integrals or derivatives, respectively, of the $Ah_{1,3}$ functions. A simple numerical integration of differentiation can be performed from $Ah_{1,3}$, and the evaluation of $\Phi_{1,p}(B)$ and $\Phi_{1,o}(B)$ obtained without much effort. (Contractor's abstract, modified)

MIT. 10:073

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SYNTHESIS OF RC TRANSFER FUNCTIONS AS UNBALANCED TWO TERMINAL-PAIR NETWORKS, by B. J. Dasher. Nov. 20, 1951, 48p. incl. diagrs. refs. (Technical rept. no. 215) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U20880; ATI-130386 Unclassified

A new general method for synthesizing RC transfer functions is based on an extension of Brune's procedure (Jour. Math. Phys., v. 10: 191-236, 1930-31) for the synthesis of driving-point impedances. Canonical sections are used for controlling transmission zeros in much the same way as they are used by Darlington (Jour. Math. Phys., v. 18: 257-353, 1939) in synthesizing lossless 2 terminal-pair networks. The following theorem is proved: given a function $F_1(\lambda)$ of suitable degree, realizable as an RC function or admittance, it is always possible to design an unbalanced 2 terminal-pair network that (a) produces a transmission zero or single pair of conjugate zeros at any given point or points, respectively, not in the right half-plane; and (b) produces the prescribed function $F_1(\lambda)$ when terminated in a second function $F_2(\lambda)$, also RC, the degree of which is less than the degree of $F_1(\lambda)$. The networks obtained take the form of ladder networks cascaded with bridge sections similar to the twin-T null network. The zero sections are obtained one at a time, each by a single application of the theorem, and this process is repeated until the original function is completely developed. When used in combination with existing synthesis techniques, the method provides a highly flexible procedure which allows limited control over impedance levels and insertion loss.

MIT. 10:074

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE MAGNETIC MOMENT OF K^{40} AND THE HYPERFINE STRUCTURE ANOMALY OF THE POTASSIUM ISOTOPES, by J. T. Eisinger, B. Bederson, and B. T. Feld. Dec. 6, 1951. 9 p. incl. diagrs. tables.

MIT. 10:075 - MIT. 10:077

refs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U23053; ATI-158905 Unclassified

Published in Phys. Rev., v. 86: 73-81, Apr. 1, 1952.

The nuclear magnetic moment and atomic hyperfine splitting of the rare K^{40} isotope have been measured by the atomic beam magnetic resonance technique. Detection of K^{40} atoms, from a source of normal potassium, was achieved by employing a conventional surface ionization detector as the ion source for a mass spectrometer, and by utilizing an electron multiplier to count the K^{40} ions. By measuring the frequencies of appropriate lines in the Zeeman pattern, the nuclear moment was redetermined with higher precision than that of previous measurements, to be $\Delta\nu$ = 1285.790 ± 0.007 mc/sec. The ratio of the nuclear g factors of K^{39} and K^{40} was measured directly by observing, in the same homogeneous magnetic field, H, the frequencies of two lines (a doublet) in the Zeeman spectrum of each isotope. The doublet separation of these lines is, in each case, proportional to $2\ g I\mu_0 H$, so that the ratio of the doublet splittings yielded directly $|g(K^{40})/g(K^{39})|$ = 1.24346 ± 0.00024. From these results and from the previously measured $\Delta\nu(K^{39})$, the hyperfine structure anomaly of these K isotopes is $\{[2I(K^{40})+1]g(K^{40})\Delta\nu(K^{39})/[2I(K^{39})+1]g(K^{39})\Delta\nu(K^{40})\}-1$ = (0.466 ± 0.019) percent. The theory of the hyperfine structure anomaly, as developed by A. Bohr and V. F. Weisskopf, has been applied to the interpretation of this result. The predictions of a number of specific models, previously suggested to account for the observed nuclear g factors, have been compared with this experiment and with previous results on the anomalies for the Rb and the abundant K isotopes. The "asymmetric core" model of A. Bohr gives the best over-all agreement, mainly on the basis of the K^{41}-K^{39} anomaly. In general, all models which are, in their essential features, based on the independent-particle model with spin-orbit coupling, give predictions in fair qualitative agreement with the experiments. The contribution of K^{40} to the hfs anomaly seems, however, to be (fortuitously) insensitive to the differences between the models investigated. (Contractor's abstract)

MIT. 10:075

Massachusetts Inst. of Tech. Research Lab. of Electronics. Cambridge.

THERMIONIC EMISSION FROM OXIDE-COATED TUNGSTEN FILAMENTS, by C. P. Hadley. Dec. 11, 1951, 25p. incl. diagrs. refs. (Technical rept. no. 218) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 6945; ATI-158301 Unclassified

Also published in Jour. Appl. Phys., v. 24: 49-52, Jan. 1953.

A study of the filaments cataphoretically coated with alkaline earth oxides revealed that emission from the oxide-coated filament was not influenced by the variation of work function with crystallographic direction of the base metal. The apparent deviation of thermionic electrons from Maxwell-Boltzmann statistics was interpreted as due to a potential drop through the coating. This interpretation led to a method for studying the resistive properties of the coating.

MIT. 10:076

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW "DOUBLE RESONANCE" METHOD FOR INVESTIGATING ATOMIC ENERGY LEVELS. APPLICATIONS TO Hg^3P_1, by J. Brossel and F. Bitter. Dec. 17, 1951 [9]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA-36-039-sc-100 and W36-039-sc-32037]) U23088; ATI-160286 Unclassified

Also published in Phys. Rev., v. 86: 308-316, May 1, 1952.

Excitations of atoms in a vapor by polarized light produces unequal population of the magnetic sublevels of the excited state. The emitted optical resonance radiation is therefore partly polarized. The application of radiofrequency or microwave fields at a magnetic resonance frequency will induce transitions between sublevels of the excited state. The degree of polarization of the emitted optical resonance radiation is altered when the magnetic resonance condition is fulfilled. As suggested by Brossel and Kastler, this effect may be used to reveal the structure of the energy level. A detailed theory applicable to, and experiments on the $^3P_1$ state of all the isotopes of mercury are reported. The results obtained indicate that double resonance phenomena constitute a valuable new tool for investigating the structure of atomic energy levels. The mean life of the $^3P_1$ state is shown by observations on the resonance line widths to be 1.55×10^{-7} sec for all the isotopes. The g factor of the $^3P_1$ state for isotopes with zero spin, measured in terms of the proton g factor, is 1.4838 ± 0.0004. (Contractor's abstract)

MIT. 10:077

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE NUCLEAR MAGNETIC MOMENT OF S^{33} FROM MICROWAVE SPECTROSCOPY, by J. R. Eshbach, R. E. Hilliger, and M. W. P. Strandberg. Dec. 20, 1951, 18p. incl. diagrs. tables, refs. (Technical rept. no. 224) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U23505; U24932 Unclassified

Also published in Phys. Rev., v. 85: 532-539, Feb. 15, 1952.

The magnetic dipole moment of the S^{33} nucleus was determined by means of the Zeeman effect on the hyperfine pattern of the $J = 1 \rightarrow 2$ rotational absorption of the molecule $O^{16}C^{12}S^{33}$ at about 24,020 mc/sec. The result is $\mu(S^{33}) = +0.633 \pm 0.010$ nuclear magnetons. The sign of this moment was determined by means of circularly polarized microwave radiation with σ-type Zeeman observations. The frequencies of all of the componenis of the hyperfine pattern were measured. All fit the nuclear electric quadrupole coupling theory to within $\pm$ 0.01 mc/sec. The measured value for eqQ of the S^{33} nucleus in $O^{16}C^{12}S^{33}$ is $eqQ(O^{16}C^{12}S^{33}) = -29.07 \pm 0.01$ mc/sec. (Contractor's absiract)

MIT. 10:078

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TABLE OF $LOG_2 \frac{1}{p}$, p. $LOG_2 \frac{1}{p}$ AND p. $LOG_2 \frac{1}{p} + (1-p)$. $LOG_2 \frac{1}{1-p}$ by L. Dolanský and M. P. Dolanský. Jan. 2, 1952 [24], incl. diagr. tables. (Technical rept. no. 227) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U21833; ATI-149630
Unclassified

Expressions of the form

$$\sum_{i=1}^{n} p_i \cdot \log_2 \frac{1}{p_i}$$ are frequently encountered in information theory, thermodynamics and elsewhere. This table conlains (a) various components of this expression, and (b)

$$\sum_{i=1}^{n} p_i \cdot \log_2 \frac{1}{p_i}$$ for n = 2. (Contractor's abstract)

MIT. 10:079

Massachuselis Insi. of Tech. Research Lab. of Electronics, Cambridge.

POSITIVE IONS IN THE AFTERGLOW OF A LOW-PRESSURE HELIUM DISCHARGE, by A. V. Phelps and S. C. Brown. Jan. 3, 1952, 8p. incl. diagr. refs. (Technical rept. no. 220) (Sponsored joinily by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U22086; U23523; ATI-149713 Unclassified

Also published in Phys. Rev., v. 86: 102-105, Apr. 1, 1952.

The production and loss of He^+ and He_2^+ ions in the afterglow of a low-pressure He discharge were studied by using a mass spectrometer to analyze the positive ions and resonant-frequency shifts in the microwave cavity containing the discharge to determine the electron density. The change of positive-ion and electron densities with time is explained by considering 3 dominant processes in the afterglow: production of He^+ ions and electrons by collisions between metastable-atom pairs, ambipolar diffusion of the ions and electrons, and He^+ to He_2^+ ion conversion by 3-body collisions with neutral atoms. The time constants for the electron-density decay at low pressures yielded 560 sq cm/sec for the ambipolar diffusion coefficient for He^+ ions and a frequency of 65/sec for He^+ to He_2^+ conversion; both were calculated at 1-mm pressure and 300°K. The He^+ mobility coefficient of 14 sq cm/v-sec at 300°K and 760-mm pressure obtained from the measured ambipolar diffusion coefficent agreed satisfactorily with the value of 12 sq cm/v-sec calculated using the quantum mechanical interaction of the He^+ ion and the neutral He atom.

MIT. 10:080

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PROBE STUDIES OF ENERGY DISTRIBUTIONS AND RADIAL POTENTIAL VARIATIONS IN A LOW PRESSURE MERCURY ARC, by R. M. Howe. Jan. 18, 1952, 27p. incl. diagrs. tables. (Technical repi. no. 221) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U22883; ATI-158168
Unclassified

Probe studies were made of the electron-energy distributions in the plasma of the low pressure Hg arc in order to obtain improvemenis over Killian's (Phys. Rev., v. 35: 1238, 1930) original determinations of radial variations of plasma potential and density in a cyclindrical discharge. The electron-energy measuremenis showed depletions from a Maxwellian distribution in the high-energy range. Coupling effects beiween adjaceni probes were investigaied and found to be small but in the proper direction for agreemeni with the Langmuir-Tonks theory. Drift-curreni distortion of the random electron-energy disiributions was measured with a bidirectional probe and compared with theory. A multisection probe exiending from iube axis to iube wall allowed a determination of radial poiential and densiiy variations. Resulis over a pressure range from 3.4 to 3.5 μ showed good agreemeni with the ambipolar diffusion theory based on cumulative ionization. A direci calculation of ionization raie in the plasma was made from the ionizaiion probabiliiy for a 1-step ionizing process: comparison of this calculation with the observed ionizaiion raie ai 1.7 μ indicaied that the ionization is half direci, half cumulative. For higher arc pressures cumulative ionization evidently predominates.

MIT. 10:081

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ATTEMPT TO PRODUCE NUCLEAR ORIENTATION IN MERCURY VAPOR, by F. Bitter and J. Brossel. Jan. 21, 1952 [1] p. incl. diagr. [Sponsored

MIT. 10:082 - MIT. 10:084

jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U23076; ATI-158904 Unclassified

Also published in Phys. Rev., v. 85: 1051, Mar. 15, 1952.

The absorption of polarized resonance radiation by a vapor produces unequal populations of the magnetic sublevels of the excited state, and also of the ground state after re-emission. Kestler has suggested that, as a consequence of these facts, polarized light may be used to orient nuclei. An experimental demonstration of this effect was attempted, and yielded a negative result. Further experimentation is under way in an attempt to isolate the reasons for the negative results reported.

MIT. 10:082

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

METHODS OF MEASURING THE PROPERTIES OF IONIZED GASES AT HIGH FREQUENCIES. I. MEASUREMENTS OF Q, by S. C. Brown and D. J. Rose. Jan. 22, 1952, 17p. incl. diagrs. (Technical rept. no. 222) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U22085; ATI-149714 Unclassified

Also published in Jour. Appl. Phys., v. 23: 711-718, July 1952.

Experimental methods for obtaining the Q of both high- and low-Q resonant cavities were investigated in connection with determining the practical measurements necessary in establishing the properties of ionized gases at microwave frequencies. The lumped circuit representation of a cavity was introduced. The system under analysis consisted of a cavity and part of the input line to which the cavity is coupled by loops through vacuum-tight, glass seals. The calculations apply explicitly to the usual case in which the cavity terminates the line. Relationships were derived for determining the impedance, the Q, and the resonant wave length of the cavity system from measurements of the voltage distribution on the line terminated by the cavity. The measurements involve determining the position of the voltage minima and the VSWR in db as functions of λ. Three Q-measuring procedures using the relationships derived are outlined: a resonance-curve method, a phase-curve method, and a technique employing an RF impedance bridge. The effect of introducing a steady-state discharge into the cavity is also considered.

MIT. 10:083

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

METHODS OF MEASURING THE PROPERTIES OF IONIZED GASES AT HIGH FREQUENCIES. II. MEASUREMENT OF ELECTRIC FIELD, by D. J. Rose and S. C. Brown. Jan. 22, 1952, 8p. incl. diagrs. (Technical rept. no. 223) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U22070; ATI-151187 Unclassified

Also published in Jour. Appl. Phys., v. 23: 719-722, July 1952.

Three general procedures are outlined whereby the electric field is determined in terms of the incident power on the cavity and the standing-wave pattern on the input line. The procedures designated for high Q_L cavities are the cavity mode method which is applied when the field configuration can be readily computed and the tuning-rate method which is applicable when the cavity has a complicated shape. For cases where the cavity Q is very low, a 4-terminal network method is proposed which is subject to the restriction that the region of the discharge is small compared to λ. A discussion is given on converting incident-power measurements at frequencies other than the cavity resonant frequency to equivalent ones at resonance. (TIP abstract)

MIT. 10:084

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE MAGNETIC MOMENT AND HYPERFINE STRUCTURE ANOMALY OF K^{40}, by J. T. Eisinger and B. Bederson. Jan. 28, 1952, 32p. incl. illus. diagrs. refs. (Technical rept. no. 212) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U24409; ATI-170042 Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Oct. 24-27, 1951.

Abstract published in Phys. Rev., v. 85: 716, Feb. 15, 1952.

The ratio of the nuclear gyromagnetic ratios of K^{40} and K^{39} was measured by an atomic-beam, magnetic-resonance method using a high-resolution RF spectrometer. The average value for the ratio was -1.24346 ± 0.00024. The nuclear moment of K^{40} was measured independently of this ratio by determining the applied magnetic field and mean frequency of the K^{40} doublet and applying the Breit-Rabi formula. The value obtained was -1.2964 ± 0.0004 mm. The gyromagnetic ratio of K^{40} was then calculated to be 0.32410 ± 0.00010. The hyperfine separation, $\Delta\nu$, of K^{40} was determined from the maximum mean frequency

of the doublet to be 1285.790 ± 0.007 mc. Results are compared with pertinent theoretical formulas and values obtained by other experimenters; they give support to nuclear models based on the independent particle model with spin-orbit coupling.

MIT. 10:085

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ANALOGUE ELECTRONIC CORRELATOR, by J. F. Reintjes. Feb. 1952, 11p. incl. illus. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100] and W36-039-sc-32037) U23054; ATI-149624 Unclassified

Also published in Proc. National Electronics Conferences, v. 7: 390-400, Feb. 1952.

In recent years widespread attention has been given to the application of statistical methods to the solution of electrical-communications problems. Involved in the statistical approach is a need for a machine capable of evaluating correlation functions of random electrical phenomena. An electronic device for evaluating correlation functions is described. The machine is capable of providing 110 points on the correlation curve of signals having frequency components in the range between 500 c/sec and 100 kc/sec. Operation is based upon the principle of discrete sampling of the input signal, in pairs, at periodic intervals. The delay, multiplication, and integration processes involved in the computation are carried out, for each pair of samples, through use of pulse techniques. The pulses used for multiplication and integration are derived from the signal amplitudes, which are stored as charges on capacitors rather than in binary form. In the design of the machine emphasis has been placed upon simplicity, stability, and portability. Included in the paper is a discussion of principles of operation, details of circuitry, and examples of experimental data taken from the machine.

MIT. 10:086

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

BEAM SYSTEM FOR REDUCTION OF DOPPLER BROADENING OF A MICROWAVE ABSORPTION LINE, by H. R. Johnson and M. W. P. Strandberg. Feb. 1, 1952, 1p. incl. diagrs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037] U23055; ATI-149237 Unclassified

Also published in Phys. Rev., v. 85: 503-504, Feb. 1, 1952.

We have observed the absorption of a plane wave in passing through a beam of $N^{14}H_3$ molecules. The direction of propagation of this plane wave was perpendicular to the beam. Only the J = 3, K = 3 line was investigated. Line half-widths at half-intensity of 20 kc/sec were obtained. The center frequency was measured as 23,870.135 ± 0.007 mc/sec. Ordinarily, the Doppler half-width is 36 kc/sec.

MIT. 10:087

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SEEMAN-EFFECT MEASUREMENTS ON MICROWAVE SPECTRA, by J. R. Eshbach and M. W. P. Strandberg. Feb. 4, 1952, 12p. incl. diagrs. refs. (Technical rept. no. 225) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U23437; ATI-161641 Unclassified

Apparatus and experimental techniques for Zeeman-effect measurements on microwave absorption spectra are described. The method uses a wave-guide-type absorption cell and provides for either π- or σ-type observations. Molecular rotational and nuclear gyromagnetic ratios were measured to about 1% accuracy. A method is also presented for sign determination of these gyromagnetic ratios using circularly polarized microwaves. The microwave components used in setting up the circularly polarized waves are described. (TIP abstract)

MIT. 10:088

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ZEEMAN EFFECT AND HYPERFINE SPLITTING OF POSITRONIUM, by M. Deutsch and S. C. Brown. Feb. 6, 1952 [2]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, Atomic Energy Commission, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100] U23800; ATI-160285 Unclassified

Published in Phys. Rev., v. 85: 1047-1048, Mar. 15, 1952.

The experimental value of the hyperfine splitting $\Delta W/h$ was found to be $2.032 \pm 0.003 \times 10^5$ mc/sec. The theoretical value is 2.044×10^5 mc/sec. Corrections to ΔW are discussed. Other causes of line width are small compared with the annihilation width.

MIT. 10:089

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NETWORK SYNTHESIS BY THE USE OF POTENTIAL ANALOGS, by R. E. Scott. Feb. 7, 1952 [4]p. incl. illus. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of

MIT. 10:090 - MIT. 10:093

Sctentiftc Research under [DA 36-039-sc-100])
ATI-192032 Unclassified

Also published tn Proc. inst. Radio Engineers, v. 40: 970-973, Aug. 1952.

Two analog devices are descrtbed which are useful tn solving the approximation problem of network synthesis. Both devices utilize a sheet of conducting Teledeltos paper to produce a two-dtmenstonal potential field which simulates a required network function. The first device stmulates the gain and phase of a network, and ts prtmarily useful in designing networks for a prescribed steady-state response. The second device simulates the real part of the function, and is useful in designing networks for a prescribed transient response. (Contractor's abstract)

MIT. 10:090

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RESOLUTION AND SENSITIVITY OF MICROWAVE SPECTROGRAPHS (Abstract), by H. R. Johnson. [1952] [1]p. (Sponsored jotntly by Signal Corps, Offtce of Naval Research, and [Air Force Offtce of Scientific Research] under [DA 36-039-sc-100])
Unclassifted

Presented at meeting of the Amer. Phys. Soc., Berkeley, Calif., Dec. 27-29, 1951.

Abstract published in Phys. Rev., v. 85: 764, Feb. 15, 1952.

Obtaining narrow lines tn mtcrowave spectroscopy ts tmportant, since tt determines whether or not fine structure can be resolved and the accuracy with which tt can be measured. Sensitivity determines whether or not weak lines can be observed at all. A Stark modulation spectrograph has been used in the laboratory for over a year; tn K-band it yields line half-widths at half intensity of 50 kc/sec and has a limiting sensitivity of 10^{-8} cm^{-1} with a Stark cell 1-m long and a 5-sec time constant. The factors responsible for this line width will be discussed, and an equation from which the ultimate sensitivity of our Stark spectrographs can be predicted will be presented. This discussion will include the effect of detector crystal noise and Stark modulation frequency. It will be shown that for most purposes a Stark modulation frequency of about 6 kc/sec is optimum, and that the generally accepted expression for optimum cell length is incorrect for our spectrographs. The optimum length is greater by a calculable factor that is typically about 5 or 10. (Contractor's abstract)

MIT. 10:091

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CODING WITH LINEAR SYSTEMS, by J. P. Costas. Feb. 20, 1952, 9p. tncl. refs. (Technical rept. no. 226) (Sponsored jotntly by Signal Corps, Office of Naval Research, and [Air Force] Offtce of Scientific Research under DA 36-039-sc-100) U22444; ATI-152743 Unclassifted

Message transmission over a notsy channel ts considered. Two linear networks were designed: one to treat the message before transmission, and the second to ftlter the treated message plus the channel notse at the recetver. The mean-square error between the actual transmission circuit output and the desired output is minimized for a given allowable average signal power by proper network design. The theory is applied to the case of a long-delay solution with no cross correlation between the message and channel notse.

MIT. 10:092

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambrtdge

APPARATUS FOR ZEEMAN EFFECT MEASUREMENTS ON MICROWAVE SPECTRA, by J. R. Eshbach and M. W. P. Strandberg. Feb. 21, 1952 [6]p. tncl. illus. refs. [Sponsored jointly by Signal Corps, Offtce of Naval Research, and Air Force Offtce of Scientific Research under DA 36-039-sc-100] AD 4050
Unclassifted

Also published in Rev. Scient. Instruments, v. 23: 623-628, Nov. 1952.

Apparatus and experimental techniques for Zeeman-effect measurements on microwave spectra are descrtbed. The method uses a wave-guide type absorption cell and provides for etther π- or σ-type observations. Molecular rotational and nuclear gyromagnetic ratios are found to be measurable to about 1% accuracy. A method is presented for sign determination of these gyromagnetic ratios using circularly polarized mtcrowaves. The mtcrowave components used in setting up circularly polarized waves are described.

MIT. 10:093

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CROSSCORRELATION FUNCTIONS OF AMPLITUDE-DISTORTED GAUSSIAN SIGNALS, by J. J. Bussgang. Mar. 26, 1952, 14p. incl. diagrs. (Technical rept. no. 216) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 585
Unclassified

The technique of correlation analysis of distorted gaussian signals is outlined. The cross-correlation function of two such signals taken after one of them has undergone a nonlinear amplitude distortion is identical except for a factor of proportionality to the

cross-correlation function taken before the distortion. Possible practical applications of this property are indicated. A number of correlation functions associated with some of the most common types of distortion are computed.

MIT. 10:094

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ALL-METAL VACUUM VALVE, by S. C. Brown and J. E. Coyls. Apr. 1, 1952 [1]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 10026 Unclassified

Also published in Rev. Scient. Instruments, v. 23: 570-571, Oct. 1952.

Alpert has reported a successful all-metal valve for vacuum systems. We have simplified his design and constructed a successful model which has been used on vacuum systems pumping to 10^{-9} mm of Hg. The main features of the valve are shown.

MIT. 10:095

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LECTURES ON COMMUNICATION THEORY, by D. Gabor. Apr. 3, 1952, 48p. incl. illus. (Technical rept. no. 238) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 17982 Unclassified

Lectures are presented on communication theory complementary to the statistical theory of communication. About one-third of the lectures are devoted to the theory of signal analysis or representation which precedes the statistical theory. The mathematical theory is followed by a physical theory of signals in which the fundamental limitations of signal transmission and recognition are discussed in the light of classical and of quantum physics. The viewpoints of communication theory are shown to represent a useful approach to modern physics. A report on the present state of speech analysis and speech compression with suggestions for further research is included.

MIT. 10:096

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN EXPERIMENTAL STUDY OF SPEECH-WAVE PROBABILITY DISTRIBUTIONS, by W. B. Davenport, Jr., Apr. 8, 1952 [10]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) U23863; ATI-171078 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 24: 390-399, July 1952.

Measurements were made of the first-probability distribution and of various conditional probability distributions of the speech wave instantaneous amplitude. Results obtained for several speakers indicate that the first-probability distribution varies exponentially with large values of amplitude and that increases in the conditional probabilities are noted for delay times of the order of magnitude of the pitch period. Measurements were also made of the first-probability distribution of the duration of the speech-wave zero-crossing periods, and of the auto-correlation function of clipped speech. These measurements were of the stationary, or "long-time," speech-wave probability distributions. Most of the results are for speech waves recorded in an anechoic chamber. Some results are included for voices recorded in a live studio. (Contractor's abstract)

MIT. 10:097

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NETWORK SYNTHESIS FOR SPECIFIED TRANSIENT RESPONSE, by W. H. Kautz. Apr. 23, 1952, 177p. incl. illus. tables, refs. (Technical rept. no. 209) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 13984 Unclassified

Three methods of solution are presented for the synthesis of finite, lumped-parameter networks for the case in which the desired behavior is prescribed in terms of transients. In the time-domain solution, the desired response is approximated by means of a finite sum of damped exponentials or sinusoids. The Laplace transform of this sum yields a ratio of polynomials in the frequency. The method combines flexibility and generality with a minimum of computational work. Certain time-frequency-domain relationships are derived which result in an approximate frequency domain solution. For this solution, continued-fraction expansions are utilized. The third method of solution combines both time- and frequency-domain approximations. The given response is first approximated in terms of intermediary functions, called constituent transients; each constituent transient is then transformed and a second approximation is made by frequency-domain expansions. The flexibility of this solution results from the fact that the approximation is carried out in two steps and that the intermediary functions are chosen to be the most convenient type for a given problem. Examples are presented which illustrate the extent of applicability of each method. (ASTIA abstract)

MIT. 10:098

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HIGH-FREQUENCY ELECTRICAL BREAKDOWN OF GASES, by W. P. Allis and S. C. Brown. Apr. 23, 1952, 13p. incl. diagrs. (Technical rept. no. 229) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U25001 Unclassified

Also published in Phys. Rev., v. 87: 419-424, Aug. 1, 1952.

Previous theoretical treatments of high-frequency electrical breakdown in gases, based on the Boltzman transport equation, were applied to specific gases and met with mathematical difficulties when applied to higher pressures. Agreement between theory and experiment with hydrogen gives confidence that the energy distribution function is correct, and the distribution function is therefore used to compute other quantities of physical interest. (Contractor's abstract)

MIT. 10:099

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

METHODS OF MEASURING THE PROPERTIES OF IONIZED GASES AT HIGH FREQUENCIES, III. MEASUREMENT OF DISCHARGE ADMITTANCE AND ELECTRON DENSITY, by S. C. Brown and D. J. Rose. May 6, 1952, 9p. incl. diagrs. table. (Technical rept. no. 230) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 3316 Unclassified

Also puhlished in Jour. Appl. Phys., v. 23: 1028-1032, Sept. 1952.

Theoretical bases are presented for the experimental determination of the complex admittance and electron density of gas discharges by microwave techniques. Application in which the discharge is contained in either high- or low-Q resonant cavities are discussed.

MIT. 10:100

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CRYSTALLOGRAPHIC VARIATIONS OF FIELD EMISSION FROM SINGLE TUNGSTEN CRYSTALS, by M. K. Wilkinson. May 7, 1952, 18p. incl. illus. diagrs. tables, refs. (Technical rept. no. 228) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 3315 Unclassified

A photometric method is described for measuring field-emission electron currents quantitatively as a function of the crystal crystallographic directions found in a single crystal emission point. A projection tube was used so that the state of contamination of the cathode would always be known from the pattern which was obtained on the phosphor. The study was made by photometering the light output along the various crystallographic directions. Slopes of the field-emission characteristics for the different crystallographic directions showed relative magnitudes of the work functions. The photometric data indicated that the dark spots on a field-emission pattern of clean tungsten are caused by the difference in the work functions of the crystallographic directions. Moreover, with a reasonable assumption of the electric field distribution around the surface of the point cathode, the data are in agreement with the theoretical equation. To insure the required constancy of the electron emission for measurement, it was necessary to maintain a supervacuum. The vacuum attained was better than 10^{-12} mm.

MIT. 10:101

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PROPAGATION OF AN ELECTROMAGNETIC WAVE ALONG A HELIX SURROUNDED BY A RESISTANCE SHEATH, by A. Tonning. May 13, 1952, 11p. incl. illus. (Technical rept. no. 232) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 12907 Unclassified

The problem is considered of wave propagation along a helix when losses are present; the problem arises in connection with the design of broadband traveling-wave tubes. Due to imperfect matching; a part of the wave will be reflected at the output end of the tube. To reduce the amplitude of the reflected wave and avoid oscillations, it is convenient to surround the helix by a sheath of glossy material. The effect of this resistance sheath on the phase velocity of the wave and the resulting attenuation is calculated. Only the case when no electron beam is present is treated. The introduction of losses in this way reduces the phase velocity, and the amount of this reduction approaches zero for very high and very low frequencies. (Contractor's abstract)

MIT. 10:102

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SIGNAL-TO-NOISE RATIOS IN BANDPASS LIMITERS, by W. B. Davenport, Jr. May 29, 1952, 18p. incl. diagrs. (Technical rept. no. 234) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U24044; ATI-165501 Unclassified

Also published in Jour. Appl. Phys., v. 24: 720-727, June 1953.

A general analysis is made of the relations between output signal and noise powers and input signal and noise powers for bandpass limiters having odd symmetry to their limiting characteristics. Specific results are given for the case where the limiter has an n-th root characteristic, and they include the ideal symmetrical limiter (or clipper) as a limiting case. This analysis shows that for the output signal-to-noise power ratio is essentially directly proportional to the input signal-to-noise power ratio for all values of the latter. The result is due to the bypass characteristics rather than to the symmetrical limiting action. (Contractor's abstract)

MIT. 10:103

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge

THE M. I. T. LINEAR ELECTRON ACCELERATOR, by P. T. Demos, A. F. Kip, and J. C. Slater. May 31, 1952, 23p. incl. illus. diagrs. refs. (Technical rept. no. 203) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100; W36-039-sc-32037; and N5ori-07806) U20229; ATI-123992 Unclassified

The M.I. T. linear electron accelerator consists of a circular wave guide fitted with uniformly spaced irises, and sustains a standing-wave, transverse magnetic π-mode oscillation at a resonant frequency of 2800 mc/sec. The phase velocity is equal to that of light. Electrons are injected into the accelerating tube at an energy of 2 mev by a Van de Graaff generator. Acceleration up to an energy of at least 18 mev has been obtained by using the 21-ft length of the accelerator. Peak accelerated currents of the order of 10 ma, and average currents of the order of 1 μa, are obtained. The accelerator is fed by 21 tunable magnetrons (Raytheon RK5586), phased in synchronism. The principles of design, constructional features, and operation are discussed. The accelerator is being used for nuclear experimentation. (Contractor's abstract)

MIT. 10:104

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RF PHASE CONTROL IN PULSED MAGNETRONS, by E. E. David, Jr. [1952] 17 p. incl. illus. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100 and W36-039-sc-32137]) U23885 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 40: 669-685, June 1952.

A description is given of the behavior of a magnetron oscillator started in the presence of an externally applied rf exciting signal whose frequency is not greatly different from the unperturbed steady-state frequency of the magnetron. Two points of view are presented: first, quasi-steady-state starting is assumed, and a differential equation representing the system within this limitation is derived. Solutions obtained specify the phase of the oscillator as a function of time subsequent to starting. Second, the inhomogeneous Van der Pol equation is used to describe the system. The oscillator is represented as a parallel RLC circuit shunted by a negative, nonlinear conductance. Approximate analytical and differential analyzer solutions of this equation are used to investigate the frequency and phase transients during starting and distortion of the build-up envelope by the exciting signal. The initial conditions for both equations are established in terms of the exciting signal-to-preoscillation noise ratio. Results of the two analyses are essentially in agreement; details of the solutions are different since reactive beam loading has been neglected in the latter case. The phase transient initiated during starting may have a duration which is long compared to the build-up time of the rf voltage on the magnetron anode. Preoscillation conditions which fix the initial phase play an important part in determining the phase for a considerable time subsequent to starting. Other influencing factors include the oscillator tuning relative to the injected frequency; the value of a coefficient directly related to the injected power and the natural frequency of the oscillator cavity, and inversely to the power output and coupling Q; and design parameters determining the rf rise time. (Contractor's summary)

MIT. 10:105

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

BROADENING OF MICROWAVE ABSORPTION LINES IN COLLISIONS WITH THE CELL WALLS, by H. R. Johnson and M. W. P. Strandberg. June 1, 1952, 2p. incl. diagr. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100 and W36-039-sc-32037) U24566; ATI-171079 Unclassified

Published in Phys. Rev., v. 86: 811-812, June 1, 1952.

In Gordy's formulas, A (a numerical factor) is given to equal $\frac{1}{2}\pi\sqrt{6}$. Experimental and theoretical reasoning is revealed which indicate that this value for A is too small. Revised values are obtained which are in satisfactory agreement with the half-widths at half intensity of the X- and K-bands determined for OCS.

MIT. 10:106

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON BASIC EXISTENCE THEOREMS. III. THEORETICAL CONSIDERATIONS ON RATIONAL FRACTION EXPANSIONS FOR NETWORK FUNCTIONS, by M. V. Cerrillo and E. A. Guillemin. June 4, 1952, 46p. incl. diagrs. (Technical rept. no. 233) (Sponsored jointly by Signal Corps, Office of Naval Research, and

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[Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 3816 Unclassified

Certain aspects concerning the rational expansion of transfer and positive-real functions are discussed. The results are a partial conclusion extracted from a study of the foundation of network theory, particularly in connection with the problem of network synthesis. A set of integral representations for Laplace transforms is established. These integrals express the necessary and sufficient condition for the existence of transfer functions. Fundamental aspects of the rational expansion of transfer functions are discussed, and 2 methods of construction are presented. The integral representations serve as the mathematical tools for the construction of such rational expansions. The general discussion is systematically supported by an integral representation along a particular contour.

MIT. 10:107

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE SLOPE OF LOGARITHMIC PLOTS OF THE FOWLER-NORDHEIM EQUATION, by J. M. Houston. June 10, 1952 [1]p. incl table (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) AD 4049 Unclassified

Also published in Phys. Rev., v. 88: 349, Oct. 15, 1952.

The slope of logarithmic plots of the Fowler-Nordheim equation for electron field emission is expressed in terms of the surface work-function and a tabulated function, s(y). This new function, s(y), is derived from Nordheim's v(y) which appears in the exponent of the Fowler-Nordheim equation. Values of v(y) are also tabulated and are believed to be more exact than Nordheim's original values. (Contractor's abstract)

MIT. 10:108

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE NUCLEAR SPIN AND MAGNETIC MOMENT OF $_{55}Cs^{134}$, by V. Jaccarino, B. Bederson, and H. H. Stroke. June 16, 1952 [2]p. incl. diagr. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) U24517; ATI-171080 Unclassified

Also published in Phys. Rev., v. 87: 676-677, Aug. 15, 1952.

The atomic beam magnetic resonance method has been applied to the measurement of the hfs interaction in the ground state of the radioactive nuclide Cs^{134}. A 200-millicurie sample of $(Cs^{134})_2 CO_3$ was prepared by neutron irradiation in the Brookhaven pile, yielding a ratio of Cs^{134} to Cs^{133} of 1 to 6000 in the sample. A directional oven of special design was used to produce the atomic beam of cesium, which after being ionized at the hot wire detector was analyzed with a mass spectrometer having an enrichment factor of 2000 per mass number at the mass 134 position.

MIT. 10:109

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

ON THE ANOMALOUS SPIN GYROMAGNETIC RATIO OF THE ELECTRON (Abstract), by J. G. King and V. Jaccarino. [1952] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Published in Phys Rev., v. 87: 228, July 1, 1952.

The anomalous spin gyromagnetic ratio of the electron has been obtained from observations of the Zeeman effect of the hyperfine structure interaction in the $P_{3/2}$ and $P_{1/2}$ states of atomic Cl^{35}, using the interaction constants previously determined by the authors. From 8 independent measurements of the atomic g_j values in fields up to 500 gauss a mean value of $g_s = 2$ (1.00121 ± 0.00010) was computed. This value of g_s for a closed shell minus an electron agrees with both theoretical and experimental values obtained for a closed shell plus an electron. (Contractor's abstract)

MIT. 10:110

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

PRECISION MEASUREMENTS OF THE hfs OF Rb^{85} AND Rb^{87} (Abstract), by B. Bederson and V. Jaccarino. [1952] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Published in Phys. Rev., v. 87: 228-229, July 1, 1952.

Using an atomic beam method we have obtained high precision measurements of the Rb^{85} and Rb^{87} hfs interaction energies ($h\Delta\nu$). The first-order field independent transitions ($F = 3$, $m_F = 0 \leftrightarrow F = 2$, $m_F = 0$) and ($F = 2$, $m_F = 0 \leftrightarrow F = 1$, $m_F = 0$) for Rb^{85} and Rb^{87}, respectively, were observed in a magnetic field of approximately 0.4 gauss and when corrected to zero field yield the following values: $\Delta\nu$ (Rb^{85}) = 3035.735 ±

0.002 mc/sec and $\Delta\nu(Rb^{87}$ = 6834.7005 ± 0.0011 mc/sec. The above transitions were positively identified by observing the frequencies and widths of all allowed $|\Delta F = \pm 1$ transitions. Factors influencing the ultimate accuracy of $\Delta\nu$ determinations (Doppler broadening, resonance widths, stability of rf sources, frequency measurement techniques, etc.) will be discussed and a comparison made of the above data with recent high field measurements. The results of more accurate measurements will be given at this time. (Contractor's abstract)

MIT. 10:111

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE RESISTANCE MINIMUM IN MAGNESIUM AT LOW TEMPERATURES (Abstract), by H. E. Rorschach, Jr. and M. A. Herlin. [1952] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Published in Phys. Rev., v. 87: 193, July 1, 1952.

The electrical resistivities of three very pure magnesium samples from different sources have been measured from 1 to 40°K by an improved mutual inductance method. All samples exhibit a minimum, although the effect is much more pronounced in one which is believed to contain more impurity than the others. Above 20°K, all of the resistivity curves can be well represented by a power law $\rho = \rho_r + aT^b$ with b equal to approximately 3.5. However, Matthiesen's rule does not hold, since at least two of the curves intersect. (Contractor's abstract)

MIT. 10:112

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A PHASE PRINCIPLE FOR COMPLEX-FREQUENCY ANALYSIS AND ITS IMPLICATIONS IN AUDITORY THEORY, by W. H. Huggins. Aug. 12, 1952 [8]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) AD 12368 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 24: 582-589, Nov. 1952.

A filtering scheme that utilizes the phase-frequency characteristic of a filter is shown to have certain advantages for analyzing signals, such as speech, which are produced by shock or noise excitation of a physical system having one or more resonances. The phase principle is shown to be particularly well suited to neural mechanisms of inhibition and facilitation, and evidence is presented that such a principle may be used by the ear to achieve its analysis of the sound that it receives. (Contractor's abstract)

MIT. 10:113

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON BASIC EXISTENCE THEOREMS IN NETWORK SYNTHESIS. IV. TRANSMISSION OF PULSES, by M. V. Cerrillo and E. F. Bolinder. Aug. 15, 1952, 168p. incl. diagrs. tables, refs. (Technical rept. no. 246) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 45533 Unclassified

This report is the fourth in a series of reports on basic existence theorems in network synthesis. The parameter representation of the time and frequency domain functions derived in earlier reports in the series has been used for an investigation of the delicate problem of transmission of narrow pulses through finite passive networks. The report starts by stating and proving the necessary and sufficient condition for a transfer function to be rational. A simple and computationally appropriate relationship between the parameter function $U(0, \lambda)$ and the time function, which eliminates the integration, is then established by means of the so-called corner theorems. Due to discontinuous time derivatives, the Stieltjes integral representation has to be used. The $U(0, \lambda)$ function is then approximated in such a way that the famous phenomenon of "ringing" is completely controlled. A rational transfer function is obtained from the approximated U function by means of an interpolation procedure. Some illustrative examples are given. The important question of minimum number of elements is treated in connection with the correlation of the number of extremal points of the U function and the number of poles of a rotational transfer function. Finally, rational approximations of transfer functions are obtained by means of a powerful nonlinear process of summability which contains the Padé summability as a special case. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

POWER GAIN IN FEEDBACK AMPLIFIERS, by S. J. Mason. Aug. 25, 1952, 15p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) AD 16449 Unclassified

An analysis is presented of the effect of the terminating impedance upon the power gain and stability of a feedback amplifier. The optimum passive source and load impedances which would give maximum power gain at

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every real frequency were obtained for a 2-terminal pair filter chosen to represent an arbitrary amplifier. However, these values were obtained subject to the specified stability margin $|T/(1-T)| = m \leq M$, where T represents the loop gain of the feed-back diagram and M is the value of the upper bound determined by practical considerations such as design tolerances. The entire analysis is also applicable to the problem in which admittances take the place of impedances. In addition, mechanical, electromechanical, and other classes of linear active systems fall within the scope of the analysis.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE SPECTROSCOPY OF THE SOLID STATE: COPPER AND CHROMIUM, by E. M. Gyorgy and G. G. Harvey [1952] [2]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) U25026 Unclassified

Published in Phys. Rev., v. 87. 861-862, Sept. 1, 1952.

The M_{23} (valence to $3P_{3/2,\ 1/2}$) emission curves of copper and chromium were obtained by using a vacuum recording spectrograph. To summarize the experimental results:

	bandwidth (ev)	M_2 emission edge (ev)
Copper	7.1 ± 0.5	75.9 ± 0.2
Chromium	7.2 ± 1.0	42.1 ± 0.2

	M_{23} separation (ev)	Ratio of M_3 to M_2 intensities
Copper	1.2 ± 0.1	0.5 ± 0.03
Chromium	0.45 ± 0.1	0.52 ± 0.04

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A RECEIVER DESIGN FOR REJECTING INTERFERENCE, by R. A. Paananen. Sept. 22, 1952, 85p. incl. illus. diagrs. tables, refs. (Technical rept. no. 245) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 28467 Unclassified

This report concerns the application of a wideband, interference-reducing theory to FM broadcast receiver design. In the first part, the space link between the transmitter and receiver is examined, with discussions of FM coverage and expected interference in a given area. This material allows the determination of some of the receiver parameters, such as selectivity and spurious responses. The second part of the report pertains to the receiver itself. Various selectivity configurations are compared, with special attention to an approximation method useful in filter amplifier design. General material relevant to crystal limiter performance is presented, and a limiter coefficient is defined. The results of a fairly complete testing of this unit are also included, together with an evaluation of the design and operating differences between this and a typical narrow-band receiver. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN INDUCTION METHOD OF MEASURING ELECTRICAL RESISTIVITY, by H. E. Rorschach, Jr. and M. A. Herlin. Oct. 12, 1952, 23p. incl. illus. table. (Technical rept. no. 125) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under DA 36-039-sc-100) AD 20074 Unclassified

A method is described for measuring the electrical resistivity of a cylindrical specimen of metal. The specimen is mounted at the center of a pair of concentric coils whose complex mutual inductance is measured. The field equations for this geometry are solved so that mutual inductance values may be used to yield resistivity values. Calculations are made for the mutual inductance of (1) a finite core in a finite cylinder and (2) an infinite core in an infinite cylinder. The sensitivity of the resistivity-measuring system is also calculated. The method is considered useful for low-temperature measurements because (1) the specimen requires no electrical or other connections, and (2) the sample size and shape are convenient for preparation and for other measurements.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOISE FIGURE OF TRAVELING-WAVE TUBES, by C. F. Muehe, Jr. Oct. 16, 1952, 38p. incl. illus. diagrs. tables, refs. (Technical rept. no. 240) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 28574 Unclassified

This report describes experiments primarily designed to measure the noise in electron beams and traveling-wave tubes at 3000 mc/sec. Since it was desirable to know the dc conditions in the electron beam, the radial positive ion flow and the beam diameter were measured along the beam. Measurement of the radial positive ion flow shows that the beam was fully neutralized by positive ions over all but a few centimeters of length near

the anode. An analysis was made of the electron trajectories, and from measurements of beam shape the fact of full ion neutralization was confirmed. With full ion neutralization there is considerable spiraling of the electrons and hence a dc velocity spread in a beam from a converging beam gun. For large magnetic fields this velocity spread causes an increase in the minima of the noise-current curve which is confirmed by experiment. Next a double velocity jump was tried, since this is supposed to reduce the noise in the beam. It was found that the maxima of the noise-current curve could be reduced, but the minima were increased, and no success was achieved in reducing the noise figure of a traveling-wave tube with this device. Finally, the noise current in an electron beam and the noise figure of a traveling-wave tube were measured under the same conditions; first with a converging beam electron gun, then with a parallel beam gun. The noise figures predicted from the noise-current curves agreed quite well when a correction was made for the nonzero minima of the noise-currect curves. Finally, it was shown experimentally that a beam from a parallel beam gun is quieter than the same beam from a converging beam gun. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOISE ANALYSIS OF A FINITE ELECTRON GUN IN AN INFINITE MAGNETIC FIELD, by H. E. Rowe. Oct. 24, 1952, 45p. incl. diagrs. tables, refs. (Technical rept. no. 239) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) AD 221425 Unclassified

A theoretical study of the noise behavior of a finite electron beam in an infinite magnetic field was made to determine the effects of the finite diameter of the beam and the transverse vartations in the velocity and current density modulation on the noise behavior of an electron beam, using the method presented by Parzen for the analysis of the gun region. The presence of the higher axially-symmetric modes results in a finite standing-wave ratio of noise current in the drift space as measured by a cavity moving along the beam, as low as 10 db in some cases, as well as a behavior of partition noise which is, at least qualitatively, in agreement with that observed experimentally. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN OUTLINE OF A THEORY OF SEMANTIC INFORMATION, by R. Carnap and Y. Bar-Hillel. Oct. 27, 1952, 48p. incl. diagrs. table. (Technical rept. no. 247) (In cooperation with Chicago U., Ill.) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100) AD 10117 Unclassified

The theory of information emphasizes semantic aspects which are deliberately neglected in prevailing communication theory. This theoretical restraint results in misapplications. The information carried by a sentence within a given language system is treated as being synonymous with the sentence content, normalized in a certain way. The amount of semantic information is explicated by various measures of this content, all based on logical probability functions ranging over the contents. Two major types of amount of information were investigated; one is additive with respect to sentences whose contents are exclusive, and the other is additive with respect to sentences which are inductively independent. The latter is formally analogous to the customary information measure function. The concepts of information and information measures were believed to be of value in various theories including those for the design of experiments and for testing. An extension of the use of the concepts to take into account the linear arrangements of the individuals is outlined.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ELECTRON-BEAM TUBE FOR ANALOG MULTIPLICATION, by E. J. Angelo, Jr. Oct. 27, 1952, 41p. incl. illus. refs. (Technical rept. no. 249) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 11807 Unclassified

Also published in Rev. Scient. Instruments, v. 25: 280-284, Mar. 1954.

An electron-beam tube developed for providing accurate, high-speed, analog multiplication was subjected to static and dynamic tests. The maximum errors in multiplication under static conditions were approximately 2% of the maximum product; the output voltage corresponding to the maximum product was 3 v. Under the conditions of the dynamic tests, the tube performance was limited by stray capacitance shunting the output circuit; accordingly, with a sinusoidal output voltage the half-power point was at 70 kc. Further measurements showed that flat response up to 100 kc should be obtained by reducing the impedance level of the output circuit. The tube multiplies in the following manner. A circular electron beam of relatively large diameter and with uniform current density is projected through a conventional beam-deflection system upon a metallic target consisting of 4 quadrants that are insulated from one another. From the 4 currents collected by the target an output current is obtained that is proportional to the product of the 2 deflecting voltages. The accuracy of multiplication depends primarily upon the uniformity of the current distribution in the beam when it reaches the target; linearity of deflection and accuracy of target construction are significant but not critical. Consideration is also given to the problem presented by positive ions created from residual gas in the tube.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PHYSICAL LIMITATIONS ON ANTENNAS, by J. Ruze. Oct. 30, 1952, 85p. incl. illus. (Technical rept. no. 248) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 62351 Unclassified

Investigation of the physical realizability of a specified radiation polar diagram from an antenna aperture of a finite size is presented in three related parts: (1) Limitations Imposed by Aperture Distribution Errors. Deviations from the theoretical aperture distribution caused corresponding deviations from the desired polar diagram. Systematic and random errors are involved, the latter forms a statistical problem. A theory is formulated for their treatment for both the discrete and the continuous aperture. For the continuous aperture it is necessary to introduce the concept of a correlation interval. The effect of aperture errors on the antenna gain and on the realizability of low side lobes is examined. Experimental work on a broadside array and on a "randomly" distorted parabolic mirror provides a verification of the theory. (2) Limitations Imposed by the Synthesis Procedure. In the antenna synthesis problem we are required to determine an aperture distribution of a specified finite width whose radiation pattern approximates the desired one. Existing synthesis procedures are examined with particular interest in the nature of the optimization condition. Two procedures are suggested for approximating a function in an approximating a function in an approximate Chebyshev sense. (3) Limitation Imposed by the Aperture "Q". It is shown by direct integration of the aperture Poynting vector that those field components with spatial variation of a period smaller than a wavelength contribute essentially reactive power. They increase the Q of the aperture and impose a limitation on the practically obtainable polar diagrams. (Contractor's abstract)

MIT. 10:123

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CENTRIFUGAL DISTORTION, by M. W. P. Strandberg. [1952] 6 p. incl. illus. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 4047 Unclassified

Also published in Ann. New York Acad. Sciences, v. 55: 808-813, Nov. 1952.

A brief theoretical discussion is presented of centrifugal distortion in molecules. Calculations are outlined which are based on both semiclassical equations and perturbation methods. These calculations are compared with experimental data obtained from the microwave spectra of NH_2D, NHD_2 and H_2CO.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SECOND-SOUND VELOCITY BELOW 1°K AS A FUNCTION OF PRESSURE, by V. Mayper, Jr. and M. A. Herlin. [Nov. 24, 1952] [2]p. incl. diagr. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] AD 12367 Unclassified

Presented at ONR GE Cryogenics Conference, Schenectady, N. Y., Oct. 6, 1952.

Also published in Phys. Rev., v. 89: 523-524, Jan. 15, 1953.

Previous findings on the velocity of second sound in liquid helium II along the vapor pressure line seem to confirm a predicted approach of c_2 to the constant $c_1/\sqrt{3}$ which is based on the proposal that the liquid should approach an ideal phonon gas at low temperatures. Specific heat measurements, showing a T^3 dependence for C_v below ~0.6°K, also indicates that excitations of the liquid are due solely to phonons at low temperatures; some discrepancies are noted between the two sets of measurements with second-sound velocities departing radically from the phonon-gas model above ~0.35°K instead of 0.6°K of the specific heat measurements. Measurements by the pulse method now in progress are reported both at vapor pressure and at higher pressure. Results at vapor pressure are in reasonably good agreement with the previous specific heat data, at least above 0.3°K; the extrapolated value for c_2 is 155 m/sec. No trace of previously-reported rise in velocity at lower temperatures was found at vapor pressure but at higher pressure results tend to indicate the low temperature rise in velocity to be a real phenomenon, becoming more apparent at higher pressure. Values at each pressure for c_2 at a temperature just below that of the sharp drop in c_2 are about 10% higher than $c_1/\sqrt{3}$ for that pressure. Data at 14.2 atmospheres shows the low temperature rise to apparently begin before the sharp rise at intermediate temperature is complete. At the very lowest temperatures, velocities have risen to near c_1. A possible explanation of this behavior is presented.

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTROMAGNETIC WAVES IN PERIODIC STRUCTURES, by L. Stark. Dec. 9, 1952, 41p. incl. diagrs. tables, refs. (Technical rept. no. 208) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 25740 Unclassified

The two problems under study are (1) the propagation

constant in iris-loaded wave guides of standard cross section, and (2) the use of an interleaved-fin structure as a slow-wave circuit for traveling wave amplifiers. In the first case an attempt is made at unification by presenting a result which is common to all standard types of wave-guide cross sections and which is general to the extent that the loading irises can be taken to be infinitely thin. The result is expressed as a quotient of infinite sums whose terms depend upon the field distribution in the aperture. The result can be solved to a quasi-stationary approximation, and in the case of a rectangular guide, the series can be virtually summed so that the result is useful in practice. The second problem is considered for the case of either open or closed lateral boundaries, and the structure is considered as a folded rectangular wave guide with either open-circuited or short-circuited side walls. The discontinuity at each bend of the folded guide is accounted for by an equivalent network. Although most of the theory neglects beam transmission holes, experiments indicate that the propagation constant is negligibly affected by even relatively large holes. The degree to which the circuit couples to a given beam is calculated from the field distribution in a model.

MIT. 10:126

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LOOKING INTO THE NUCLEUS, by F. Bitter. Dec. 22, 1952 [4]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 26-039-sc-100) AD 12919 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 43: 233-236, Apr. 1953.

This paper provides a brief elementary account of the insight into nuclear structure which has been obtained from investigations of the hyperfine structure of atomic energy levels.

MIT. 10:127

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A METHOD OF WIENER IN A NONLINEAR CIRCUIT, by S. Ikehara. Dec. 10, 1952. 22p. incl. illus. refs. (Technical rept. no. 217) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 1800 Unclassified

The Wiener method (M.I.T. Radiation Lab. rept. no. 129) is discussed which is to solve for the voltage across a nonlinear device in terms of the entire random voltage and then to get statistical averages, on the assumption that the current-voltage function of the nonlinear element and the system transfer function are given. A case is treated in which random voltage passes through a filter before entering the circuit. Explicit formulas depending only on the assumptions can be given for the moments of all orders of the voltage across part of the circuit, and similarly, for its frequency spectrum. The method of computation explicitly requires the use of the Wiener theory of Brownian motion (Acta Math., v. 55: 117, 1930 and Amer. Math. Soc., Colloquium Publications XIX, Chap. 9, 1934).

MIT. 10:128

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NUCLEAR MOMENTS, by B. T. Feld. [1953] [22]p. incl. diagrs. tables, refs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] AD 10051 Unclassified

Published in Ann. Rev. Nuclear Science, v. 2: 239-260, 1953.

A brief review is presented of recent developments in the techniques of determining the moments (including the mechanical moment or spin) of nuclear levels and the understanding of the values of observed nuclear moments in terms of possible nuclear models. Intended to cover mainly the highlights of work reported in 1951, it is not an exhaustive literature survey. A total of 178 foreign and domestic references are cited.

MIT. 10:129

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A FIVE-CHANNEL ELECTRONIC ANALOG CORRELATOR, by M. J. Levin and J. F. Reintjes. [1953] [10]p. incl. illus. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) AD 10280 Unclassified

Also published in Proc. National Electronic Conference, v. 8: 647-656, Jan. 1953.

Recent applications of statistical theory to communication problems require the evaluation of the correlation functions of electrical phenomena. Most exciting correlators consume considerable time in computing these functions, since they are capable of obtaining only one point of the curve at a time. More rapid evaluation of correlation functions would extend the usefulness of these techniques. This paper describes an electronic analog correlator which computes five points of a correlation curve simultaneously. The correlator obtains these points from the actual time series under consideration within 2 to 30 sec and displays them in the form of spot displacements on the face of a cathode-ray tube. Input signal frequencies from 200 cps to 500 kcps are handled accurately. Values of delay between adjacent points ranging from 1 to 400 μsec are available.

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The equipment utilizes pulse-circuits techniques for the computing circuits. The correlator is especially useful for the study of time series whose characteristics change with time. Results of brief studies of some of these nonstationary series are presented.

MIT. 10:130

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HEAD-END DESIGN FOR FM TUNERS. A DETAILED ANALYSIS OF THE PROBLEMS ASSOCIATED WITH THE DESIGN OF FM TUNER HEAD-ENDS, WITH PRACTICAL SOLUTIONS, by H. H. Cross. 1952 [7]p. incl. illus. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 52543 Unclassified

Also published in TV and Radio Engineering, v. 23: Feb.-Mar. 1953.

The design of signal-frequency and frequency-changing sections of narrow-band VHF superheterodyne receivers for the FM broadcast band is analyzed. It is shown that since, noise factor varies inversely as the power efficiency of the input network, any finite -Q input network must compromise between noise factor and selectivity. For a given number of tuned circuits, the best arrangement is one which utilizes one tuned circuit for the input network and the rest to obtain interstage selectivity. Mixer operation is considered, and the optimum adjustment is found to be relatively low oscillator injection combined with RF gain sufficient to make the amplifier input noise one to ten times the power of the noise generated in the mixer tube. Tuners built in accordance with these principles are described briefly. Experimental data show that their performances compare favorable with those of medium-frequency receivers.

MIT. 10:131

Massachusetts Inst. of Tech. Research Lab. of Electronics Cambridge.

SYNTHESIS OF TRANSFER FUNCTIONS WITH POLES RESTRICTED TO THE NEGATIVE REAL AXIS, by L. Weinberg. 1953 10 p incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039 sc 100) Unclassified

Published in Jour. Appl. Phys., v. 24: 207 216, Feb. 1953.

A procedure for the synthesis of general RC transfer functions by means of unbalanced networks is described. The transfer function need not be minimum phase but may have zeros anywhere in the complex plane except on the positive real axis. Use is made of the technique of zero shifting as in the Guillemin procedure; but the additional use of a network theorem divides the desired network into 2 parts, with a consequent reduction of the problem to 2 simpler problems. Zero shifting can now be performed in 2 directions from within the total network. The theorem plus a method of using fewer paralleled ladders yield a final network with fewer ladders and fewer elements than that given by the Guillemin procedure. In the illustrative example given, 26 elements are used, whereas the Guillemin procedure would use 66. (Contractor's abstract)

MIT. 10:132

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A BIBLIOGRAPHY OF INFORMATION THEORY – COMMUNICATION THEORY – CYBERNETICS, by F. L. Stumpers. Feb. 2, 1953, 46p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) ATI-193720 Unclassified

This bibliography of approximately 1000 entries on information theory includes works covering the following spheres: (1) general theory; (2) transmission capacity, signal-to-noise ratios, and a comparison of systems; (3) definition; (4) correlation, prediction, filtering, and storage; (5) radar; (6) biophysical applications; (7) technological applications; (8) miscellaneous applications; (9) mathematics; and (10) pulse modulation.

MIT. 10:133

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FEEDBACK THEORY. I. SOME PROPERTIES OF SIGNAL FLOW GRAPHS, by S. J. Mason. Feb. 2, 1953, 25p. incl. illus. (Technical rept. no. 153) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100) AD 11294 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 41: 1144-1156, Sept. 1953.

The fundamentals are presented of flow-graph topology, which exposes the structure (Gestalt) of the functional relationships associated with a signal flow graph. The latter is interpreted as a signal transmission system in which each node is a repeater station. The station receives signals via incoming branches, combines the information, and transmits the result along each out going branch. The manipulative techniques are shown by which flow graphs may be transformed or reduced, thereby solving or programming the solution of the accompanying [illegible]ations. Illustrative examples are given. Spec[illegible]tion to linear flow graphs yields results which are useful for the discussion of the general theory of feedback in linear systems, as well as for

the solution of practical linear analysis problems.

MIT. 10:134

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

SYNTHESIS OF UNBALANCED RLC NETWORKS, by L. Weinberg. [1953] [7]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-100]) Unclassified

Published in Jour. Appl. Phys., v. 24: 300-306, Mar. 1953.

A method is demonstrated for synthesizing an unbalanced RLC network with lossy coils, i.e., each inductance has an associated series resistance. The network realizes a minimum phase transfer function whose numerator and denominator are of degree not higher than the third and fourth, respectively, and whose poles and zeros may lie anywhere in the left half of the complex frequency plane. It is shown that in many cases higher degree functions may be realized as one network. For a transfer function of arbitrary degree, factoring into component transfer functions is carried out, each components having the above characteristics; the components are then realized separately and isolated from each other by vacuum tubes supplying gain. The method makes use of the following new features: (1) A breakdown of a Hurwitz polynomial into two Hurwitz polynomials so that a division by one of them yields a sum of unity plus a positive real RLC function, each of whose partial-fraction terms (complex poles taken in pairs, or course) is positive real. (2) An application of a network theorem which divides the desired network into two networks, thus simplifying the synthesis problem. (3) A method of zero shifting to any point in the left half-plane with at least one pair of complex poles. A further advantage of the procedure is that the network may be designed to possess input and output shunt capacitances so that tube capacitances may be automatically provided for. (Contractor's abstract)

MIT. 10:135

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HYPERFINE STRUCTURE AND NUCLEAR MOMENT RATIOS OF THE STABLE BROMINE ISOTOPES, by J. G. King and V. Jaccarino. Mar. 26, 1953 7 p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100) AD 44506 Unclassified

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Also published in Phys. Rev., v. 94: 1610-1616, June 15, 1953.

The hyperfine structure of the $^2P_{3/2}$ state of atomic Br^{79} and Br^{81} was investigated by the atomic-beam magnetic-resonance method. The ratio of the magnetic dipole interaction constants a^{81}/a^{79} is 1.07794 ± 0.00001, and the ratio of the electric quadrupole interaction constants b^{79}/b^{81} is 1.9707 ± 0.00003. Applying the results of recent theoretical calculations by Sternheimer, Koster, and Feld, the following values of nuclear quadrupole moments were computed: $Q^{79} = 0.335 \times 10^{-24} cm^2$, $Q^{81} = 0.280 \times 10^{-24} cm^2$. (Contractor's abstract)

MIT. 10:136

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

IF AND DETECTOR DESIGN FOR FM. PART I. EXAMINATION OF TYPICAL CONDITIONS UNDER WHICH RECEIVERS MUST OPERATE. VARIOUS EFFECTS OF INTERFERENCE. PART II. PERFORMANCE REQUIREMENTS FOR THE IF SECTION, AND DESIGN PROCEDURE INVOLVED. LIMITER CHARACTERISTICS. PART III. LIMITERS CONCLUDED. THE FREQUENCY DETECTOR. COMPLETE TUNER CIRCUIT DIAGRAM AND CONCLUDING REMARKS, by R. A. Paananen. [1953] [23]p. incl. illus. refs. (Parts 1, 2, and 3 of its Rept. on IF and Detector Design for FM, AD 52544; Pt. 1, AD 52544(a); Pt 2, AD 52544(b); Pt. 3, AD 52544(c)) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 52544 Unclassified

Also published in TV and Radio Engineering, Pt. 1, v. 23, Apr.-May 1953; Pt. 2, v. 23, June-July, 1953; Pt. 3, v. 23, Aug.-Sept. 1953.

This paper concerns the application of a wide-band, interference-reducing theory to FM broadcast receiver design. The first part concerns the space link between the transmitter and receiver, with regard to wave propagation, coverage, and interference. This material facilitates specification of some receiver characteristics, such as selectivity and spurious responses. The second part pertains to receiver design, beginning with a chapter on IF amplifiers. Various selectivity configurations are compared, with special attention given to an approximation method useful in filter design. Overloading, phase-shift distortion, and detailed design are also covered. The section on limiters contains general material relevant to crystal limiter performance, defines a limiter coefficient, and discussed the 6BN6 tube as a limiter. A ratio detector circuit is evolved in the next section, and data are given from experiments on a 100 kc detector. Wiring data for the receiver and the results of tests on the complete unit are then given. The final sections concern possible improvements as well as an evaluation of the design and operating differences between this receiver and a typical narrow band unit.

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MIT. 10:137

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

METHODS OF MEASURING THE PROPERTIES OF IONIZED GASES AT HIGH FREQUENCIES. IV. A NULL METHOD OF MEASURING THE DISCHARGE ADMITTANCE, by L. Gould and S. C. Brown. Apr. 8, 1953 [4]p. incl. diagrs. (Technical rept. no. 256) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 52553 Unclassified

Also published in Jour. Appl. Phys., v. 24: 1053-1056, Aug. 1953.

The admittance of a gas discharge may be obtained from measuring the ratio of the transmitted power through a microwave cavity to the incident power as a function of signal frequency near the cavity resonance. The method involves balancing the transmitted and incident signals to zero at the cavity resonance after they have passed through two separate receiving systems. When the signal frequency is changed, an attenuator is used to rebalance the two signals. The change in frequency from resonance and the corresponding change in attenuation gives the necessary data which will plot as a straight line whose slope yields the desired information. (Contractor's abstract)

MIT. 10:138

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ZEEMAN EFFECT IN ROTATIONAL SPECTRA OF ASYMMETRIC-ROTOR MOLECULES, by B. F. Burke and M. W. P. Strandberg. [1953] [6]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Cambridge, Mass., Jan. 22-24, 1953.

Published in Phys. Rev., v. 90: 303-308, Apr. 15, 1953.

The theory of rotational molecular magnetic moments is applied to the study of the Zeeman effect in microwave rotational spectra of asymmetric-rotor molecules. Measurements on absorption lines of H_2O, D_2O, and HDO are used to verify the theory, and the gyromagnetic tensors associated with these molecules are deduced. A discussion of electronic perturbation of rotational energy levels is appended. (Contractor's abstract)

MIT. 10:139

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SOME EXPERIMENTS ON THE RECOGNITION OF SPEECH, WITH ONE AND TWO EARS, by E. C. Cherry. May 5, 1953 [5]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 26317 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 25: 975-979, Sept. 1953.

This paper describes a number of objective experiments on recognition, concerning particularly the relation between the messages received by the two ears. Rather than use steady tones or clicks (frequency or time-point signals) continuous speech is used, and the results interpreted in the main statistically. Two types of test are reported: (a) the behavior of a listener when presented with two speech signals simultaneously (statistical filtering problem) and (b) behavior when different speech signals are presented to his two ears. (Contractor's abstract)

MIT. 10:140

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE SPECTRUM OF THE WATER MOLECULE, by D. W. Posener. May 14, 1953, 156p. incl. tables, refs. (Technical rept. no. 255) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 14660 Unclassified

The centrifugal distortion theory applicable to the H_2O molecule and its isotopic modifications was rederived. Rotational constants and distortion parameters were calculated for the H_2O, D_2O, and HDO molecules by a utilization of the theory with infrared data; the resulting theoretical transition frequencies were compared with those observed in the microwave region. Theoretically calculated parameters were employed to obtain Q-branch frequencies in HDO; a relationship was established between the theoretical and observed values. The comparison indicated that the theoretical distortion corrections represented true conditions; a simple variation of the effective moments provided reasonable agreement with experiment. The parameters accounted for the known $|\Delta J| = 1$ transitions in HDO. The validity of the Hillger-Strandberg-Kivelson-Wilson approximation for calculating the Q-branch frequencies in HDO is discussed. The effective reciprocal moments of inertia for HDO are: a = 7.0396 ± 0.0005 x 10^5 mc/sec, b = 2.7360 ± 0.0005 x 10^5 mc/sec, and c = 1.9186 ± 0.0005 x 10^5 mc/sec with K = 0.6841 ± 0.0002. The new transitions observed in the microwave spectra of D_2O and HDO are: D_2O $2_{20} \rightarrow 3_{13}$, 10,919.39 ± 0.05 mc/sec; HDO $8_{45} \rightarrow 8_{44}$, 24,844.77 ± 0.05 mc/sec; HDO $10_{56} \rightarrow 10_{55}$, 8836.95 ± 0.1 mc/sec; and HDO $11_{57} \rightarrow 11_{56}$, 22,581.1 ± 0.2 mc/sec. A line at 26,880.38 ± 38 ± 0.05 mc/sec was identified as the $6_{24} \rightarrow 7_{17}$ transition of HDO.

MIT. 10:141

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CORRECTED VALUES OF FOWLER-NORDHEIM FIELD EMISSION FUNCTIONS v(y) AND s(y), by R. E. Burgess, H. Kroemer, and J. M. Houston. [1953] [1]p. incl. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100])
Unclassified

Published in Phys. Rev., v. 90: 515, May 15, 1953.

Corrected values are given for the function v(y) which appears in the exponent of the Fowler-Nordheim equation for field emission from a metal. Values are also given for the function s(y) which relates to the slope of logarithmic plots of the Fowler-Nordheim equation. (Contractor's abstract)

MIT. 10:142

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

M-EMISSION BANDS OF THE TRANSITION METALS IN THE SOLID STATE, by E. M. Gyorgy. May 25, 1953, 34p. incl. diagrs. tables, refs. (Technical rept. no. 254) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 28470
Unclassified

M-emission bands of Cr, Mn, Fe, Ni, and Cu were studied with a modified vacuum spectrograph which employed the grazing-incidence Rowland mounting with a movable photodetector capable of measuring radiation intensities in the range of 50-800 A. The spectra discussed were produced by transitions of valence electrons in the excited $3\,P_{3/2,\ 1/2}$ states of the atom. An explanation of several of the observed features of the bands is permitted by assuming (1) the observed bands represent only the density of d-type electrons; or (2) an appreciable part of the experimental bands is due to the conduction electrons. The emission process and some aspects of background radiation are discussed. Experimental emission curves, emission edges, emission bandwidths, and electron distribution curves are included for the metals studied.

MIT. 10:143

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

COMMUNICATION IN THE PRESENCE OF ADDITIVE GAUSSIAN NOISE, by F. A. Muller. May 27, 1953, 17p. incl. diagrs. refs. (Technical rept. no. 244) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100) AD 33859 Unclassified

This report presents an analysis of the properties of finite segments of noise taken from correlated gaussian noise. This analysis is applied to the problem of optimal detection of signals when a communication channel adds gaussian noise and introduces a linear distortion. Some specific examples are discussed briefly, such as the point-by-point measurement of a quantity as a function of some parameter, or applications to the problem of communication in a limited band, disturbed by uncorrelated noise. (Contractor's abstract, modified)

MIT. 10:144

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A COMPUTER FOR SOLVING INTEGRAL FORMULATIONS OF ENGINEERING PROBLEMS BY METHODS OF SUCCESSIVE APPROXIMATIONS, by J. M. Ham. May 28, 1953, 54p. incl. illus. diagrs. tables, refs. (Technical rept. no. 241) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 28573
Unclassified

Variational methods of successive approximations for solving the linear operational equation $P\alpha + \beta = 0$ are examined, where P is an n x n matrix, β is a known vector, and α is an unknown vector. The equation is used to represent linear simultaneous equations, integral equations, and boundary value problems in differential equations. The variational principle informing the methods of solution is that of associating with the basic equation a scalar-valued functional $W(\alpha)$ that attains its extrema when the equation is satisfied; $W(\alpha)$ defines a surface over the n-space of the operator P. In this space the solution sequences $\alpha_0, \alpha_1, \ldots, \alpha_m$ generated by relaxation and classical iterative methods describe particular types of vector trajectories that terminate under the extrema of $W(\alpha)$. It is concluded that small and relatively simple special-purpose computers designed for use by the research worker can contribute significantly to the effective application of methods of successive approximations. The design and application of such a computer is described. The internal operations are in part digital and in part analog. The major mathematical function performed by the machine is that of transforming an n-vector by an n x n matrix. A 40-vector may be so transformed in approximately 40 sec. The machine carries 9 binary digits. The machine is effective for evaluating integral transformations such as Fourier, correlation, and convolution integrals.

MIT. 10:145

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

APPARATUS FOR MICROWAVE SPECTROSCOPY, by M. W. P. Strandberg, H. E. Johnson, and J. E. Eshbach. June 12, 1953. 17 p. incl. illus. refs.

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[Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-100] AD 53357 Unclassified

Also published in Rev. Scient. Instruments, v. 25: 776-791, Aug. 1954.

Design considerations are presented for a video microwave spectrograph using Stark modulation and a crystal or bolometer detector. Crystal and source noise is explicitly included in the treatment. A detailed description of some of the equipment in use in the laboratory is given. Some of the advantages and disadvantages of other systems are mentioned. (Contractor's abstract)

MIT. 10:146

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CORRELATION FUNCTIONS AND SPECTRA OF MUSIC AND SPEECH, by I. Uygur. June 15, 1953, 42p. incl. illus. refs. (Technical rept. no. 250) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 22267 Unclassified

A history of the study of music and speech in the field of communication is given. A discussion is given of the basic ideas and tools in the statistical theory of communication connected to music and speech. The electronic technique for performing the necessary mathematical operations to obtain correlation functions which yield to spectra are described, with emphasis on the delay problem. The experimental results of a study of music and speech with these methods are presented.

MIT. 10:147

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE USE OF FREQUENCY MODULATION FOR TELEVISION TRANSMISSION, by R. D. Stuart, L. B. Arguimbau and others. July 6, 1953, 25p. incl. illus. (Technical rept. no. 259) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 18975 Unclassified

Investigations were made of FM television transmissions. A facsimile system having an 1800-c AM carrier was detected, and the video wave form was used to frequency modulate a 14-kc carrier. A signal which was acoustically delayed 25 msec and a direct signal were added to simulate multipath transmissions. Doubleside-band operation was used over a bandwidth equivalent to 5 mc for a 140-mc carrier. Interfering signals up to 70% of the desired signal were investigated. The tests were made with a 3-element Butterworth filter having 3-db points at the equivalent of 140 ± 2.5 mc. The test signal was frequency modulated with a trapezoidal wave having a rise time equivalent to 0.08 μsec. The investigations indicated that under multipath-transmission conditions, the stronger signal may capture in an FM system even in the presence of strong interference. The characteristic ghost of spike interference was present, and its repetition rate depended on the frequency, with the bandwidth the same as the highest components of the transmitted wave form, the spike frequency fell in a region of the spectrum containing picture information. Effective filtering in the latter case appeared difficult; pre-emphasis simplified but did not solve the problem. The use of wider bandwidths for effective interference reduction was considered possible.

MIT. 10:148

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HYPERFINE STRUCTURE OF IODINE (Abstract), by J. G. King, H. H. Stroke, and V. Jaccarino. [1953] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 476, July 15, 1953.

The atomic beam magnetic resonance method was used to investigate the $^2P_{3/2}$ atomic ground state of the stable isotope of iodine. From observations of the Zeeman frequencies in a known weak magnetic field, the value of 5/2 ħ for the nuclear spin I was verified. Further work is in progress to determine the nuclear magnetic dipole and electric quadrupole interaction constants. There has been considerable interest in the hyperfine structure of iodine for some time because of the possible existence of a nuclear magnetic octupole interaction. (Contractor's abstract)

MIT. 10:149

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A "MAGNETIC SCANNING" METHOD FOR INVESTIGATING HYPERFINE STRUCTURE AND ISOTOPE SHIFT, by F. Bitter, H. H. Plotkin and others. [1953] 1 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Published in Phys. Rev., v. 91: 421, July 15, 1953.

A new technique for observing hyperfine structure and isotope shift in absorption lines is applied to a study of the resonance lines of vaporized natural Hg isotopes as well as the radioactive Hg^{197}. The 2537A radiation emitted axially from a Hg^{198} lamp in a magnetic field, and passed through a quarter wave plate and Nicol

prism to obtain one of the two σ-components of the normal Zeeman triplet, provides a variable-frequency monochromatic light source for selective excitation of components of the entire hyperfine structure pattern of the resonance line of natural Hg; fields up to 10,000 gauss vary the frequency, while resonance radiation intensity is observed with a photomultiplier. Computation of frequency from the magnetic field was in good agreement with previous findings but anomalous results were found for intensities. Observation of small samples of Hg^{197}, produced from deutron-bombarded gold showed in addition to the normal five hyperfine components of the natural Hg spectrum, presumably due to contamination, several new components whose intensity changed with time. It was not possible to identify these lines in our preliminary experiments, but the results seem at present to be compatible with the spin assignments of the shell model, and of experiments on γ-emission, namely f3/2 for the isomeric state and f/2 for the ground state. Further experiments attempting to identify the various newly discovered lines are also in progress.

MIT. 10:150

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MEASUREMENT OF THERMAL DIFFUSIVITY OF MAGNESIUM AT LOW TEMPERATURES BY VARIABLE STATE TECHNIQUES (Abstract), by S. Waldron and M. A. Herlin. Apr. 30, f953 [f p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc f00) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, f953.

Published in Phys. Rev., v. 9f: 447, July f5, f953.

The measurement of thermal properties of metals at low temperatures by a pulsed and a sinusoidal heating of a rod of the metal has been investigated. The pulse measurements are shown to be seriously limited by the thermal resistance of the heater-to-sample interface. The sinusoidal measurements, however, are able to yield the thermal diffusivity (ratio of thermal conductivity to specific heat) and thus form a convenient method of obtaining this quantity. The method has been applied to magnesium, whose specific heat is known. Two samples have been investigated, one of high purity, and one containing sufficient manganese impurity to show a pronounced electrical resistance minimum. The thermal conductivity derived from these results shows the normal linear variation with temperature at low temperatures for the pure sample, but a nonlinear variation in the direction expected from the electrical conductivity anomaly for the impure sample. Both samples show the characteristic maximum at higher temperatures. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NUCLEAR RESONANCE LINE STRUCTURE IN HD AND MOLECULAR SHIELDING IN HD, H_2, AND D_2 (Abstract), by T. F. Wimett. [f953] [f]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-f00]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, f953.

Published in Phys. Rev., v. 9f: 478, July f5, f953.

Line splitting in both the proton and deuteron magnetic resonances in HD was predicted by Ramsey and Purcell and has been observed by means of the radio-frequency pulse technique and also by a line broadening measurement. We will report a measurement of this splitting by the direct recording of the lines obtained in a nuclear resonance absorption experiment of very high resolution. As measured at f5 kilogauss, the splitting observed was $\sigma = 42.7 \pm 0.7$ cycles. By comparing the ratio of proton and deuteron resonance frequencies in HD with that observed in a mixture of H_2 and D_2 gases, the following difference between the molecular shielding factors for H_2 and D_2 was obtained: $\sigma D_2 - \sigma H_2 = (0.65 \pm 0.59) \times f0^{-7}$. The difference in the shielding fields in D_2 and HD was obtained by measuring the shift between the deuteron resonance in D_2 from that in HD using a single sample containing both gases. The following result was found: $\sigma D_2 - \sigma HD = (0.48 \pm 0.32) \times f0^{-7}$. (Contractor's abstract)

MIT. f0:f52

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STARK EFFECT IN HIGH TEMPERATURE MICROWAVE SPECTROSCOPY (Abstract), by P. [A.] Tate and M. W. P. Strandberg. [f953] [f]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-f00) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, f953.

Published in Phys. Rev., v. 9f: 464, July f5, f953.

A simple high temperature microwave spectrograph was built. Four rotational transitions in $K^{39}Cl^{35}$ and two in $K^{39}Cl^{37}$ were observed. Those in $K^{39}Cl^{35}$ agree with the same transitions observed by Stitch, Honig, and Townes. Rotational constants agree within experimental error with those found by molecular beam methods. The Stark patterns for the transitions J 2 → 3, v 0 in $K^{39}Cl^{35}$ and J f → 2, v 0 in $Na^{23}Cl^{35}$ were studied. From these the electric dipole

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moments of $K^{39}Cl^{35}$ and $Na^{23}Cl^{35}$ were determined. (Contractor's abstract)

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Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THERMOMECHANICAL EFFECT IN LIQUID HELIUM II TO 0.9°K (Abstract), by D. H. Rogers and M. A. Herlin. [1953] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 489, July 15, 1953.

The thermomechanical pressure in liquid helium II has been measured as a function of temperature difference and ambient temperature to slightly below 0.9°K ambient. The full thermomechanical pressure as given by the London equation is observed. At the lower temperature limit the phonon contribution to the entropy is over half of the total entropy, indicating that the phonons contribute to the thermomechanical pressure reversibly as has been observed for the higher temperature excitations. A nonlinear dependence of thermomechanical pressure on temperature difference has been found to be completely explained by the change of entropy with temperature, substantiating the assumption of reversibility. It has been found possible to sustain a fairly large temperature difference across the filter element even at the low temperature end of the observed range without introducing irreversible effects. (Contractor's abstract)

MIT. 10:154

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ULTRASONIC MEASUREMENTS IN LIQUID HELIUM (Abstract), by C. E. Chase. [1953] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-100]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 489, July 15, 1953.

Measurements of the velocity and absorption of ordinary sound in liquid helium were made in the temperature range from 0.85°K to the normal boiling point, using a pulsed ultrasonic technique at frequencies of 2, 6, and 12 mc/sec. The velocity measurements indicate the absence of detectable dispersion over this frequency range. The attenuation measurements disclose a very rapid rise in the attentuation below 1.6°K. Above 1.2°K quantity α/ω^2 is independent of frequency; a marked departure from this behavior at lower temperatures indicates the presence of relaxation effects. These results are in qualitative agreement with the theoretical predictions of Khalatnikov, whose calculations are based on the assumption of finite relaxation times for the processes leading to a change in the number of elementary excitations present in the liquid. (Contractor's abstract)

MIT. 10:155

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NETWORK SYNTHESIS BY IMPULSE RESPONSE FOR SPECIFIED INPUT AND OUTPUT IN THE TIME DOMAIN, by F. Ba Hli. July 31, 1953, 65p. incl. diagrs. refs. (Technical rept. no. 261) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 51989 Unclassified

A solution to the general problem of synthesis in the time domain is presented: given an arbitrary time function as the specified input to an electrical network and another such time function as the desired output, a design procedure is offered for a network for obtaining the required relationship. These arbitrary time functions may be prescribed either graphically, or as analytic functions, or merely as sequences of values at stated intervals of time. The specified input-output pair is reduced to a single function which is known as the impulse response of the network by a simple, straightforward, synthetic division procedure. The physical realizability of the network is tested by two, easy-to-apply, criteria in the time domain that are the analogs of the Hurwitz test used on functions of s. Then three original methods are presented for calculating the network system function directly from the impulse response in the time domain. All three methods offer the advantages of being simple and computationally rapid. Moreover, it is possible to get rational function approximations to transcendental network system functions by an algebraic method which yields great economy of network elements with good tolerances in the time domain.

MIT. 10:156

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

POWER GAIN IN FEEDBACK AMPLIFIERS, by S. J. Mason. Aug. 25, 1953, 13p. incl. illus. (Technical rept. no. 257) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 31774 Unclassified

Also published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-1: 20-25, June 1954.

A linear transistor model (or other linear

two-terminal-pair device) is imbedded in a lossless passive network N and the properties of the complete system, as measured at two specified terminal pairs, are described by the open-circuit impedances Z_{11}, Z_{12}, Z_{21}, Z_{22}. The quantity

$$U = \frac{(Z_{21} - Z_{12})^2}{4(R_{11}R_{22} - R_{12}R_{21})}$$

where R_{jk} is the real part of Z_{jk}, is defined as the unilateral gain of the transistor. Quantity U is independent of the choice of N and is (consequently) invariant under permutations of the three transistor terminals and also under replacement of the open-circuit impedances by short-circuit admittances. If U exceeds unity at a specified frequency, then N can always be chosen to make R_{11} and R_{22} positive and Z_{12} zero at that frequency. Quantity U is identifiable as the available power gain of the resulting unilateral structure. An arbitrary coupling network may be decomposed into a portion that accomplished unilateralization and a remaining complementary portion that provides feedback around the unilateralized structure. Such decomposition brings some of the methods of elementary feedback theory to bear upon nonunilateral circuit problems and offers a viewpoint from which signal flow and power flow can be simply related. (Contractor's abstract)

MIT. 10:157

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INFORMATION FLOW IN TASK-ORIENTED GROUPS, by R. D. Luce, J. Macy, Jr. and others. Aug. 31, 1953, 95p. incl. diagrs. tables. (Technical rept. no. 264) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 49440 Unclassified

Chapter I: A nonaction-quantized group experiment in which the subjects were conditioned in one communication network and tested in another is described. The difficulties of this general information flow problem are pointed out. Chapter II: The group results for time, number of messages, content of messages, and errors are presented. It is shown that interesting carry-over effects occur; that the dominant effect is that of the present communication network. Chapter III. Individual decisions are characterized in terms of conditional probabilities for certain ambiguous and unambiguous conditions, but the determinants of behavior in the ambiguous situations are not well understood. Chapter IV: It is shown that individual decision times and probabilities of decision are not directly interdependent; that both depend on the information state. The exponential distribution is again found adequate for individual decisions and it is shown that the decision rate is nearly content for serial decisions. Chapter V: Subjects' knowledge of the network and their attitudes toward experiences in the groups are examined and previous network experience are given. Chapter VI: Conclusions from this and previous studies are drawn, and generalizations are made concerning future developments and applications. (Contractor's abstract)

MIT. 10:158

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PERSONALITY FACTORS AND THEIR INFLUENCE ON GROUP BEHAVIOR: A QUESTIONNAIRE STUDY, by G. O. Rogge. Aug. 31, 1953, 35p. incl. tables, refs. (Technical rept. no. 265) (Sponsored jointly Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 49536 Unclassified

The purpose of this report is twofold: (a) to describe the construction and analysis of a questionnaire instrument designed to measure some aspects of the individual's personality organization which, it was hypothesized, would influence his behavior in, and reactions to, task-oriented groups; and (b) to report significant relations found between the personal characteristics measured by the questionnaire and several features of behavior exhibited in an experimental group. (Contractor's abstract)

MIT. 10:159

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

COMPUTATIONAL TECHNIQUES WHICH SIMPLIFY THE CORRELATION BETWEEN STEADY-STATE AND TRANSIENT RESPONSE OF FILTERS AND OTHER NETWORKS, by E. A. Guillemin. [Sept. 2, 1953] [20]p. incl. illus. (Technical rept. no. 268) (Sponsored jointly Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 55312 Unclassified

Also published in Proc. National Electronic Conference, v. 9: 513-532, Feb. 1954.

In some wave filter applications it is significant to determine the transient response for the contemplated excitation as well as to control the pertinent sinusoidal steady-state transmission and rejection properties. In others it may be necessary to consider simultaneously the tolerance specifications on the transient response as well as on the steady-state frequency response of the filter in its design. The difficulty involved in handling such specifications lies primarily in finding a reasonably simple way (computationally as well as logically) of correlating tolerances or errors in the time domain with their counterparts in the frequency domain. Formally, this correlation is expressible through use of the Laplace transform; but from the standpoint of computational ease and interpretive clarity this mathematical relationship leaves much to be desired. The method proposed in this paper effects the desired correlation without integration, and in many

cases the pertinent results can be written down by inspection. While not an exact method, it is a very much better approximation than some other approximate procedures that have previously been proposed. The same techniques also make possible easy computation of the minimum phase associated with a specified magnitude vs frequency variation. From this can be obtained a relatively simple and direct way of computing transient response from a specified gain or loss characteristic that is as accurate as need be and one in which the appropriate asymptotic character of the filter characteristic is properly taken into account. (Contractor's abstract, modified)

MIT. 10:160

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STATISTICAL THEORY APPLIED TO COMMUNICATION THROUGH MULTIPATH DISTURBANCES, by R. Price. Sept 5, 1953, 70p. incl. diagrs. refs. (Technical rept. no 266; Lincoln Lab. tech. rept. no. 34) (In cooperation with M. I. T. Lincoln Lab. under AF 19(122)458) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100) AD 28497 Unclassified

This work is concerned with the synthesis and evaluation of integrated communication systems constructed specifically to perform in the presence of channel disturbances of the form encountered in multipath propagation. In the communication system considered, information is conveyed from source to user by encoding it into electrical symbols at the transmitter and decoding it at the receiver. Statistical theory, including information theory, is used throughout the paper. Gross aspects of multiple-mode propagation in ionospheric scattering are discussed, and previous efforts to improve systems affected by these disturbances are reviewed. System capacities are computed for the transmission of band-limited white Gaussian signals through fixed multiple-mode disturbances, and the optimum spectral distribution of transmitter power is found. In general, presence of additional paths does not upset the message-handling capabilities of the channel if suitable wide-band signals are used. Quasi-stationary path fluctuations are considered, and a technique for measurement of the multipath characteristic by the receiver is suggested. Capacities are found for slow path delay fluctuations. Single-mode scatter propagation is considered as a complex multiplicative Gaussian process. The probability computing receiver is found analytically, and a physical realization is developed for small signal-to-noise ratios. Lower bounds to system capacity are found for a binary transmission through scatter. Incidental results are system capacities for a related multiplicative channel, and the capacity for a binary transmission through white Gaussian noise. (Contractor's abstract)

MIT. 10:161

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE TRANSITION FROM FREE TO AMBIPOLAR DIFFUSION, by W. P. Allis and D. J. Rose. Sept. 9, 1953, 10p. incl. diagrs. tables. (Technical rept. no. 271) (In cooperation with Bell Telephone Labs., Inc.) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-100; continued by DA 36-039-sc-42607) AD 39056 Unclassified

Also published in Phys. Rev., v. 93: 84-93, Jan. 1, 1954.

This paper deals with the spatial distributions of the charged particles, space-charge fields, and voltages in certain types of gas discharge plasmas and with the rate of ionization necessary to maintain the plasma in a steady state. In gas discharge plasmas with very low charge densities, the charged particles diffuse freely in directions perpendicular to the applied electric field because the space-charge field is negligible. At high charge densities, the space-charge field saturates and gives rise to a combination of diffusive and mobility flow termed ambipolar. The transition between these limits is examined theoretically for the case of plasmas maintained through ionization by electron impact. The ionization frequency per electron, one of the principle parameters of the transition, can be re-expressed in terms of an effective diffusion coefficient; it falls from a high value at the free diffusion limit to a low value at the ambipolar limit as the electron density increases over many orders of magnitude. The transition is accompanied by changes in the charge distributions and by the development of a positive ion sheath. The current equations determining the process are examined, and approximate solutions are obtained. Second approximations are obtained for the case where the ratio of electron to ion energies is much greater than unity. Machine solutions are presented both for the above case and for an isothermal plasma in which this ratio equals unity. An application to the afterglow is shown. (Contractor's abstract)

MIT. 11:001

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A METHOD OF MEASURING FREQUENCY DETECTOR RESPONSE, by G. M. Rodgers. Oct. 20, 1953, 6p. incl. illus. (Technical rept. no. 243) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607; continuation of DA 36-039-sc-100) AD 23570 Unclassified

A method is presented for measuring the distortion in a frequency detector by using the frequency derivative of the detector's response curve. A study indicates that the proposed method, by reducing the effects of

distortion arising in the oscillator and frequency modulator from first to second order, has less intrinsic error than the wave-analyzer method. A laboratory application of the method is suggested.

MIT. 11:002

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CONVERSION OF A BRUNE CYCLE WITH AN IDEAL TRANSFORMER INTO A CYCLE WITHOUT AN IDEAL TRANSFORMER, by F. M. Reza. Nov. 3, 1953 [5]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 44509 Unclassified

Also published in Jour. Math. and Phys., v. 33: 194-198, July 1954.

Bott and Duffin's result has been arrived at by the continuation of the Brune synthesis procedure. This provides an alternative proof to that of Bott and Duffin for the existence of a network configuration without an ideal transformer for any positive real function. This method of approach suggests a more unified synthesis procedure: first follow the Brune synthesis procedure. If a Brune cycle with an ideal transformer is confronted, convert that cycle into a cycle without a transformer. Numerical values of the elements of the latter cycle are found in terms of elements of the corresponding Brune cycle.

MIT. 11:003

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE EXCITATION OF PLASMA OSCILLATIONS, by D. H. Looney and S. C. Brown. Nov. 24, 1953 [5]p. incl. illus. refs. (Technical rept. no. 273) (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 52551 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Oct. 22-24, 1953.

Also published in Phys. Rev., v. 93: 965-969, Mar. 1, 1954.

A beam of high energy electrons, injected into the plasma of a dc discharge from an auxiliary electron gun, excited oscillations in the plasma at the plasma electron oscillation frequency given by the Tonks-Langmuir equation. A movable probe showed the existence of a standing wave patterns of the oscillatory energy in the region of the plasma in and around the electron beam. Nodes of the patterns coincided with the electrodes which limited the region of the plasma traversed by the beam. The standing wave patterns were independent of the frequency of the oscillation. At any particular frequency, the standing wave was determined by the thickness of the ion sheaths on the bounding electrodes. The mechanism of the energy transfer from the electron beam to the oscillation of the plasma electrons was established as a velocity-modulation process by the detailed behavior of the frequency of oscillation and the transitions in the standing-wave patterns as the sheath thickness was varied. Experimental attempts to produce plasma oscillations as predicted by Bohm and Gross proved to be fruitless. (Contractor's abstract)

MIT. 11:004

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DYNAMIC REVERSIBILITY AND BOLTZMANN EQUATION (Abstract), by L. Tisza. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) Unclassified

The limits of validity of Boltzmann's integral equation is investigated from the point of view of the principle of dynamic reversibility. The traditional theory turns out to be only a first approximation that provides correct results for the kinetic coefficients such as viscosity, heat, and electrical conductivity, but fails to contain the space-time fluctuations of the densities and currents. The relation between dynamic reversibility and reciprocity is discussed. (Contractor's abstract)

MIT. 11:005

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THE NUCLEAR MAGNETIC MOMENT OF S^{35} BY MICROWAVE SPECTROSCOPY, by B. F. Burke, M. W. P. Strandberg and others. [1954] [2]p. incl. diagr. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office Scientific Research under DA 36-039-sc-42607) Unclassified

Published in Phys. Rev., v. 93: 193-194, Jan. 1, 1954.

The nuclear magnetic moment of S^{35} has been measured by the Zeeman effect in the microwave spectrum of OCS yielding a value of 1.00 ± 0.04 nm. A value of the electric quadrupole coupling constant in OCS is found to be 21.90 ± 0.04 mc/sec. (Contractor's abstract)

MIT. 11:006

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE SYNTHESIS OF SEQUENTIAL SWITCHING CIRCUITS, by D. A. Huffman. Jan. 10, 1954. 60 p.

MIT. 11:007 - MIT. 11:010

incl. diagrs. tables, refs. (Technical rept. no. 274) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-[42607]) AD 33857 Unclassified

Also published in Jour. Franklin Inst., v. 257: 161-190; 275-303, Mar.-Apr. 1954.

An orderly procedure is developed by which the requirements of a sequential switching circuit (one with memory) can be reduced to the requirements of several combinational switching circuits (those without memory). Important in this procedure are: (1) the flow table: a tabular means by which the requirements of a sequential switching circuit may be stated precisely and by which redundancy in these requirements may be recognized and eliminated; and (2) the transition index: a new variable which indicates the stability (or lack of stability) of a switching device. The role of those switching devices which are not directly controlled by the input of a sequential switching circuit is investigated thoroughly. The resulting philosophy, which is exploited in synthesis procedures for circuits using either relay or vacuum-tube switching devices, is valid for circuits using other devices as well. (Contractor's abstract)

MIT. 11:007

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A TIME-GATED AMPLITUDE QUANTIZER FOR NEURAL SIGNALS. AN APPLICATION TO ELECTRIC SIGNALS FROM THE AUDITORY NERVOUS SYSTEM, by K. Putter. Jan. 13, 1954, 41p. incl. illus. diagrs. table, refs. (Technical rept. no. 275) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 37045 Unclassified

Equipment is described which was designed specifically to aid in the first stages of the analysis of data obtained in electrophysiological experiments with acoustic stimuli. The time-gated amplitude quantizer (TGAQ) automatically quantizes the amplitudes of preselected portions of the signals and makes possible a partial analysis during the course of the experiment. Quantization is achieved by an electromechanical method. The TGAQ is sufficiently flexible to select and quantize signals present at cortical and peripheral locations of the auditory nervous system. The TGAQ may be modified to accept responses to stimuli other than single clicks. The TGAQ model was used in a number of experiments dealing with peripheral responses. A comparison of visual quantization and TGAQ quantization is given.

MIT. 11:008

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

MICROWAVE MEASUREMENT OF THE VELOCITY DEPENDENCE OF THE COLLISION CROSS SECTION OF SLOW ELECTRONS IN HELIUM (Abstract), by L. Gould. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Oct. 22-24, 1953.

Published in Phys. Rev., v. 93: 648, Feb. 1, 1954.

A microwave method previously reported for determining the collision probability for momentum transfer of slow electrons has been modified so that a variation in average electron energy from 0.012 to 3 electron volts may be obtained. Measurements of the ratio of the real to the imaginary part of the complex conductivity, using a null method, are made in the afterglow of a pulsed discharge. The average electron energy is varied by applying a microwave electric field in the afterglow, and, under appropriate assumptions, the average energy is determined theoretically from this field. Measurements from 0.012 to 0.052 electron volt are also obtained by varying the gas temperature from 95°K to 400°K. The value of the collision probability in helium is 18.3 ± 2% from 0 to 0.75 electron volt and increases slowly to a peak value of 19.2 ± 2% at 2.2 electron volts. (Contractor's abstract)

MIT. 11:009

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SPECTROSCOPY OF THE SOLID STATE: SOME OF THE TRANSITION ELEMENTS, by E. M. Gyorgy and G. G. Harvey. [1954] [5]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) Unclassified

Published in Phys. Rev., v. 93: 365-369, Feb. 1, 1954.

The $3P_{3/2, 1/2}$ emission curves of nickel, manganese, and iron have been obtained by using a vacuum recording spectrograph. A plausible interpretation of a number of features of the experimental bands is discussed. (Contractor's abstract)

MIT. 11:010

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STARK EFFECT IN THE MICROWAVE SPECTRA OF KCl AND NaCl, by P. A. Tate and M. W. P. Strandberg. Feb. 8, 1954 [4]p. incl. diagr. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-42607]) AD 44508 Unclassified

Also publtshed in Jour. Chem. Phys., v. 22: 1380-1383, Aug. 1954.

Some further lines in the microwave spectrum of KCl have been observed at frequencies predicted by the rotational constants given by recent molecular beam work. Measurements have been made on the Stark patterns of the $J = 2 \rightarrow 3$, $v = 0$ line of $Na^{23}Cl^{35}$. The dipole moments of these molecules have been determined to be 10.1 ± 0.2 Debye units for KCl and 8.5 ± 0.2 Debye units for NaCl. The KCl value is in fair agreement with the results of molecular beam investigations. (Contractor's abstract)

MIT. 11:011

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PHASE STABILIZATION OF MICROWAVE OSCILLATORS, by M. Peter and M. W. P. Strandberg. Feb. 25, 1954, rev. May 6, 1955, 5p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 102871 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 869-873, July 1955.

A circuit has been developed with which microwave oscillators may be phase-locked to weak but stable reference signals. The circuit was operated with S-band oscillators (707B klystron; 2C37 triode oscillator) and a 2K50 K-band klystron. It is possible to lock a microwave oscillator directly or through a cascade of such circuits to a quartz-stabilized oscillator. The statistical theory of random noise is used to obtain an analysis of the stabilizing effect of the circuit, and the power spectrum of the stabilized microwave source is calculated. The scheme can also be applied in divider operation. Modifications are discussed. A modified circuit that uses carrier-suppressed modulation of the reference signal has also been realized. In another circuit, the oscillator frequency is converted by means of a stable reference, and compared with a second reference that can be of low frequency and tunable. These latter circuits allow elimination of the excess noise introduced by crystal diodes. In the original straight dc circuit this noise cannot be eliminated, but calculation shows that its influence on the output power spectrum is very small. (Contractor's summary)

MIT. 11:012

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SYNTHESIS WITHOUT IDEAL TRANSFORMERS, by F. M. Reza. Mar. 3, 1954 [1]p. incl. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 44501 Unclassified

Also published in Jour. Appl. Phys., v. 25: 807-808, June 1954.

Regarding a synthesis procedure suggested by Bott and Duffin that avoids mutual couplings in the realization of the driving-point impedance functions, it was found that: (a) a direct continuation of the Brune synthesis procedure leads to a result identical with that obtained by Bott and Dufftn; (b) each element of the Bott and Duffin structure (referred to here as a "conversion cycle") can be solely described in terms of the elements of the corresponding Brune cycle and a constant k, which also appears in the same Brune cycle. The conversion cycle contains two remainder functions that are explicit functions of the elements of the same Brune cycle; and (c) it is also possible to find an equivalent structure for the Brune cycle in the form of an unbalanced bridge. This is an improved conversion cycle as it presents one element less per cycle than the original Bott and Duffin structure. This bridge conversion cycle provides a method of avoiding mutual couplings without undergoing much additional computation. Once the Brune synthesis is accomplished, the bridge conversion cycle follows directly.

MIT. 11:013

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EQUIVALENT CIRCUIT FOR A PASSIVE NONRECIPROCAL NETWORK, by H. A. Haus. Mar. 25, 1954 [3]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607] AD 80342 Unclassified

Also published in Jour. Appl. Phys., v. 25: 1500-1502, Dec. 1954.

An equivalent circuit is proposed for a linear, passive, nonreciprocal, four-terminal network. It introduces an ideal amplifier and phase shifter. It is shown that the proposed equivalent circuit has certain advantages over equivalent network representation that use gyrators. In particular, standard measuring techniques used on reciprocal networks lead directly to the determination of six elements of the equivalent circuit. One additional measurement gives the remaining two parameters.

MIT. 11:014

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

INFORMATION CONSERVATION AND SEQUENCE TRANSDUCERS, by D. A. Huffman. [1954] [17]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 76836 Unclassified

MIT. 11:015 - MIT. 11:018

Also published in Proc. Symposium on Information Networks, Polytechnic Inst. of Brooklyn, N. Y., Apr. 12-14, 1954, p. 291-307.

The applicability is demonstrated of modern statistical theory of information to those systems which process data which have been coded into some discontinuous form. Such systems include, among others, communication channels with pulse modulated signals, digital computers and switching control circuits. Particular attention is given to those systems which have a "memory," i.e., systems which may be conditioned so that their present behavior is modified by their past history.

MIT. 11:015

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INFORMATION THEORY AND GENERALIZED NETWORKS, by R. M. Fano. [1954] [7]p. incl. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-42607) AD 76833 Unclassified

Published in Proc. Symposium on Information Networks, Polytechnic Inst. of Brooklyn, N. Y., Apr. 12-14, 1954, p. 3-9.

The relationship is pointed out between two apparently unrelated fields — information theory and network theory. The fundamental theorems developed in the field of information theory are briefly discussed and interpreted with emphasis on points in common with network theory.

MIT. 11:016

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON WIENER FILTERS AND PREDICTIONS, by Y. W. Lee. 1954 11 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under [DA 36-039-sc-42607]) AD 76834 Unclassified

Also published in Proc. Symposium on Information Networks, Polytechnic Inst. of Brooklyn, N. Y., Apr. 12-14, 1954, p. 19-29.

The Wiener theory of filtering and prediction is based upon the minimum mean square error criterion. This paper presents the theory under the minimum integral square crosscorrelation error criterion. An interesting point in the new criterion is that it involves the same autocorrelation and crosscorrelation functions as in the original Wiener theory, and no higher order correlations. Another matter under consideration is the generalization of the filter and predictor formulas for the inclusion of certain problems which are more complicated than simple filtering and prediction.

MIT. 11:017

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

OPTICAL SYSTEMS AS COMMUNICATIONS CHANNELS, by P. Elias. [1954] [8]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 76835 Unclassified

Also published in Proc. Symposium on Information Networks, Polytechnic Inst. of Brooklyn, N. Y., Apr. 12-14, 1954, p. 321-328.

A discussion is presented of the application to optical systems of some ideas which are current in network theory and in the statistical theory of communication. These ideas have to do with both the channels for communication which are provided by optical instruments, and with the two-or more-dimensional messages which may be transmitted over these channels.

MIT. 11:018

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

FINE STRUCTURE OF POSITRONIUM (Abstract), by R. Weinstein, M. Deutsch, and S. [C.] Brown. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 758, May 1, 1954.

Experiments on the Zeeman splitting of the 1^3S state of positronium (Phys. Rev., v. 85: 1047, 1952) have been extended, using higher RF power, and improved control of the magnetic field. The reduction of the three quantum annihilation at resonance ranged from 5 to 20 percent and agreed with the theoretically expected quenching within the experimental uncertainty. The width of the resonance at half maximum, ΔH H $\simeq 4 \times 10^{-3}$, agrees with the annihilation width broadened by a doppler effect due to a kinetic energy of the order of 1 ev. The position of the resonance was found to be independent of the nature and pressure of gas in the cavity. He, A, Kr, and CF_2Cl_2 were used at pressures between 1.3 and 4.3 atmospheres. The singlet triplet splitting of the ground state, calculated to order α^2 from the Zeeman splitting, is $\Delta W = 2.03350 \pm 5$ mc, compared with a theoretical value (Phys. Rev., v. 86: 257, 1952) of 2.03370 mc. (Contractor's abstract)

MIT. 11:019

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ENERGY DISTRIBUTION FUNCTION OF ELECTRONS IN PURE HELIUM, by F. H. Reder and S. C. Brown. May 14, 1954 [5]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 44503 Unclassified

Also published in Phys. Rev., v. 95: 885-889, Aug. 15, 1954.

A solution for the Boltzmann transport equation is presented, which allows prediction of high-frequency gas discharge breakdown fields in gases with constant collision frequency of the electron. Theoretical values are in good agreement with the experimental data. This is used to justify the use of the distribution function for determining the average electron energy and the various power losses of an electron in a discharge as a function of E/p. (Contractor's abstract)

MIT. 11:020

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE HYPERFINE STRUCTURE OF THE $3P_{3/2}$ STATE OF Na^{23}, by P. L. Sagalyn. [1954] [8]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607.]) Unclassified

Published in Phys. Rev., v. 94: 885-892, May 15, 1954.

Two of the separations in the hyperfine structure of the $3P_{3/2}$ state of Na^{23} were measured. The results are 61 ± 2 mc/sec and 36.6 ± 2 mc/sec. These results were assigned to the (F = 3 ↔ F = 2) and (F = 2 ↔ F = 1) separations. A value of Q = +0.1 ± 0.06 x 10^{-24} cm^2 was calculated for the nuclear electric quadrupole moment. (Contractor's abstract)

MIT. 11:021

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THERMOELECTRIC EFFECTS IN SILVER HALIDES, by W. Grattidge. May 16, 1954. 15p. incl. diagrs. table, refs. (Technical rept. no. 272) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 51988 Unclassified

Measurements of the electrical conductivity and the thermoelectric power as a function of temperature in the range 30°C to 300°C were made for silver chloride and silver bromide single crystals. Variations of these properties from past history were examined for annealed and quenched states. An appendix gives the details of a scale expander for a recording potentiometer used in this study.

MIT. 11:022

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ULTRASONIC MEASUREMENTS IN MAGNETICALLY COOLED LIQUID HELIUM, by C. E. Chase and M. A. Herlin. [May 19, 1954] [2]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 44504 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Also published in Phys. Rev., v. 95: 565-566, July 15, 1954.

Measurements were made of the velocity and attenuation of ordinary (first) sound in liquid helium between 0.1°K and 1°K, at 12.1 mc/sec. These temperatures were produced by adiabatic demagnetization of ferric ammonium alum from a starting temperature near 0.9°K, produced by a large oil diffusion pump. Since helium was admitted by an arrangement of concentric thin-walled stainless-steel cones (originated by Dr. J. Ashmead, Mond Laboratory), the demagnetization chamber could be isolated or placed in direct communication with the bath. Warmup times approximating one hour were obtained. The velocity remains essentially constant below 1°K at 240 ± 5 m/sec. Although the inherent difficulty of a fixed path length makes it less accurate than the earlier 239 ± 2 m/sec found above 0.85°K, the value shows that no gross changes occur. The attenuation passes through two clearly resolved maxima slightly below 1°K, falls smoothly toward zero as absolute zero is approached. This agrees qualitatively with Khalatnikov's theory which explains the anomalously high absorption of helium in terms of two relaxation times resulting from elastic interactions of phonons with phonons and of phonons with rotons. (Contractor's abstract)

MIT. 11:023

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DOPPLER LINE WIDTH REDUCTION, by M. W. P. Strandberg and H. Dreicer. [1954] [2]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 94: 1393-1394, June 1, 1954.

MIT. 11:024 - MIT. 11:027

Use of a combination of microwave spectroscopic and molecular beam techniques produces about a six-fold reduction in the Doppler width of a molecular absorption line by utilizing the effect of matter on the electromagnetic radiation. The high resolution of molecular beam experiments afforded by the interaction of the radiation field and the transverse molecular beam is thus made available for microwave spectroscopic use. An exploratory study of the ammonia inversion absorption transition for the rational state J = 3 is reported wherein K = 3 was observed with the microwave radiation propagated transverse to the beam of ammonia molecules. Conventional means were used to detect and display the radiation. Because of the resulting narrow line-width the microwave was swept in saw-tooth fashion only over a region 80 kc/sec wide, centered at about 23870 mc/sec. Figures are included showing the absorption signal of the ammonia inversion lines (J = 3, K = 3) as observed transverse to the ammonia molecular beam. Further development and use of the procedure is discussed.

MIT. 11:024

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW BASIC THEOREM OF INFORMATION THEORY, by A. Feinstein. June 1, 1954, 28p. (Technical rept. no. 282) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-[42607]) AD 49439 Unclassified

A new theorem for noisy channels, similar to Shannon's in its general statement but giving sharper results, is formulated and proven. It is shown that the equivocation of the channel defined by the present theorem vanishes with increasing code length. A continuous channel is defined in a manner that permits the application of these results. Detailed proof of the equivalence of this definition and Shannon's is given in an appendix. (Contractor's abstract)

MIT. 11:025

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

BASIC DATA OF ELECTRICAL DISCHARGES, by S. C. Brown and W. P. Allis. June 2, 1954, 77p. incl. illus. tables, refs. (Technical rept. no. 283) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 49438 Unclassified

Basic data of electrical discharges is presented under the following eight major headings: (I) Potential Energies; (II) Collision Probabilities; (III) Surface Phenomena; (IV) Motions of Electrons and Ions; (V) Production and Decay of Ionization; (VI) Breakdown; (VII) Electron Energy Loss; and (VIII) Discharge Characteristics.

MIT. 11:026

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CRITERIA FOR DOCILE BEHAVIOR OF FEEDBACK AMPLIFIERS, by S. J. Mason. June 10, 1954, 8p. incl. diagrs. (Technical rept. no. 258) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 57122 Unclassified

A docile amplifier is one that remains stable when connected to an arbitrary passive network of a specified type. Docility criteria are developed for end-loading, for ideal-transformer feedback, and for an arbitrary passive feedback network. (Contractor's abstract)

MIT. 11:027

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HYPERFINE STRUCTURE OF I^{127}. NUCLEAR MAGNETIC OCTUPOLE MOMENT, by V. Jaccarino, J. G. King and others. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42697]) AD 44505 Unclassified

Also published in Phys. Rev., v. 94: 1798-1799, June 15, 1954.

The hyperfine structure of the atomic $^2P_{3/2}$ ground state of the stable isotope of iodine has been studied by the atomic-beam magnetic-resonance method. Mathematical analysis shows the measured intervals as not fitted by dipole and quadrupole-like interactions alone. A mathematical expression for energy levels is given which includes magnetic dipole, electric quadrupole, and magnetic octupole terms. Matrix elements of the dipole and quadrupole moment operators, nondiagonal with respect to J for a given F, are calculated by use of second-order perturbation theory. With the effects of these perturbations by the neighboring $^2P_{1/2}$ fine-structure level included, the measured zero-field intervals are found to be:

Uncorrected

$F=4 \leftrightarrow F=3$: 4226.172 ± 0.015 mc/sec;
$F=3 \leftrightarrow F=2$: 1965.884 ± 0.010 mc/sec;
$F=2 \leftrightarrow F=1$: 737.492 ± 0.008 mc/sec;

Corrected

$F=4 \leftrightarrow F=3$: 4226.161 ± 0.015 mc/sec,
$F=3 \leftrightarrow F=2$: 1965.895 ± 0.010 mc/sec,
$F=2 \leftrightarrow F=1$: 737.492 ± 0.008 mc/sec.

Experimental values for each of the three intervals were obtained by observing transitions for which $\Delta F = 1$, in the region of zero external magnetic field. The corrected intervals give the following values for the interaction constants:

a = 827.265 ± 0.003 mc/sec,
b = 1146.356 ± 0.010 mc/sec,
c = 0.00245 ± 0.00037 mc/sec (att errors rms). From this vatue of c the nuctear magnetic octupote moment is calculated: $(1/2\ (5_z{}^3-3_{zr}{}^2)\ divM)_{I,I} = +0.3\mu_n \times 10^{-24}$ cm^2. This result is not inconsistent either in magnitude or sign with the expected octupote moment of lodine.

MIT. 11:028

Massachusetts Inst. of Tech. [Reseatch Lab. of Electronics] Cambridge.

SIMPLIFIED LCAO METHOD FOR THE PERIODIC POTENTIAL PROBLEM, by J. C. Slater and G. F. Koster. [1954] [32]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 94: 1498-1529, June 15, 1954.

The LCAO, or Bloch, or tight binding, approximation for solids is discussed as an interpolation method, to be used in connection with more accurate calculations made by the cellular or orthogonalized plane-wave methods. It is proposed that the various integrals be obtained as disposable constants, so that the tight binding method will agree with accurate calculations at symmetry points in the Brillouin zone for which these calculations have been made, and that the LCAO method then be used for making calculations throughout the Brillouin zone. A general discussion of the method is given, including tables of matrix components of energy for simpte cubic, face-centered and body-centered cubic, and diamond structures. Applications are given to the results of Fletcher and Wohlfarth on Ni, and Itowarth on Cu, as illustrations of the fcc case. In discussing the bcc case, the splitting of the energy bands in chromium by an antiferromagnetic alternating potential is worked out, as well as a distribution of energy states for the case of no antiferromagnetism. For diamond, comparisons are made with the calculation of Herman, using the orthogonalized plane-wave method. The case of such crystals as InSb is discussed, and it is shown that their properties fit in with the energy band picture. (Contractor's abstract)

MIT. 11:029

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CENTRIFUGAL DISTORTION IN ASYMMETRIC TOP MOLECULES. III. H_2O, D_2O, AND HDO, by D. W. Posener and M. W. P. Strandberg. Mar. 1, 1954 11]p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 44507 Unclassified

Also published in Phys. Rev., v. 95: 374-384, July 15, 1954.

Structurat and potential constants obtained from tnfrared data are used with the theory of vibration-rotation tnteraction to obtain rotationat and distortion parameters for the motecules H_2O, D_2O, and HDO; transition frequencies calcutated using these parameters are compared with those observed in the microwave region, and, in the case of HDO Q-branch lines, a simple relation between the two sets is obtained. The validity of approximation theortes as applied to HDO Q-branch transitions is discussed. Methods of analyzing the observed spectrum of HDO are described, and so-catted "observed" parameters for this motecule are obtained; the rotational constants are found to be a = 7.0396 ± 0.0005 x 10^5 mc/sec, b = 2.7360 ± 0.0005 x 10^5 mc/sec, c = 1.9186 ± 0.0005 x 10^5 mc/sec, k = 0.6841 ± 0.0002. (For Parts I and II see item nos. MIT. 10:028 and MIT. 10:029.)

MIT. 11:030

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

CONDUCTION ELECTRON SPIN RESONANCE ABSORPTION IN SODIUM (Abstract), by I. H. Solt, Jr. and M. W. P. Strandberg. [1954] [1]p. (Sponsored jointly by Signat Corps, Office of Navat Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 607, July 15, 1954.

In order to understand more ctearly the uegree of spin-orhit coupling experienced by the conduction electrons in metals, an accurate measurement has been made of the g value of the spin resonance absorption in sodium. Colloidal suspensions of sodium particles (less than 4 microns in size), ultrasonically dispersed in paraffin wax, were tnvestigated at 9000 mc/sec. The measured g values are g = 2.0012 ± 0.0002 at 300°K and 78°K, and g = 2.0014 ± 0.0002 at 4°K. These values disagree outside the range of experimental error with the value of 2.0019 calculated by Yafet (Phys. Rev., v. 85: 478, 1952). Line-shaped and line-width measurements were also made. The observed line shape was asymmetric and could be explained as the sum of the reat and imaginary parts of the susceptibility where the tmaginary part had a Lorentz shape. The line width at the half power points of the imaginary part of the susceptibility was 11.5 gauss at room temperature and decreased linearly with temperature. This corresponds to a relaxation time of about 5 x 10^{-9} sec at room temperature. (Contractor's abstract)

MIT. 11:031 - MIT. 11:034

MIT. 11:031

Massachusetts Insl. of Tech. [Research Lab. of Electronics] Cambridge.

EFFECTS OF THE DEVIATION OF O_2 FROM HUND (b) (Abstract), by M. W. P. Strandberg and M. Tinkham. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented al meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 623, July 15, 1954.

The rotational Hamiltonian of the oxygen molecule, including lhe spin-spin interaction, is not exactly diagonal in the Hund (b) representation (J^2, J_z, K^2, S^2) where $J = K + S$. Hence K is not a good quantum number, and three poinls should be made. First, the intensities of the oxygen spin triplel spectrum at 5 mm are not exact as given by Van Vleck. He has used the matrix elemenls of S_z in the Hund (b) represenlation rather than in lhe representation which diagonalizes the Hamiltonian. Thus inference of the breadths of the oxygen lines from the observed pressure and intensity, using the Van Vleck formulas, is only approximate. Exact calculation shows that such a procedure will overestimate the actual line width for low K lransitions. Second, lines "forbidden" under the previous analysis now become allowed. For example, the three lowest frequency lines corresponding to changes in $K = 1 \rightarrow 3$ are predicted to be al 368,522 mc/sec, 424,787 mc/sec, and 487,274 mc/sec, wilh intensities respectively of $0.64 \times 10^{-6} cm^{-1}$, and 10^{-6} cm^{-1}, assuming the same $\Delta\nu$ as the 5-mm lines. Third, the weak field Zeeman splitlings will not exactly follow the simple vector model predictions for Hund (b). (Contractor's abstract)

MIT. 11:032

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THE INFLUENCE OF COVALENCE ON ION ORDERING AND DISTORTION IN SPINELS, I (Abstract), by A. L. Loeb and J. B. Goodenough. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 616, July 15, 1954.

In previous attempts to explain the catio[n] distribution in spinel lattices on the basis of elastic and electrostatic energies, covalence was resorted to in order to account for the preference of certain cations for tetrahedral sites. A later treatment, based on the perturbation of d shells by a crystalline field due to surrounding ions, is limited by the assumption of ionic lattice elements. A mechanism based on covalent bonding due to overlap of hybrid orbitals is proposed here to predict the cation distribution and related properties of spinels. Cations in tetrahedral sites usually bond through tetrahedral sp^3 orbitals; in octahedral sites cations are bound ionically, or covalently through either octahedral d^2sp^3 or planar dsp^2 bonds. In the last case the cation is bound covalently to four oxygen ions at the corners of a square, and ionically to two oxygen ions on an axis normal to the square, so that tetragonal distortion of the lattice results. Covalence decreases the electrostatic and modifies the elastic energies. A covalence exchange mechanism is proposed for the indirect interaction between incomplete d shells. (Contractor's abstract)

MIT. 11:033

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

LIGHT DECAY FROM ELECTROLUMINESCENT PHOSPHORS (Abstract), by S. H. Autler and W. F. Roat. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented al meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 599, July 15, 1954.

A series of sludies has been made on powdered electroluminescent phosphors. The phosphors which were of the ZnS:Cu:Pb blue-green type were excited by sharp pulse of current of the order of a microsecond in duration. The pulse of light which followed each current pulse was detected by a photomultiplier after passing through a monochromator. The decay of the light intensity was recorded for several thousand microseconds and was thus observed during a period when the plate was not being excited. The decay rate depended on the wavelength of the light, but in all cases the light fell off much slower than either a linear or bimolecular process would predict. A second current pulse applied in the same direction before the light has ceased completely results in a momentary decrease in output. This suggests that, before emission occurs, electrons must diffuse back to the emission centers from which they have been pulled by the original electric field. Irradiating the phosphor with infrared has marked effects upon its light output and this will be discussed. (Contractor's abstract)

MIT. 11:034

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

MICROWAVE SPECTRUM OF OCS (Abstract), by M. Peter and M. W. P. Strandberg. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research,

and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 622, July 15, 1954.

The $J = 1 \rightarrow J = 2$ transition of OCS has been studied with a microwave spectroscope designed for high sensitivity and high resolution. The line $v_3 = 1$ has been found at 0.85 ± 0.1 mc/sec above the $v_1 = 2$ line. This is the frequency predicted with the α_3 value determined from infrared spectra by Thompson, and agrees with his value within his limits of error. Several quadrupole components of OCS_{33} in the states $v_1 = 1$; $v_2 = 1$; $l = \pm 1$; and $v_2 = 2$ have also been measured and analyzed. (Contractor's abstract)

MIT. 11:035

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

PARAMAGNETIC RESONANCE ABSORPTION IN AMMONIUM CHROME ALUM (Abstract), by C. F. Davis, Jr. and M. W. P. Strandberg. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 607, July 15, 1954.

A study has been made of the paramagnetic resonance absorption in diluted single crystals of ammonium chrome alum at room temperature. Work was done at X, S, and K band and at various orientations of the crystal. These data have been checked with the theoretical predictions of line intensity and position (based on the assumption that the chromium ion is in an electric field of trigonal symmetry). Paramagnetic resonance spectra of single ammonium chrome alum crystals at 77°K have been studied in an attempt to explain the anomalous two splittings of the ground state. (Contractor's abstract)

MIT. 11:036

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THE PHENOMENA OF PLASMA RESONANCE (Abstract), by K. S. W. Champion and S. C. Brown. [1954] 1 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 634, July 15, 1954.

Plasma resonance is associated with the transmission of externally applied high-frequency electromagnetic waves through a plasma. Two types of resonance will be discussed. The first impedance resonance, occurs when the E field at a point has a relative maximum. The second, dielectric resonance, occurs when the dielectric constant is zero at the point considered. Impedance resonance occurs when $ne^2/m\varepsilon_0\omega^2 = 1$ and dielectric resonance when $ne^2/m\varepsilon_0(v_c^2 + \omega^2) = 1$, where n represents the electron density and v_c the electron collision frequency. At low pressures, when $v_c^2 << \omega^2$, the two types of resonance coincide, but they differ at high pressures. Impedance resonance corresponds to greatest ionization and excitation rates. Above dielectric resonance the transmitted electromagnetic waves are strongly attenuated and there is a reflected wave. A special tunable 100 mc/sec resonance cavity was designed so that discharges above plasma resonance could be produced in relatively large volumes. Discharges were obtained which, under the appropriate conditions, exhibited the properties of impedance and dielectric resonance. (Contractor's abstract)

MIT. 11:037

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

SELECTION RULES IN THE MICROWAVE MAGNETIC RESONANCE SPECTRUM OF OXYGEN (Abstract), by M. Tinkham and M. W. P. Strandberg. [1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 622-623, July 15, 1954. 1954.

The X band paramagnetic resonance spectrum of molecular oxygen consists of about 120 lines of observable intensity for magnetic fields below 12 kilogauss. Forty of these lines have been identified by rather tedious calculations. To aid in identifying the others, a circularly polarized radiation field in the cavity containing the sample gas has been used. This field is provided by exciting the two degenerate orthogonal TE_{111} modes in a cylindrical cavity 90° out of phase. This field configuration gives pure circularly polarized radiation only along the axis. Averaging H^2 over the cavity, 52% is circular in one sense, 4% is circular in the other sense, and 44% is axial. Comparison of the two observed spectra with the two senses of rotation unambiguously separates $\Delta M = \pm 1, 0$ transitions. The results are that approximately 95 lines have $\Delta M = +1$, the rest have $\Delta M = -1$. The absence of $\Delta M = 0$ lines

is consistent with detailed calculations which show that their intensities should be down by a factor of at least 100. Another result of the identification is that about two-thirds of the lines observed have the "forbidden" $\Delta J = \pm 2$. They are allowed here because J is not a good quantum number in the presence of the magnetic perturbation. (Contractor's abstract)

MIT. 11:038

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SYNAPTIC TRANSMISSION, by W. S. McCulloch, P. D. Wall and others. Progress rept. for 1953-1954. Aug. 4, 1954, 33p. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 40853 Unclassified

Studies were undertaken to determine if the known properties of peripheral nerve are sufficient to account for some phases of synaptic transmission under the geometrical conditions known to exist. A cat was anesthetized with Dial-Urethane (0.6 cc/kg IP) a tracheal cannula was installed, and artificial respiration was established. The spinal cord was transected at the first cervical vertebra. Heating lamps which were controlled by a subscapular thermistor maintained the body temperature at 38° ± 0.1°C. The lumbar enlargement was exposed and covered with mineral oil which was aerated with 95% O and 5% CO_2. The fifth and sixth dorsal roots on one side were severed about 8 cm from the cord and placed on bipolar electrodes for test and conditioning stimulation, respectively. Supramaximal shocks of 0.1-msec duration were delivered every 2 sec through isolating transformers. Records of potentials throughout the transverse plane in the ipsilateral half of the spinal cord a few mm rostral to the fifth lumbar were obtained through microelectrodes (10-μ Pt wire) which were coated with a thin layer of glass and sharpened. About 1500 recordings were obtained. The existence of a conditioned block in primary afferent fibers within the cord was shown by (1) source-sink maps within the cord and (2) direct records of conducted volleys in the thoracic dorsal columns. A new method which was devised for tracing the anatomical course of axons up to their terminals involved local antidromic stimulation of the collaterals. This antidromic stimulation was used to measure the threshold change of collaterals caused by activity in the collaterals or neighboring fibers.

MIT. 11:039

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

MICROWAVE DETERMINATION OF THE PROBABILITY OF COLLISION OF ELECTRONS IN HELIUM, by L. Gould and S. C. Brown. [1954] [7]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 44502 Unclassified

Also published in Phys. Rev., v. 95: 897-903, Aug. 15, 1954.

A previously reported microwave method for determining the collision probability for momentum transfer of slow electrons has been modified so that a variation in average electron energy from 0.012 ev to 3 ev may be obtained. Measurements of the ratio of the real part to the imaginary part of the electron conductivity are performed in the afterglow of a pulsed helium discharge in a microwave resonant cavity. The average electron energy is varied by applying a microwave electric field in the afterglow and, under appropriate assumptions, the average electron energy is determined theoretically from this field. Measurements are also obtained by varying the gas temperature from 77°K to 700°K. The value of the collision probability for momentum transfer in helium is 18.3 ± 2% cm^2/cm^3 per mm Hg from 0 to 0.75 electron volts and increases slowly to a peak value of 19.2 ± 2% at 2.2 ev.

MIT. 11:040

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

WHY AND HOW DO WE STUDY THE SOUNDS OF SPEECH? by M. Halle. [1954] [11]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 52555 Unclassified

Also published in Georgetown U. Monograph Series on Languages and Linguistics, No. 7: 73-83, Sept. 1954.

The purpose of this paper is to show, contrary to the viewpoint of many linguists and phoneticians, that a sharp distinction between phonetics and phonemics cannot usefully be maintained; that phonetics actually makes use of considerations which are strictly phonemic; that physical criteria are an integral part of phonemics; and that a description of language on any level, from phonetics to stylistics, cannot be properly evaluated without considering its consequences on all other levels.

MIT. 11:041

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

WAVE FUNCTIONS FOR IMPURITY LEVELS, by G. F. Koster and J. C. Slater. [1954] [10]p. incl. diagrs. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-42607] Unclassified

Published in Phys. Rev., v. 95: 1167-1176, Sept. 1, 1954.

The calculation of impurity levels in crystals is set up in terms of a linear combination of Wannier functions. The coefficients of this linear combination are shown to satisfy a set of difference equations. These difference equations are solved for two simple linear chain impurity problems. The difficulties encountered in solving the difference equations are explored on the basis of these examples and a general method of solving difference equations arising from impurity calculations is presented. This method seems to have advantages over previous methods of solving the impurity problem in crystals. (Contractor's abstract)

MIT. 11:042

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOISE IN ONE-DIMENSIONAL ELECTRON BEAMS, by H. A. Haus. Sept. 9, 1954 [12]p. incl. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-[42607]) AD 96415 Unclassified

Also published in Jour. Appl. Phys., v. 26: 560-571, May 1955.

A generalized theory of noise in one-dimensional electron beams is developed with the aid of the theory of four-terminal networks. No specific assumptions are made as to the input noise velocity and current modulations and their correlation at the potential minimum. The ensuing theory is simpler and more general than the corresponding theories used in the past. Transformations are discussed of the standing wave of the meansquare noise current in drift regions by means of "lossless beam transducers." It is shown that such transformations can be reduced to the formalism of conventional impedance transformations. Expressions are derived for the minimum obtainable noise figures of a velocity-jump amplifier, a klystron, and a traveling wave tube. It is proved that these expressions present an ultimate limit for the noise figures of the respective tubes with regard to transformations by beam transducers with and without loss. (Contractor's abstract)

MIT. 11:043

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THEORY OF SCATTERING IN SOLIDS, by G. F. Koster. [1954] [8]p. incl. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 95: 1436-1443, Sept. 15, 1954.

The scattering of an electron by an imperfection in a lattice is set up in terms of a linear combination of the Wannier functions associated with the lattice. The difference equations which the coefficients of the Wannier functions satisfy are discussed in the light of simple examples. A Green's function formulation of the difference equations is then introduced which leads to the proper asymptotic behavior of the scattered wave. This approach avoids many of the unwarranted assumptions usually made in the discussion of scattering in solids.

MIT. 11:044

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TRANSATLANTIC FREQUENCY-MODULATION EXPERIMENTS, by L. B. Arguimbau, J. Granlund and others. Sept. 20, 1954, 49p. incl. illus. (Technical rept. no. 278) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 54506 Unclassified

This report describes a series of three transatlantic frequency-modulation experiments that were conducted in 1950, 1951, and 1953. The purpose of the first test was to investigate the possibility of establishing a radio link of local broadcast quality over an ionospheric path by using a special frequency-modulation receiver particularly designed to combat two-signal and two-path interference. The desired audio-quality was not achieved in this test. An attempt was made in the second test to improve the quality of the received program by using a type of nonlinear filter; in the third, by using a highly directive antenna; but even with the aid of these devices, broadcast quality was not achieved. The failure of the frequency-modulation system is explained in terms of the complexity of the ionospheric path. This complexity is illustrated in a series of pictures of patterns received during pulsed-carrier transmissions. A system called frequency-shift modulation, which should be capable of providing high-quality transmission through a dispersive medium, such as the ionosphere, is described in the appendix. (Contractor's abstract)

MIT. 11:045

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ERROR-FREE CODING, by P. Elias. Sept. 22, 1954, 12p. incl. diagr. (Technical rept. no. 285) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 61872 Unclassified

Presented at Symposium on Information Theory, Mass. Inst. of Tech., Cambridge, Sept. 15-17, 1954.

Also published in I. R. E. Trans. of Professional Group on Information Theory, PGIT-4: 29-37, Sept. 1954.

MIT. 11:046 - MIT. 11:048

Some simple constructive procedures are given for coding sequences of symbols to be transmitted over noisy channels. A message encoded by such a process transmits a positive amount of information over the channel, with an error probability which the receiver may set to be as small as it pleases, without consulting the transmitter. The amount of information transmitted is less than the channel capacity, so the procedures are not ideal, but they are quite efficient for small error probabilities. It is shown that there exist codes of the same error-free character which transmit information at rates arbitrarily near the channel capacity. (Contractor's abstract)

MIT. 11:046

Massachusetts Inst. of Tech. Research Lab. of Electronics. Cambridge.

PRINTED MICROWAVE SYSTEMS, by M. Schetzen. Sept. 30, 1954, 39p. incl. diagrs. tables, refs. (Technical rept. no. 289) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607)
AD 66376 Unclassified

The results of a theoretical and experimental investigation of the free modes that propagate on the strip transmission line are reported. A Fourier integral solution is obtained for the free modes. Since the integrals must be solved by numerical methods, approximate equations for the phase velocity, attenuation, and the characteristic impedance are developed for the "two-conductor" H-E mode. It is shown that a static assumption for the H-E mode is good only as a first approximation. In the course of the discussion, it is proved that the only free modes that may exist on any n-conductor system of arbitrary but constant cross section in homogenous and simply connected space are TEM modes. Previously known methods for the determination of the guide wavelength and attenuation required that the standing waves of the strip transmission line be known. It was found that these could not be measured directly. Since precedent measuring methods were found to be inadequate, a new simple method for measuring the attenuation of any transmission line through a junction is presented. (Contractor's abstract)

MIT. 11:047

Massachusetts Inst. of Tech. Research Lab. of Electronics. Cambridge.

THEORY OF THE INTERACTION OF HINDERED INTERNAL ROTATION WITH OVER-ALL ROTATIONS. I. SYMMETRIC ROTORS: METHYL SILANE, by D. Kivelson. Oct. 1954 7 p. incl. diagr. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607.) Unclassified

Published in Jour. Chem. Phys., v. 22: 1733-1739. Oct. 1954.

An approximate theory of the interactions of hindered internal rotation with over-all rotations of symmetric rotors is given. This treatment considers the interdependence of hindered internal rotation and vibrations and their effect upon the rotational energy levels. The resulting expression for the frequencies of $\Delta K = 0$, $\Delta J = 1$ transitions is:
$\nu = 2J[B_v + F_v(m|1-\cos 3\theta|m) + G_v(m|\Pi_z^2|m) + L_v K(m|\Pi_z|m)]$, where B_v, F_v, G_v, and L_v are constants independent of the rotational quantum numbers, m represents the basis that diagonalizes the Hamiltonian corresponding to pure internal rotation, Π_z is the internal angular momentum operator, and θ is the angle of internal rotation. Procedures for evaluating $(m|1-\cos 3\theta|m)$ and $(m|\Pi_z^n|m)$ in terms of a parameter α are given. This theory has been applied to the $J = 0 \rightarrow 1$ transitions of methyl silane. The parameters B_v, F_v, G_v, and α were obtained empirically and were then used to calculate frequencies. The agreement between observed and calculated values was quite good. Furthermore, the anomalous ordering of the lines observed by Lide and Coles is explained by these calculations. Assuming a cosine potential, the barrier height V_0 is proportional to the parameter α. The value of V_0 was set at 558 cm^{-1} + 17 cm^{-1}. The constant B_v, which is the rotational constant in the ground torsional state for the limiting case of $V_0 = 0$, is 10985.79 mc/sec and 9636.50 mc/sec for CH_3SiH_3 and CH_3SiD_3, respectively. (For Parts II, III, IV see item nos. MIT. 12:066, 067, and 097.)

MIT. 11:048

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HELICAL COUPLING SYSTEM, by A. J. Lichtenberg. Oct. 6, 1954, 27p. incl. diagrs. table, refs. (Technical rept. no. 290) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607)
AD 63865 Unclassified

A theory of power coupling between concentric, contrawound sheath helices has been presented by Kompfner and further amplified by Wade. In Section I of this report a modification of this theory is presented in the light of experimental results, in order to give a more accurate picture of the conditions for complete power transfer from one helix to the other. From the assumption of a sheath helix in free space, a beat wavelength is determined. Correction factors are applied to this result to account for the fact that an actual wire helix is used, and to account for the presence of an environment other than free space. The validity of these correction factors is examined by comparison with experimental results. In Section II the problem of matching a helix to a coaxial line is investigated. A procedure is developed by which the impedance of a helix within a shield may be matched to a coaxial line. With these data and the material developed in Section I, a complete coupling, capable of use on a traveling-wave tube or backward-wave

oscillator, is designed and tested. (Contractor's abstract)

MIT. 11:049

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NUCLEAR MAGNETIC OCTUPOLE MOMENTS OF THE STABLE GALLIUM ISOTOPES, by R. T. Daly, Jr. and J. H. Holloway. [1954] [2]p. incl. illus. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) Unclassified

Published in Phys. Rev., v. 96: 539-540, Oct. 15, 1954.

The measured and corrected hyperfine structure intervals of the metastable $^2P_{3/2}$ states of Ga^{69} and Ga^{71} are reported for F = 0 $\longleftrightarrow$ F = 1, F = 1 $\longleftrightarrow$ F = 2, and F = 2 $\longleftrightarrow$ F = 3. The magnetic dipole (a), electric quadrupole (b), and magnetic octupole (c) interaction constants are calculated from the corrected intervals: (for Ga^{69}) a = 190.794280 ± 0.000150 mc/sec, b = 62.522470 ± 0.000300 mc/sec, c = 84 ± 6 cycles/sec; for (Ga^{71}) a = 242.433950 ± 0.000200 mc/sec, b = 39.399040 ± 0.00400 mc/sec, c = 115 ± 7 cps. The nuclear octupole moments for Ga^{69} and Ga^{71} are $0.107 \pm 0.02 \times 10^{-24}$ and $0.146 \pm 0.02 \times 10^{-24}$ nuclear magneton cm^2.

MIT. 11:050

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXCITATION OF CIRCULAR POLARIZATION IN MICROWAVE CAVITIES, by M. Tinkham and M. W. P. Strandberg. Oct. 28, 1954, rev. Jan. 21, 1955 [5]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 76341 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 734-738, June 1955.

The usefulness of exciting a single circulatory-polarized mode in a microwave cavity is indicated. A matrix method is presented then for the analysis of the operation of various components, such as transition pieces and differential phase shifters on waves propagating in waveguides with two degnerate orthogonal modes. This method is applied to describe three distinct systems for generating the desired circular polarization in a cavity that is coupled directly to the side wall of a waveguide. The final system, which involves a minimum of critical adjustments, is described in more detail and its performance is indicated. It is shown that purely circular radiation can be set up along the axis of the cavity. However, the largest preponderance of one rotating mode over the other which can be set up, if one averages over the entire cavity volume, is 11.5 to 1. This value is obtained with the TE_{11_n} modes. (Contractor's summary)

MIT. 11:051

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LIMITATIONS ON THE NOISE FIGURE OF MICROWAVE AMPLIFIERS OF THE BEAM TYPE (Abstract), by H. A. Haus. [Nov. 1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) Unclassified

Presented at joint meeting of I. R. E. Professional Group on Electron Devices and Working Group on Microwave Tubes, Symposium on Fluctuation Phenomena in Microwave Sources, New York, Nov. 18-19, 1954.

Published in I. R. E. Trans. of Professional Group on Electron Devices, v. ED-1: 238-257, Dec. 1954.

An analysis based on one-dimensional, single-velocity assumptions leads to the result that all microwave amplifiers of the beam type (such as traveling-wave tubes, velocity jump amplifiers, klystrons, and the like) have a minimum obtainable noise figure of the form

$$F_{min} = 1 + \frac{2\pi}{kT} K(S_o - \pi_o) \quad (1)$$

where S_o and π_o are parameters of the beam noise e expressed in terms of the noise fluctuations at a cross section slightly beyond the potential minimum in the electron gun, T is the temperature of the circuit, and K is a constant of the particular structure employed. Expression (1) holds for any optimized noise-reducing scheme. It includes, for instance, a prehelix that is excited by the noise in the beam and feeds into the main helix of a traveling-wave tube in an attempt to cancel part of the noise in the beam. The dependence of the constant K upon the particular structures used will be discussed. (Contractor's abstract)

MIT. 11:052

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOISE MEASUREMENTS ON LONG ELECTRON BEAMS (Abstract), by L. D. Smullin. [Nov. 1954] [1]p. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under AF 19(122)458 and DA 36-039-sc-42607] Unclassified

Presented at joint meeting of I. R. E. Professional Group on Electron Devices and Working Group on Microwave Tubes, Symposium on Fluctuation Phenomena in Microwave Sources, New York, Nov. 18-19, 1954.

MIT. 11:053 - MIT. 11:056

Published in I. R. E. Trans. of Professional Group on Electron Devices, v. ED-1: 168-183, Dec. 1954 (Title varies).

Measurements of microwave noise have been made on electron beams formed by several different guns. They include parallel beam guns with cathode emersed in the magnetic field and converging flow guns with cathode outside the magnetic field. In general, two regions of behavior have been noted: one in which the noise current density varies sinusoidally with distance; one in which the noise current increases rapidly with distance. The latter behavior has been called the growing noise wave. The way in which these two different noise regimes respond to various parameters will be described. (Contractor's abstract)

MIT. 11:053

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

SIMPLIFIED IMPURITY CALCULATION, by G. F. Koster and J. C. Slater. [1954] [16]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 96: 1208-1223, Dec. 1, 1954.

The methods of previous papers by the authors are applied to a simplified impurity calculation. This is the case of a localized perturbation in a simple cubic lattice. The effect is considered of the perturbation on a single band which is describable in terms of a Wannier function which only has nearest neighbor interactions. The results of this calculation are compared with some approximate treatments of impurity calculations. (Contractor's abstract)

MIT. 11:054

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

OPTICAL STUDIES OF RADIOACTIVE MERCURY, by F. Bitter, S. P. Davis and others. [1954] [9]p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, [Air Force Office of Scientific Research, and Atomic Energy Commission under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 96: 1531-1539, Dec. 15, 1954.

A technique has been developed for studying the hyperfine structure of the resonance radiation of mercury. A single Zeeman component of the 2536A line of Hg^{198} is used as a variable-frequency monochromatic light source, and the field strength applied to the arc lamp to produce resonance absorption in a resonance lamp as a measure of the resonance frequency. Natural mercury, and radioactive mercury produced by bombarding gold with 15-mev deuterons were investigated in this way and also (by means of an echelle spectrograph) in the emission spectrum of an electrodeless discharge. Several observed lines have not been conclusively identified. The magnetic moment of Hg^{197} is 4 percent greater than that of Hg^{199}. The isotope shift of isotopes with even mass number decreases with decreasing mass number. This effect may be due in part to the increasing quadrupole moment with neutron deficiency in these isotopes. (Contractor's abstract)

MIT. 11:055

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN APPROXIMATION METHOD WITH RATIONAL FUNCTIONS, by N. DeClaris. Dec. 30, 1954, 27p. incl. diagrs. refs. (Technical rept. no. 287) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 63864 Unclassified

A general method is developed for finding functions of a single complex variable s, which approximates an assigned network characteristic, within the special class of functions realizable as networks of linear lumped parameter elements. The method is based upon an interpolation technique with a series of general rational functions on the unit circle of the z-plane. A number of transformations that map the interval of interest of the s-plane into the unit circle of the z-plane are discussed. A great advantage of this method is that it allows one to preassign the pole location of the desired rational function anywhere in the left-half of the s-plane. Following a formal mathematical treatment, procedures are outlined for three cases of approximation in both the frequency and the time domain. A number of examples illustrate the wide range of applicability.

MIT. 11:056

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ANALOGUE STUDY OF ELECTRON TRAJECTORIES, by B. F. Logan, G. R. Welti, and G. C. Sponsler. [1954] [14]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 89136 Unclassified

Also published in Jour. Assoc. Computing Machinery, v. 2: 28-41, Jan. 1955.

The Dynamic Analysis and Control Lab. (D. A. C. L.) at M. I. T. demonstrated another usefulness of simulation techniques by applying the D. A. C. L. Generalized Computer to a problem in electron optics. Standard D. A. C. L. analogue computing components were employed, together with an electrolytic tank, to

generate electron trajectories directly at speeds of the order of 1 in./sec. With minor setup changes, the same equipment was used to map the electrostatic field in the tank.

MIT. 11:057

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STUDIES ON THE NATURE OF REFLEX INHIBITION PRODUCED BY THE INTERACTION OF VOLLEYS RUNNING IN NEIGHBORING DORSAL ROOTS, by B. Howland, J. Y. Lettvin and others. [Jan. 1954] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607; and in part by the Bell Telephone Labs., Inc. and the Teagle Foundation) Unclassified

Published in Jour. Neurophysiol., v. 18: 1-17, Jan. 1955.

Dorsal roots L_6 and L_5 were stimulated in such a way that a volley in one inhibited the motor response to a volley in the other. With multiple microelectrode placements, the potential changes were measured and the current distribution calculated in a cross section of the cord traversed by these dorsal root fibers. This enabled the intramedullary course of afferent impulses to be followed. It was shown that, after stimulus of L_6, test volleys in L_5 failed to invade collaterals of the primary axons. It is concluded that one type of inhibition involves blocking afferent nerve impulses before they have reached the region of cells. (Contractor's abstract)

MIT. 11:058

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TWO BITS WORTH OF INFORMATION THEORY (Abstract), by R. M. Fano. [Jan. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039 sc 42607) Unclassified

Presented to the AIEE Technical Group on Communication (Boston Section), Boston, Mass., Jan. 4, 1955.

The process of communication plays a predominant role in most human activities. Information theory has provided a new and powerful way of analyzing communication problems such as those that arise in the study of languages, hearing, and vision, as well as those arising in the design of electrical communication systems. After a brief presentation of the basic concepts of information theory, a number of illustrative examples selected from recent research in various fields will be discussed. (Contractor's abstract)

MIT. 11:059

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HIGH-FREQUENCY GAS DISCHARGE PLASMA IN HYDROGEN, by D. J. Rose and S. C. Brown. [Jan. 13, 1955] [7]p. incl. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) AD 106988 Unclassified

Also published in Phys. Rev., v. 98: 310-316, Apr. 15, 1955.

The high-frequency electric field required to maintain a hydrogen plasma has been measured as a function of pressure and plasma electron density. A theory of the plasma based on a solution of the Boltzmann transport equation has been developed to predict this field; it agrees satisfactorily with experiment. The theory has no adjustable parameters, and uses only the probabilities of collision, excitation, and ionization of the gas by electrons, and the ionic mobility. (Contractor's abstract)

MIT. 11:060

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

VELOCITY ANALYSIS OF THERMIONIC EMISSION FROM SINGLE-CRYSTAL TUNGSTEN, by A. R. Hutson. Jan. 13, 1955 [13]p. incl. illus. tables, refs. (Technical rept. no. 260) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 68083 Unclassified

Also published in Phys. Rev., v. 98: 889-901, May 15, 1955.

A 180° magnetic velocity analyzer tube has been used to observe the energy distributions of the thermionic emission from various crystallographic directions of a single-crystal tungsten filament. The distributions were the same in all of the directions and were not Maxwellian. An energy-dependent reflection coefficient for the tungsten surface, previously proposed by Nottingham, is capable of explaining the shape of the distributions quite well. The tube permitted measurements of the differences between the true work-functions of the various directions. The changes of true work functions with temperature between 1700°K and 2000°K were also measured for all directions except the (110). The non-Maxwellian character of the energy distributions and the temperature variations of the work functions can largely explain the discrepancy between the emission constant, A 120, of Richardson's equation and the Richardson plot emission constants obtained for the various directions of a tungsten crystal by Nichols and by Smith. (Contractor's abstract)

MIT. 11:061 - MIT. 11:063

MIT. 11:061

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF HYPERFINE STRUCTURE I, by C. Schwartz. [1955] [16]p. incl. diagrs. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-42607]) Unclassified

Published in Phys. Rev., v. 97: 380-395, Jan. 15, 1955.

Considering the classical electric and magnetic interactions between atomic electrons and the nucleus, a representation is arrived at of the hyperfine interactions in terms of a multipole expansion of the field potentials. Treating these noncentral interactions in first order perturbation theory, the form can be given of the general interval structure and analyzed for the multipole interaction constants using Racah coefficients. Pertinent matrix elements for a single valence electron are calculated relativistically. Some second order terms of the dipole and quadrupole interactions are calculated as they affect the interpretation of the first order octupole interaction. Also, the effect of some electronic configuration interactions is quantitatively considered. Finally the value of nuclear magnetic octupole moments expected according to different models are calculated and compared with the experimental data thus far collected. Generally the measured octupole moments are in as good agreement with the values predicted by the single-particle shell model as are the corresponding dipole moments. (Contractor's abstract)

MIT. 11:062

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TIME-DOMAIN COMPENSATION FOR CLOSED-LOOP SYSTEMS BY A DELAY LINE METHOD, by Y.-C. Ho. Jun. 17, 1955. 33p. incl. illus. diagrs. tables, refs. (Technical rept. no. 288) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607) AD 85767 Unclassified

This report presents a new approach to the synthesis and analysis of closed-loop systems in the time domain. In general, it investigates the effect of the discrete filter

$$D(s) = \sum_{k=0}^{n} a_k e^{-skT} = a_0 + a_1 e^{-sT} + \ldots + a_n e^{-snT}$$

in compensating for feedback systems, and its resultant transient response. First the generality, simplicity, and flexibility of the discrete filter are demonstrated. The properties of D(s) when cascaded with other elements are then studied in both the time and the frequency domain. The procedure for designing D(s) to compensate a given system is carried out entirely in the time domain. It is based on the "reshaping of the open-loop impulse response of the system." Saturation and other constraints can be taken into account during the determination of D(s). The procedure is iterative and is carried out graphically in terms of the time functions involved; it is simple, effective, and down-to-earth. The basis of this method is analyzed in terms of servo and network theory. Several methods are presented for calculating the closed-loop response of the compensated system. A specific example is designed according to the procedure and its transient response calculated. The results agree well with similar ones obtained by computer simulation. An actual experimental servo system was designed on this basis. The realization of a practical D(s) for servo systems is discussed; several methods of doing this are presented. The performance of the experimental system further verifies the validity of this approach. (Contractor's abstract)

MIT. 11:063

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF THE FINE STRUCTURE OF THE MOLECULAR OXYGEN GROUND STATE AND THE MEASUREMENT OF ITS PARAMAGNETIC SPECTRUM, by M. Tinkham and M. W. P. Strandberg. Feb. 1, 1955 [30]p. incl. diagrs. tables, refs. (Technical rept. no. 281) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-42607; continued by DA 36-039-sc-64637) AD 63863 Unclassified

Also published in Phys. Rev., v. 97: 937-966, Feb. 15, 1955.

Part I. Theory of the Fine Structure of the Molecular Oxygen Ground State: A rather complete solution for the fine-structure problem in the oxygen molecule is given in the framework of the Born-Oppenheimer approximation. The reduction of the effect of the electronic state on the fine structure to an effective Hamiltonian, involving only the resultant electronic spin in addition to rotational and vibrational quantum numbers, is demonstrated. In this Hamiltonian the parameters λ and α measure the effective coupling of the spin to the figure axis and the rotational angular momentum, respectively. The contributions to these parameters which are diagonal in electronic quantum numbers, namely λ^{-1} and α^{-1}, are evaluated by using an expression for the electronic wave function as a superposition of configurations. The second-order contributions of spin-orbit coupling and rotation-induced electronic angular momentum to λ and α, and the electronic contribution to the effective moment of inertia are related to each other. This interrelation enables them all to be essentially evaluated experimentally. Part II. Interaction of Molecular Oxygen with a Magnetic Field: The dominant interaction of O_2 with a magnetic field is through the electronic spin magnetic moment. However, a precise comparison with experiment of the results of calculating the microwave paramagnetic spectrum, assuming only this interaction,

shows a systematic discrepancy. This discrepancy is removed by introducing two corrections. The larger is a correction for the second-order electronic orbital moment coupled in by the spin-orbit energy. The smaller is a correction for the rotation-induced magnetic moment of the molecule. Since the dependence of this contribution on quantum numbers is quite unique, this coefficient can also be determined by fitting the magnetic spectrum. A new result is the rotational magnetic moment of -0.25 ± 0.05 nuclear magnetrons per quantum of rotation. Knowledge of this moment allows the electronic contribution to the effective moment of inertia to be determined. Theoretical intensities of a number of the microwave transitions are calculated and successfully compared with experiment over a range of 100 to 1 in magnitude. (Contractor's abstract, modified)

MIT. 12:001

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DOCILE BEHAVIOR OF FEEDBACK AMPLIFIERS, by S. J. Mason. Feb. 10, 1955 [7]p. incl. illus. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637; continuation of DA 36-039-sc-42607] AD 103572 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 781-787, June 1956.

A docile amplifier is one that remains stable when connected to any passive network of a specified class. A simplified geometrical approach is used to derive that docility criteria for passive-end-loading. Ideal transformer feedback, bilateral passive feedback, and arbitrary passive feedback.

MIT. 12:002

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CAVITIES AND WAVEGUIDES WITH INHOMOGENEOUS AND ANISOTROPIC MEDIA, by A. D. Berk. Feb. 11, 1955. 58p. incl. diagrs. (Technical rept. no. 284) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 107541 Unclassified

With the advent of ferrites at microwave frequencies, the treatment of electromagnetic boundary-value problems involving anisotropic substances has become more than an academic exercise. Since exact methods of analysis often encounter formidable mathematical difficulties, it is necessary to resort to approximate calculations. Two such methods are developed. The first one is based on a mode-expansion analysis, the second on variational calculations. The former is applied to the determination of resonant frequencies and impedance matrices of cavities and to the determination of propagation constants of waveguides. The variational method is utilized in obtaining approximate expressions for resonant frequencies of cavities and for cut-off frequencies and propagation constants of waveguides. Several examples with emphasis on microwave components containing ferrites are worked out. The results indicate that it is often possible to obtain approximate, yet sufficiently accurate, solutions of problems of which the exact solutions are extremely difficult. The interesting problems of the completeness of a set of cavity modes is briefly treated in Appendix I. Several points of view are reviewed and reconciled with some modification. It appears that Slater's treatment of "empty" cavities is, for all practical purposes, complete. (Contractor's abstract)

MIT. 12:003

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE STUDY OF POSITIVE ION COLLECTION BY PROBES, by G. J. Schulz and S. C. Brown. Feb. 14, 1955 [8]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 102872 Unclassified

Also published in Phys. Rev., v. 98: 1642-1649, June 15, 1955.

The theory of the positive ion saturation region of probes at low pressure is modified to take into account the directed current at the sheath edge. This drift current explains the discrepancy between the theoretical and experimental ratio of the electron saturation probe current to the positive ion saturation probe current. The theory is checked using microwave methods to obtain an independent measurement of the ion density. Probe and microwave measurements are compared in the pressure region of 0.05 - 6 mm Hg in hydrogen, argon, and helium. (Contractor's abstract)

MIT. 12:004

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

ANTIFERROMAGNETISM, by G. W. Pratt, Jr. [1955] [7]p. incl. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force] Office of Scientific Research under DA 36-039-sc-64637.]) Unclassified

Published in Phys. Rev., v. 97: 926-933, Feb. 15, 1955.

The nature of the spin coupling in MnO is discussed, the details of the discussion being based on a very simplified three-center system. The coupling between magnetic ions whose charge densities interact with an intervening nonmagnetic ion but not directly with each other is described as the result of the polarization of

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the nonmagnetic ion. The configuration interaction representation of this polarization is treated by non-orthogonal orbitals, orthogonal orbitals, and by Kramers' method. These three approaches are applied to a numerical example. It is concluded that a reliable description of the simple three-center problem is more complicated than generally believed due to the importance of highly excited states of the system which have been neglected in previous treatments of the problem. (Contractor's abstract)

MIT. 12:005

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INTERACTION OF MOLECULAR OXYGEN WITH A MAGNETIC FIELD, by M. Tinkham and M. W. P. Strandberg. [1955] [16]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Published in Phys. Rev., v. 97: 951-936, Feb. 15, 1955.

The dominant interaction of O_2 with a magnetic field is through the electronic spin magnetic moment. However, a precise comparison with experiment of the results of calculating the micro-wave paramagnetic spectrum, assuming only this interaction, shows a systematic discrepancy. This discrepancy is removed by introducing two corrections. The larger (~0.1 percent, or 7 gauss) is a correction for the second-order electronic orbital moment coupled in by the spin-orbit energy. Its magnitude is proportional to the second-order term μ'' in the spin-rotation coupling constant. The smaller (~1 gauss) is a correction for the rotation-induced magnetic moment of the molecule. Since the dependence of this contribution on quantum numbers is quite unique, this coefficient can also be determined by fitting the magnetic spectrum. A total of 120 X-band and 78 S-band lines were observed. The complete corrections have been made on 26 lines with a mean residual error of roughly 0.5 mc/sec. This excellent agreement confirms the anomalous electronic moment to 60 parts per million (ppm) and also confirms the validity of the Zeeman effect theory. A new result is the rotational magnetic moment of -0.25 ± 0.05 nuclear magnetons per quantum of rotation. Knowledge of this moment allows the electronic contribution to the effective moment of inertia to be determined. Making this correction of 65 ppm, and using the latest fitting of the universal atomic constants, the equilibrium internuclear distance is recomputed to be R_e = 1.2074 ± 0.00002 A. It is deduced that the magnitude of γ'', the second-order spin-orbit contribution to the coupling of the spin to the figure axis, is 465 ± 50 mc/sec, or less than one per cent of the total coupling constant γ. Theoretical intensities of a number of the microwave transitions are calculated and successfully compared with experiment over a range of 100 to 1 in magnitude. It turns out that $\Delta M = 0$ transitions are over a hundred times weaker than the $\Delta M = \pm 1$ transitions and thus are too weak to observe. Also, J breaks down as a quantum number in the presence of a magnetic field. This allows $\Delta J = \pm 2$ transitions to comprise roughly half of all lines observed. (Contractor's abstract)

MIT. 12:006

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ATOMIC FREQUENCY STANDARD (Abstract), by J. R. Zacharias, J. G. Yates, and R. D. Haun, Jr. [Mar. 1955] [2]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the I. R. E. National Convention, New York, Mar. 21-24, 1955.

The hyperfine-structure resonance line of atomic cesium at approximately 9192.632 mc/sec has been used to stabilize the frequency of a microwave signal generator. This resonance frequency, describable as the Larmor precession frequency of the valence electron of atomic cesium in the magnetic field of the atomic nucleus, is observed by the atomic beam magnetic resonance method as a resonance curve with a half-width of approximately 200 cps. The choice of an atomic beam of cesium for this purpose was suggested by Professor I. I. Rabi sometime before 1940, but the techniques necessary to make it into a practical device have become available only in the last few years in connection with researches on rare isotopes of the alkali atoms. These techniques will be described. The atomic beam is contained in a stainless steel tube, 6 feet long and 10 inches in diameter. The atoms emerge at a temperature of about 80°C as a directed beam from 100 long canals forming the exit to a reservoir which holds the metallic cesium; they then pass through an inhomogeneous field of about 10,000 gauss/cm to produce a sideways deflection of their motion; they then pass through two cavities resonant at 9192 mc/sec and 66 cm apart; then through another inhomogeneous magnetic field similar to the first, and finally to a hot wire detector to measure the number of those atoms which have absorbed or emitted radiation in the resonant cavities. After striking the hot wire they are re-evaporated as positive ions which are accelerated to the first plate of a cascade electron multiplier. The impact of each ion results in a burst of about 10^7 electrons at the final stage of the electron multiplier, thus permitting counting of individual atoms or determining the average atom current. The resonant cavities are fed in-phase by a passive frequency tripler which receives its power from an oscillator at 3064 mc/sec. The power in the cavities is sufficient to effect absorption or stimulated emission by the atoms of the beam. Either process so changes their motion to enable them to strike the detector and be counted. The output of the detector is used in a variety of ways, one of which is to provide a voltage to lock the frequency of the oscillator to the resonance frequency of the atom. Preliminary results show that the short time stability thus obtained (for times less than 1 sec) is better than 1 part

in 10^9 and that the average stability for long times will be considerably better than this. The beam tube has run satisfactorily for periods as long as 50 days, indicating that a sealed-off tube with a life of several years should be quite possible. Commercial production of a sealed-off version of this device has been started. (Contractor's abstract)

MIT. 12:007

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CODING FOR NOISY CHANNELS (Abstract), by P. Elias. [Mar. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the I. R. E. National Convention, New York, Mar. 21-24, 1955.

Published in I. R. E. Convention Record, Pt. IV: 37-46, 1955.

A remarkable result of Shannon's Mathematical Theory of Communication is the fact that information can be transmitted at a definite rate over a noisy channel, with as low an error probability as is desired, by properly matching the message to the noisy channel. The matching process is called "coding." The problem of designing codes for particular noisy channels is central for many applications of the theory. This paper reviews the progress which has been made in coding, especially for the noisy binary channel. Some new results will be presented on the dependence of error probability and efficiency on coding delay and equipment complexity. (Contractor's abstract)

MIT. 12:008

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A METHOD OF RATIONAL FUNCTION APPROXIMATION FOR NETWORK SYNTHESIS, by N. DeClaris. [Mar. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the I. R. E. National Convention, New York, Mar. 21-24, 1955.

Published in I. R. E. Convention Record, Pt. II: 51-58, 1955.

A general method is developed for finding functions of a single complex variable s, which approximates an assigned network characteristic within the special class of functions realizable as networks of linear lumped parameter circuits. The method is based upon an interpolation technique with a series of general rational functions on the unit circle of the z-plane. A number of transformations that map the interval of interest of the s-plane into the unit circle of the z-plane are discussed. A great advantage of the method presented in this paper is that it allows preassigning, if so desired, the pole location of the desired rational function anywhere in the left half of the s-plane. In addition to this freedom, it also makes it possible to approximate on some contour of the complex plane the function itself rather than its modulus. Indeed, in some applications of electric circuits, one is interested in both the magnitude and phase characteristics of a network in a specified frequency interval. Following a formal mathematical treatment, procedures are outlined for three cases of approximation in both the frequency and the time domain. (Contractor's abstract)

MIT. 12:009

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PREDICTIVE CODING. PARTS I AND II, by P. Elias. [1955] [18]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 76343 Unclassified

Also published in I. R. E. Trans. on Information Theory, v. IT-I: 16-33, Mar. 1955.

Predictive coding is a procedure for transmitting messages which are sequences of magnitudes. In this coding method, the transmitter and the receiver store past message terms, and from them estimate the value of the next message term. The transmitter transmits, not the message term, but the difference between it and its predicted value. At the receiver this error is added to the receiver prediction to reproduce the message term. This procedure is defined and messages, prediction, entropy, and ideal coding are discussed to provide a basis for Part II, which will give the mathematical criterion for the best predictor for use in the predictive coding of particular messages, will give examples of such messages, and will show that the error term which is transmitted in predictive coding may always be coded efficiently. In part I predictive coding was defined and messages, prediction, entropy, and ideal coding were discussed. In the present paper the criterion to be used for predictors for the purpose of predictive coding is defined: that predictor is optimum in the information theory (IT) sense which minimizes the entropy of the average error-term distribution. Ordered averages of distributions are defined and it is shown that if a predictor gives an ordered average error term distribution it will be a best IT predictor. Special classes of messages are considered for which a best IT predictor can easily be found, and some examples are given. The error terms which are transmitted in predictive coding are treated as if they were statistically independent. If this is indeed the case, or a good approximation, then it is still necessary to show that sequences of message terms which are statistically independent may

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always be coded efficiently, without impractically large memory requirements, in order to show that predictive coding may be practical and efficient in such cases. This is done in the final section of this paper. (Contractor's abstract)

MIT. 12:010

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE USE OF POTENTIAL ANALOGS IN NETWORK SYNTHESIS, by R. E. Scott. [Mar. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the I. R. E. National Convention, New York, Mar. 21-24, 1955.

Published in I. R. E. Convention Record, Pt. II: 2-8, 1955.

A summary is given of the use of potential analogs for synthesis in the time domain, the frequency domain, and the real-part domain. Most of the analogs discussed are based on current flow in a resistive sheet. In addition, a new device is described which combines the three types and yields essentially instantaneous curves of the gain function, the phase function, the real part, the imaginary part, and the transient response. This device can be used for network synthesis by any of the three methods and for checking the relations between them. Throughout the discussion particular attention is devoted to the use of symmetry and conformal mapping to reduce the size of physical devices and decrease the errors. (Contractor's abstract)

MIT. 12:011

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE DETERMINATION OF THE AVERAGE MASSES OF ELECTRONS AND HOLES IN GERMANIUM, by J. M. Goldey and S. C. Brown. Mar. 3, 1955 [3 p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 102873 Unclassified

Also published in Phys. Rev., v. 98: 1761-1763, June 15, 1955.

Free current carriers in a medium make a contributions to its dielectric coefficient. The present experiment utilizes this effect to determine the effective masses of electrons and holes in germanium by measuring the microwave dielectric coefficient at several temperatures. The dielectric coefficient was determined by measuring the complex transmission coefficient at 24.15 kilomegacycles through a thin slab of germanium. The effective mass for electrons was $(0.09 \pm 0.05)m_0$; for holes it was $(0.30 \pm 0.05)\,m_0$. (Contractor's abstract)

MIT. 12:012

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

LINE BREADTHS IN THE MICROWAVE MAGNETIC RESONANCE SPECTRUM OF OXYGEN, by M. Tinkham and M. W. P. Strandberg. Mar. 4, 1955 [3]p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 102874 Unclassified

Also published in Phys. Rev., v. 99: 537-539, July 15, 1955.

The line-breadth parameters of a number of lines of the X-band magnetic resonance spectrum of O_2 have been measured an interpreted with the aid of a previously reported theory of the spectrum. The results are that the M-dependence of the line width is negligible, and there is only a slight decrease in width with increasing K. A typical width (half-width at half-intensity) at 300°K is 2.2 (mc/sec)/mm Hg. At pressures up to 8 mm Hg, the line centers have been found to shift less than 2 percent of the line width. The average temperature dependence of the normalized line breadth parameter $(\Delta\nu/P)$ is found to be $T^{-0.75}$. This may be compared with the theoretical $T^{-0.627}$ and the $T^{-0.85}$ found by previous workers. It was found that $O_2 - N_2$ collisions were no less effective than $O_2 - O_2$ collisions in producing broadening. (Contractor's abstract)

MIT. 12:013

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN EXISTENCE THEOREM FOR DRIVING POINT IMPEDANCE FUNCTIONS, by N. DeClaris. Mar. 8, 1955 [6 p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 100284 Unclassified

Also puhlished in Jour. Math. and Phys., v. 35: 83-88, Apr. 1956.

Of concern are networks of RC type except for one inductance. It is shown that the driving point impedance will have at most one pair of complex conjugate zeros and one pair of complex conjugate poles. If the real poles and zeros are arranged in order of magnitude, then no more than three zeros or three poles can occur in succession. (Math. Rev. abstract)

MIT. 12:014

Massachusetts Inst. of Tech Research Lab. of Electronics, Cambridge.

A STUDY OF THE MEMORY REQUIREMENTS OF SEQUENTIAL SWITCHING CIRCUITS, by D. A. Huffman. Mar. 14, 1955, 28p. incl. diagrs. (Technical rept. no. 293) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 85768 Unclassified

The number of elementary binary memory devices necessary for the realization of an arbitrary asynchronous sequential switching circuit is considered. The least upper bound is discovered to be approximately equal to twice the greatest lower bound. The minimum conceivable interstate transition time for a sequential circuit is the reaction time of a single memory element. A solution which achieves this minimum time is derived and its relationship to the Hamming single-error correcting code is shown. The fundamental limitations of error correction schemes which compensate for malfunctioning of memory elements are discussed. These schemes are feasible in synchronous circuits but have slightly impaired practicability in asynchronous circuits. (Contractor's abstract)

MIT. 12:015

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ULTRASONIC PROPAGATION IN MAGNETICALLY COOLED HELIUM, by C. E. Chase and M. A. Herlin. [1954] [6]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Also published in Phys. Rev., v. 97: 1447-1452, Mar. 15, 1955.

Measurements have been made of the velocity and attenuation of ordinary sound in liquid helium at a frequency of 12.1 mc/sec, over the temperature range from 1°K down to 0.1°K. The velocity is essentially independent of temperature and has the value 240 ± 5 m/sec. The attenuation passes through two closely spaced maxima near 0.9°K and then falls smoothly to zero as the absolute zero is approached. These results agree qualitatively with the theoretical predictions of Khalatnikov. (Contractor's abstract)

MIT. 12:016

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE OPTICAL PROPERTIES OF ATOMIC VAPORS NEAR RESONANCE, by F. Bitter. Mar. 16, 1955. 20p. incl. diagrs. tables. (Technical rept. no. 292) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 66375 Unclassified

This report summarizes and amplifies well-known results in order to facilitate the design of magnetic scanning experiments and to lay the ground for a further analysis of double-resonance phenomena produced by simultaneous rf and optical resonance. The reflection, refraction, and attenuation of light incident on the plane face of a cell containing an atomic vapor are calculated for frequencies in the vicinity of an absorption frequency. The significance of the results obtained is discussed and a few numerical examples are considered. It is found that observation of the attenuation of a transmitted beam offers certain advantages over observation of scattered light in scanning experiments. (Contractor's abstract)

MIT. 12:017

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN EXAMINATION OF INFORMATION THEORY, by Y. Bar-Hillel. [1955] [20]p. incl. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 106989 Unclassified

Also published in Philos. Sci., v. 22: 86-105, Apr. 1955.

The so-called "theory of information" is outlined. It is implied that no direct impact on semantics is to be expected from this new science. On the other hand, however, the calculus employed in it may turn out to be a powerful tool in a number of fields including (inductive) semantics. A number of new insights into the process of communication achieved recently are cited. Their importance for semiotics is demonstrated. Clarification of a number of basic misconceptions regarding information theory is undertaken to a limited extent.

MIT. 12:018

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE GAS DISCHARGE BREAKDOWN, by S. C. Brown. [1955] 12 p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 85883 Unclassified

Presented at International Symposium on Electrical Discharge in Gases, Delft (Netherlands), Apr. 1955.

Also published in Appl. Scient. Res., v. 5: 97-108, 1955.

A brief survey of microwave gas discharge breakdown

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is given. The conditions for breakdown in electron attaching and non-attaching gases is discussed. Results for air show both electron attachment and diffusion are operating. Hydrogen is taken as an example of a gas in which electron attachment is absent. For this case, data in low pressure region, in the diffusion controlled region, and in the mobility controlled region are discussed and the results of the many studies in these regions are shown to be consistent with each other.

MIT. 12:019

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SIGNAL-FLOW-GRAPHSMANSHIP (Abstract), by S. J. Mason. [Apr. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the I. R. E. Professional Group on Circuit Theory, Symposium on Signal Flow Graphs, Philadelphia, Pa., Apr. 14, 1955.

In the analysis of electronic circuits the circuit equations are often conveniently representable as a signal-flow-graph. This graph represents an abstraction of the electrical circuit model, just as the circuit model is itself an abstraction of the physical device. In the construction and manipulation of a flow graph, horrible or beautiful things can happen. Signal-flow-graphsmanship is the art of maximizing the beauty-to-horror ratio. (Contractor's abstract)

MIT. 12:020

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE MINIMUM NOISE FIGURE OF MICROWAVE BEAM AMPLIFIERS, by H. A. Haus and F. N. H. Robinson. Apr. 1, 1955, rev. May 27, 1955 [11]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 75635 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 981-991, Aug. 1955.

A matrix description of microwave amplifiers such as klystrons, traveling wave tubes, and backward-wave amplifiers, in which an electron beam interacts with longitudinal RF fields, is developed. Certain relations between the matrix elements are derived as a consequence of the conservation of energy and these relations set a lower limit to the noise figure attainable with amplifiers of this class. It is shown that the minimum noise figure of any amplifier of this type with lossless RF structures is identical with that already found by several authors for the traveling-wave tube and is entirely determined by the noise parameters of the beam. These in turn depend only on conditions in the immediate neighborhood of the cathode. Special cases involving lossy structures are investigated and in each case the presence of loss is shown applied to calculate the minimum noise figure of a double-stream amplifier. (Contractor's abstract)

MIT. 12:021

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

SOME ASPECTS OF PLASMA RESONANCE (Abstract), by K. S. W. Champion and S. C. Brown. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637) Unclassified

Presented at Seventh Annual Gaseous Electronics Conference, New York, Oct. 14-16, 1954.

Published in Phys. Rev., v. 98: 559, Apr. 15, 1955.

The impedance (ρ) to high-frequency electromagnetic waves of any region of a plasma, divided by the wavelength, (ρ/λ) is plotted as a function $N\lambda^2$ (where n is the electron density) and $p\lambda$ (where p is the pressure). The resulting surface is of particular interest in the vicinity of plasma resonance and is important for two reasons. One is that it gives a plot of the impedance any plasma presents to the transmission of microwaves. It not only confirms the measurements of Goldstein and Makinson of the microwave impedance of dc plasma, but also indicates immediately the range over which plasma resonance properties can be used as a "microwave probe" to measure electron densities. Experimentally this technique of density measurement has been used with high-frequency discharges for the first time. The second reason for the importance of the impedance plot is that it enables the properties of microwave discharges to be predicted. In particular, more extensive calculations have been made which enable the appearance of any microwave discharge to be predicted quantitatively, provided its diameter exceeds four times its height. (Contractor's abstract)

MIT. 12:022

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A "STROBOSCOPIC" APPROACH TO THE ANALYSIS OF PERIODIC AND MODULATED WAVES, by E. J. Baghdady. [May 1955] 1 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

A useful approach to the Fourier analysis of modulated and periodic waves is derived from well established elementary considerations. The basic mechanism of the conventional analysis is first examined and found to lend naturally to a picture based on the fact that a

rotating phasor which represents a pure sine function may be brought to rest, relative to two orthogonal reference axes, by rotating the latter at the angular frequency of the former. Then, by determining the projections of the phasor upon the axes, it is possible to describe the phasor uniquely. Thus, to investigate the presence of a component of any specified frequency in the structure of a given sinusoid modulated in an arbitrary fashion by a general type of periodic function, it is merely necessary to imagine the orthogonal reference axes to be rotating in the positive direction at the specified angular frequency. This will reduce the instantaneous frequencies of all the spectral components, and hence of their resultant phasor, relative to the frequency of the rotating reference axes by an amount equal to the frequency of the latter. If a spectral component with the specified angular frequency is present, it will therefore be made stationary relative to the reference axes. Thus, long-time averages of the instanteous projections of the resultant phasor representing the modulated wave, upon the rotating reference axes, will yield the corresponding components of the desired spectral component, and therefore uniquely determine it. Illustrative examples are given: the theory is then shown to be formally equivalent to the standard technique of Fourier analysis and to be just a novel way to view the mechanism of this analysis. Finally, the graphical application in its most general form is described and found to circumvent possible inconveniences with the conventional approach. (Contractor's abstract)

MIT. 12:023

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE TEACHING OF MATHEMATICS TO THE BLIND, by C. M. Witcher. [1955] [8]p. incl. illus. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research] under DA 36-039-sc-64637) AD 76342 Unclassified

Published in Math. Teacher, v. 48: 314-321, May 1955.

Although the use of Braille is satisfactory for beginning courses in mathematics, in the study of fractions and algebra and higher mathematics it is unsatisfactory. Some recent developments in the field of mathematics for the blind make use of an adapted abacus or soraban for numerical calculation and a practical form of circular slide rule which is suitable for fairly rapid touch reading. The latter permits the computation of powers and roots with the help of simple mental multiplication or division. In addition desk calculators and comptometers have been adapted for touch reading. A new method was developed in 1948 with the use of certain plastics and the use of cellulose acetate and a moisture-proof cellophane for a drawing media to provide for the production of diagrams and graphs, etc. A very significant developme , in the field has been the Nemeth system of Braille mathematical notation. It is simple and is quite useful in algebra and trigonometry. By the use of "level indicator" symbols it enables the blind to deal with exponents and subscripts. The system is also quite useful in vector analysis and theory of functions.

MIT. 12:024

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOISE IN ELECTRON BEAMS, by C. Fried. May 2, 1955, 44p. incl. illus. diagrs. table, refs. (Technical rept. no. 294) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 103532 Unclassified

This report contains an experimental investigation of beam and noise behavior in various types of electron streams. A continuous, reliable, and semi-automatic measuring technique and apparatus is described. Steady-flow and pulsed operating conditions are applied to convergent and confined flow guns. An extensive investigation of beam contour, noise standing-wave pattern, growing noise wave, and beam instability is given. The effect of magnetic field, ion neutralization, and interception current is measured over considerable operating ranges. Certain aspects of cathode temperature, type, activity, and quality of cathode are included. A low-noise three region gun is measured under steady-flow conditions. The transformation of the noise standing-wave pattern by the accelerating anodes is demonstrated. The constancy of the average of the rms noise current standing wave is verified experimentally. (Contractor's abstract)

MIT. 12:025

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CARRIER EFFECTIVE MASSES IN GERMANIUM (Abstract), by J. M. Goldey and S. C. Brown. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98: 1192, May 15, 1955.

Current carriers in a medium make a contribution to its dielectric coefficient. An experiment, similar to those of Benedict and Shockley, which utilizes this effect has been performed to determine the effective masses of electrons and holes in germanium by measuring its microwave dielectric coefficient at several temperatures. The dielectric coefficient was determined by measuring the complex transmission coefficient for 24.15 kilomegacycle radiation through a thin slab of germanium. The values obtained for the effective masses were $M^* = (0.09 \pm 0.05) M_0$ for electrons and $M^* = (0.30 \pm 0.05) M_0$ for holes. These

MIT. 12:026 - MIT. 12:029

results are in agreement with those obtained by cyclotron resonance and magnetic susceptibility measurements, but disagree with those of Benedict and Shockley.

MIT. 12:026

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE ELECTRON LOSS PROCESS IN THE HYDROGEN AFTERGLOW, by K.-B. Persson and S. C. Brown. May 19, 1955 [5]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 88739 Unclassified

Also published in Phys. Rev., v. 100: 729-733, Oct. 15, 1955.

Electron loss processes in the afterglow of very pure hydrogen have been studied by the microwave technique. The conclusion is drawn that within the error of the experiment, no electron-ion recombination is observed, and that high mode diffusion is very evident. By properly accounting for the high diffusion modes, the results are given as $D_a p = 700 \pm 50$ cm^2 mm Hg sec^{-1} with the electron-ion recombination less than 3×10^{-8} cm^{-3} sec^{-1}. Electron loss processes in the hydrogen afterglow have been studied by the microwave method by a number of workers. Although the results are related, no agreement has been achieved up to the present time as to the actual loss processes in hydrogen. In view of the result of the work presented here, it is possible to understand the disagreement between the previous investigations of the hydrogen loss processes. The main result is that, if sufficiently pure hydrogen is used, the loss process for the electrons in the ranges covered previously, as well as now, is explained by an ambipolar diffusion mechanism. If the electron-ion recombination is present, this loss process is so small that it cannot be measured with methods available at present. (Contractor's abstract)

MIT. 12:027

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

1/F NOISE AND RELATED SURFACE EFFECTS IN GERMANIUM, by A. L. McWhorter. May 20, 1955. 112p. incl. illus. (Technical rept. no. 295; Lincoln Lab. rept. no. 80) (In cooperation with Mass. Inst. of Tech. Lincoln Lab., by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637]) AD 64023 Unclassified

By modulating the surface conductivity of germanium with external electric fields ("field effect" experiment) at sub-audio frequencies, it has been found that the capture time τ of these traps varies from spot to spot along the surface, with a distribution function for τ which is approximately proportional to $1/\tau$ up to times greater than 100 sec. The filling and emptying of the traps can alter the conductivity by producing (1) changes in the majority carrier concentration near the surface, as required to maintain charge neutrality, and (2) an injection-extraction of hole-electron pairs, due to a complex interaction between the surface recombination centers and the traps. The two processes have been analyzed and found to give a 1/f noise of the correct order of magnitude. There are two distinct types of excess reverse currents observed in p-n junctions; a water-induced leakage current, which flows externally to the germanium, and a "channel" current, which occurs whenever a strongly n- or p-type surface increases the effective rectifying area of the junction. Measurements of 1/f noise in reverse-biased p-n junctions have shown that the noise associated with the leakage current varies roughly at V^2G, where V is the applied voltage and G is the conductance of the leakage path, while the noise associated with the channel seems to vary as $I_c^2 V^{1/2}$, where I_c is the channel current. (Contractor's abstract, modified)

MIT. 12:028

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

BOUNDS TO THE ENTROPY OF TELEVISION SIGNALS, by J. Capon. May 25, 1955, 53p. incl. illus. diagrs. tables, refs. (Technical rept. no. 296) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 99356 Unclassified

Statistics of pictures were measured, including the second-order probabilities of successive cells, and the autocorrelation function. These quantities, obtained by independent methods, are used to compute an upper bound to the entropy per sample. The results are compared and used to estimate the amount by which the channel capacity required for television transmission might be reduced through exploitation of the statistics measured. (Contractor's abstract)

MIT. 12:029

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON BINARY CHANNELS AND THEIR CASCADES, by R. A. Silverman. May 25, 1955, 9p. incl. diagrs. table. (Technical rept. no. 297) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 94195 Unclassified

Also published in I. R. E. Trans. on Information Theory, v. IT-1: 19-27, Dec. 1955.

A detailed analysis of the general binary channel is given, with special reference to capacity (both

separately and in cascade), input and output symbol distributions, and probability of error. The infinite number of binary channels with the same capacity lie on doubly-branched equicapacity lines. Of the channels on the lower branch of a given equicapacity line, the symmetric channel has the smallest probability of error and the largest capacity in cascade, unless the capacity is small, in which case the asymmetric channel (with one noiseless symbol) has the smallest probability of error and the largest capacity in cascade. By simply reversing the designation of the output (or input) symbols, we can decrease the probability of error of any channel on the upper branch of the equicapacity line can be decreased and the capacity in cascade of any asymmetric channel on the upper branch can be increased. In a binary channel neither symbol should be transmitted with a probability lying outside the interval $[1/e, 1-(1/e)]$ if capacity is to be achieved. The maximally asymmetric input symbol distributions are approached by certain low-capacity channels. For these channels, redundancy coding permits an appreciable fraction of capacity in cascade if sufficient delay can be tolerated. (Contractor's abstract)

MIT. 12:030

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CONSTANT-RESISTANCE AGC ATTENUATOR FOR TRANSISTOR AMPLIFIERS, by C. R. Hurtig. [June 1955] [6]p. incl illus. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 75634 Unclassified

Also published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-2: 191-196, June 1955.

This paper describes a unique circuit the gain of which may be varied as a function of a control current, but the input resistance of which is fairly constant over a large range of the controlled gain. A constant-resistance agc attenuator is described with these characteristics: (1) the circuit employs one junction diode and, at most 3 resistors and 2 capacitors per resistor agc stage, and is suitable for use with either triode or tetrode transistors, (2) at signal voltage levels under 1 mv, a gain variation per transistor agc stage of 50 db at 1000 cps and greater than 20 db at 10 mc may be produced by an external control voltage. The gain variation is accompanied by only slight variations in the effective input impedance of the stage, (3) the control power is dependent upon the required constancy of input resistance over the agc range, but in most cases milliwatts of control power are sufficient, and (4) a square-low device for a positive polarity input voltage is described which has an accuracy of ± 10% over a dynamic range exceeding 40 db. Polarity and frequency response limitations of this basic device are removed by a new circuit design for a balanced modulator the output of which is a linear function of both the modulating and control signals.

MIT. 12:031

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NOTES ON THE FLOW OF SCHEDULED AIR TRAFFIC, by R. B. Adler and S. J. Fricker. [1955] [10]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Published in I. R. E. Trans. of Professional Group on Aeronautical and Navigational Electronics, v. ANE-2: 22-31, June 1955.

Some of the effects upon air traffic of scheduling the aircraft and of controlling them en route are presented quantitatively in this report in the form of theoretical studies of four problems: (a) relations between the random en route deviations of aircraft from their schedules, and the resulting stack and total delays; (b) effectiveness of a single en route control point when 1) it reschedules the aircraft in an attempt to reduce terminal congestion; 2) it attempts to bring each plane back onto its original schedule; (c) congestion caused by relaxing the schedule; and (d) effect of a sudden shutdown of the terminal. The limiting cases of random arrival and continuous control are discussed briefly, and some aspects of multipoint discrete en route control are treated. Numerical analysis, using IBM punched-card machines, is employed extensively in problems (a)-(c). Problem (d) has been simplified enough so that purely analytic methods could be applied. It is presented merely for comparison purposes. (Contractor's abstract)

MIT. 12:032

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SYNTHESIS AND REALIZATION OF CRYSTAL FILTERS, by D. I. Kosowsky. June 1, 1955, 60p. incl. diagrs. tables, refs. (Technical rept. no. 298) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 94194 Unclassified

A new technique has been developed for the synthesis and realization of bandpass filters employing quartz resonators. By the use of approximation methods, crystal filter design is simplified to the point at which synthesis may be accomplished with only a slide rule and a number of plotted curves. The problem of obtaining piezoelectric resonators adjusted to extremely close tolerance was solved by the development of a new crystal-measuring procedure. Several crystal filters were constructed, and an excellent correspondence was found between calculated and measured characteristics. (Contractor's abstract)

MIT. 12:033 MIT. 12:036

MIT. 12:033

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INVESTIGATIONS OF IONOSPHERIC FOWARD-SCATTER PROPAGATION AT FREQUENCIES EXCEEDfNG MUF, by W. G. Abel, J. T. DeBettencourt and others. June 3, 1955, 181p. incl. illus. tables, refs. (Technical rept. no. 262; Lincoln Lab. rept. no. 81) (In cooperation with Mass. Inst. of Tech. Lincoln Lab., AF 19(122)458) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 76494 Unclassified

Results are presented of studies of ionospheric forward-scatter propagation at frequencies exceeding normal MUF in the high HF and low VHF ranges for the purpose of investigating potential point-to-point communications. Data were analyzed from about 13,000 hr of operation on frequencies of about 50 mc on circuits of about 1000 mi. Nominal 30-kw transmitters and large rhombic transmitting antennas were employed. The median received signal levels were about 100 db below free-space values. Fading during short periods in the absence of meteoric or sporadic-E enhancements was Rayleigh distributed; the fading was essentially Gaussian for periods of about 1 hr. In general, the normalized median levels were lower and the diurnal variations were less marked than those previously reported for a 773-mi path. The median levels were higher in winter and summer and lower in spring and fall. Lower levels were indicated with decreasing gun-spot activity. The vertically polarized component of the received signal was about 6 db (median) lower than the horizontally polarized component when using the 2000-ft horizontal rhombic transmitting antenna. Studies were made of off-path signal levels and measurements of cosmic noise. Preliminary analysis of pulse-transmission data for a 387-mi path indicated daytime ionospheric-scatter heights of 80 to 90 km. The level and characteristics of 27.8-mc signals are discussed. Additional measurements at 22.9 mc are described for a 1059-mi path. Observations at 21.6 mc are reported for signals received over a 997-mi path.

MIT. 12:034

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HYPERFINE STRUCTURE ANOMALY fN ATOMIC P-STATES, by C. Schwartz. June 10, 1955 [2]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 105288 Unclassified

Also published in Phys. Rev., v. 99: 1035-1036, Aug. 1, 1955.

It is shown that, as a result of electronic-configuration mixing, there can be in principle a hyperfine structure anomaly Δ in any atomic state. This effect is calculated for Ga. Further, before a measured value of Δ can be used to study the nuclear magnetic structure through the Bohr-Weisskopf theory (C. A., v. 44, 1799c), the contribution to Δ of other mechanisms must be substracted. The net B.-W. effect in Ga is smaller than expected. Its precise value remains uncertain. (C. A., 1955:15473f)

MIT. 12:035

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RELATIVE INFLUENCE OF MAJORITY AND MINORITY CARRIERS ON EXCESS NOISE IN SEMICONDUCTOR FILAMENTS, by L. Bess. [June 24, 1955] [5]p. incl. diagrs. (In cooperation with Mass. Inst. of Tech. Lincoln Lab.) (Sponsored by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 88789 Unclassified

Also published in Jour. Appl. Phys., v. 26: 1377-1381, Nov. 1955.

An experiment has been devised whereby excess noise is measured along various different directions in a germanium filament after the directions of current flow for the majority and minority carriers had been altered by a magnetic field. From this experiment it is possible to determine that whereas shot noise is caused by both majority and minority carrier fluctuation, 1/f noise is essentially produced only by majority carrier fluctuation. (Contractor's abstract)

MIT. 12:036

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MEASUREMENT OF SECOND-ORDER PROBABfLITY DfSTRIBUTIONS OF PfCTURES BY DIGITAL MEANS, by J. C. Stoddard. July 13, 1955, 21p. incl. illus. diagrs. tables. (Technical rept. no. 302) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 111879 Unclassified

The transmission of a picture was approached from the point of view of statistics and information theory. A picture was approximated by the processes of sampling and quantizing the video waveform that represents the intensity of the picture as it is scanned. Transmission of each sample of the picture is reduced to the problem of sending a number that indicates which of the 32 possible intensity levels occurred in that sample. Equipment that measures the second-order probability distribution of a video waveform from a facsimile transmitter by digital means was designed and built. System tests were made to permit evaluation of the potential accuracy of measurement. Although perfectly repeatable results from a known waveform

could not be obtained, measurement of the complete joint probability distribution of one picture was made by running the data until consistent results could be obtained for each set of levels. A value of entropy representing an upper bound to the information content of the picture was computed from the measured second-order probability distribution of intensity in adjacent samples. (Contractor's abstract)

MIT. 12:037

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ANALOG CORRELATOR SYSTEM FOR BRAIN POTENTIALS, by J. S. Barlow and R. M. Brown. July 14, 1955, 41p. incl. illus. refs. (Technical rept. no. 300) (In cooperation with Massachusetts General Hospital, Boston) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637])
AD 82439 Unclassified

A description is presented of an analog correlator system for brain potentials. Brain potentials are first amplified by standard electr encephalographic equipment and then recorded on a multichannel FM magnetic tape recorder. Autocorrelation and crosscorrelation functions of the tape-recorded signals are automatically computed as the tapes are played back repeatedly by an electronic analog multiplier and integrator; a magnetic drum introduces the desired interchannel delays. Provision is also made for computation of correlation functions for signal sources other than magnetic tape (oscillators, noise generators, etc). The electrophysiological signals are taken from the amplifiers at a level of amplification sufficient to yield the desired input level to the tape recorders, for which 1 v rms of a sine wave produces 100% modulation of the FM carrier. Examples are presented of correlation functions for brain potentials and for known signals.

MIT. 12:038

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTRONIC CONTRIBUTION TO EFFECTIVE NUCLEAR MASSES IN MOLECULES (Abstract), by M. W. P. Strandberg. Apr. 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 667, July 15, 1955.

The problem of the interaction of molecular rotational and electronic states has been extensively investigated in the past. Quite briefly stated, it has been demonstrated that the molecular electrons contribute to the molecular moment of inertia tensor an amount which is directly and simply related to the molecular magnetic moment tensor. Examples of this correction have been made with the experimental results on several molecules, and the measured corrections to the principal moments of inertia arising from the molecular electrons have been discussed. A recent paper reporting the deuterium-tritium mass ratio evaluated from microwave measurements attempted a discussion of this correction without apparently realizing that it is a matter which may be reduced to measurement. The electronic correction to spectroscopic mass ratio measurements will be discussed in terms of past work. (Contractor's abstract)

MIT. 12:039

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

EXCITED TORSIONAL STATES IN ASYMMETRIC HINDERED ROTORS (Abstract), by P. R. Swan [Jr.] and M. W. P. Strandberg. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 667, July 15, 1955.

Investigation has been undertaken of the $J = 0 \rightarrow 1$ transition of methyl alcohol. Because of internal torsion in this type of molecule the transition is split into a series of doublets, each doublet corresponding to a particular internal torsion state. A preliminary model used was that of a rigid symmetric top attached at an arbitrary angle to a rigid asymmetric frame and allowed to rotate about its symmetry axis under the influence of a threefold cosine potential barrier. The resulting Hamiltonian was found to be incapable of predicting the torsional splitting when applied to the methyl-alcohol molecule. A semiempirical combination of Kivelson's formula for the corresponding transition in a symmetric hindered rotor with matrix elements from this methyl-alcohol Hamiltonian was found to give a close fit to the observed spectrum. An additional feature of the methyl-alcohol spectrum is the large fourth-order Stark effect of one of the lines of the $J = 0 \longrightarrow 1$ series. The Hamiltonian necessary to describe these rotation-torsion interaction effects is discussed. (Contractor's abstract)

MIT. 12:040

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INTERNAL MOTION IN METHYL AMINE (Abstract). by D. Kivelson and D. R. Lide, Jr. [Apr. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) Unclassified

MIT. 12:041 - MIT. 12:043

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 667, July 15, 1955.

The microwave spectrum of methyl amine exhibits hindered internal rotation of the NH_2 group with respect to the CH_3 group, as well as inversion doubling arising from the fact that there are two equally likely orientations of one NH bond with respect to the other. An approximate theory has been worked out for these two internal motions and their mutual interaction. By a suitable choice of variable the kinetic energies can be completely separated; the potential energy can be reduced to a term accounting for inversion, a term accounting for hindered internal rotation, and an interaction term. If the latter is neglected the two internal motions can be treated independently except for their interrelated dependence upon the periodic boundary conditions. The interaction term can be treated by a Van Vleck transformation. This theory is applied to methyl amine. (Contractor's abstract)

MIT. 12:041

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MOLECULAR-BEAM MICROWAVE-ABSORPTION SPECTROSCOPE (Abstract), by M. Peter and M. W. P. Strandberg. Apr. 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 667, July 15, 1955.

A microwave absorption spectroscope has been developed, whose absorption-line half-power — half-width is determined by the average time that the molecules under observation are exposed to the microwave field. This is an improvement over the similar previous device by Strandberg and Dreicer, in which the Stark modulation frequency limited the resolution. In both devices the Doppler broadening, which limits the resolution of the usual microwave spectroscopes, is eliminated. An improvement by a factor of twelve is now obtained over such usual systems, and a half-power — half-width of 3 kc has been observed. To use such resolution it has been necessary to develop a stabilization circuit which maintains the phase of a K-band klystron to within a few degrees of the phase of some harmonic of a very stable quartz oscillator. The resolution of the present system is therefore limited only by geometry and may thereby be improved by use of longer average observation times, i.e., use of longer molecular beams. (Contractor's abstract)

MIT. 12:042

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THERMODYNAMIC PROPERTIES OF CHROME ALUM (Abstract), by L. D. Jennings and M. A. Herlin. Apr. 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 668, July 15, 1955.

A new method was applied to the measurement of the thermodynamic properties of potassium chromium alum in the region of temperatures reached by adiabatic magnetization curves which approach an asymptotic value at large fields characteristic of the analogous ideal paramagnetic gas at the same entropy. The entropy of the actual salt is then given as that of the ideal salt which has the same large field magnetization. The temperature of the salt is given by a method, previously described, which makes use of the deviation of the behavior of the actual salt from that of the ideal. Each adiabat is identified by T, the magnetic temperature at that entropy. Good agreement was found with other workers for T(T), but less satisfactory agreement for S(T) in the region T = 0.1 to T = 0.2. This discrepancy is attributed to a failure of the usual computation of entropy near 1°K, in the need to extrapolate the results at high magnetic fields, or to an actual difference among samples. (Contractor's abstract)

MIT. 12:043

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE CONDUCTION MECHANISM IN OXIDE COATED CATHODES, by E. B. Hensley. July 20, 1955, 5p. incl. diagrs. table, refs. (Technical rept. no. 267) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 100283 Unclassified

Also published in Jour. Appl. Phys., v. 27: 286-290, Mar. 1956.

Measurements have been made on a system composed of two parallel planar cathodes so arranged that their surfaces may be pressed together or separated by a small gap. Low field conductivity measurements show that above approximately 700°K, the conductance of the system does not depend on physical contact between the cathode surfaces; a result that is interpreted as confirmation of the theory that the high temperature conductivity of oxide cathodes is a property of the electron gas in the cathode pores. The ratio of the conductivity

to the thermionic emission was measured under conditions designed to preserve the state of activation of the cathode surface. The results of these measurements agreed with the theoretically predicted value and demonstrate that the higher values of this ratio previously reported were attributable to the fact that the surface of an oxide cathode is normally in a lower state of activation than the interior of the cathode. (Contractor's abstract)

MIT. 12:044

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FEEDBACK THEORY. [II]. FURTHER PROPERTIES OF SIGNAL FLOW GRAPHS, by S. J. Mason. July 20, 1955 [7]p. (Technical rept. no. 303) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under DA 36-039-sc-64637) AD 108350 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 920-926, July 1956.

Some elementary properties of linear signal flow graphs are cited. The means to formulate flow graph gain is outlined. Illustrative examples of gain evaluation by inspection of paths and loop sets are presented. Also described are illustrative applications of flow graph techniques to practical analysis problems. Finally, proof of the general gain expression is offered. (For Part I, see item no. MIT. 10:133)

MIT. 12:045

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HIGH-FREQUENCY GAS DISCHARGE BREAKDOWN, by S. C. Brown. July 25, 1955, 63p. incl. illus. refs. (Technical rept. no. 301) (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 85873 Unclassified

In this report an attempt is made to summarize our knowledge of high-frequency gas discharge breakdown. The types of processes discussed include diffusion controlled, mobility-controlled, and electron-resonance breakdown, as well as breakdown phenomena in the presence of magnetic and dc electric field superimposed on the high-frequency electric field. (Contractor's abstract)

MIT. 12:046

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW APPROACH TO THE PROBLEM OF CASCADE SYNTHESIS, by E. A. Guillemin. July 25, 1955 9 p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637])
AD 93533 Unclassified

Also published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-2: 347-355, Dec. 1955.

Several familiar procedures in the synthesis of driving-point and transfer impedances yield a network in the form of a cascade of two-terminal-pair networks, each of which is responsible for a set of zeros of the even part of the prescribed impedance. In each of these procedures, the computation of the typical component network begins with the determination of the equivalent T-circuit; and then a remainder function (from which other component networks are to be found) is determined by substracting the T's branch impedances (or admittances) from previously determined functions. In general, an equivalent circuit of some other configuration must be determined from the T-circuit, to achieve physical realizability. These computational procedures are laborious, and the substractions may seriously reduce accuracy. In this paper, a more direct approach is suggested. It leads to the same ultimate networks in a more logical way, and obviates much computational tedium. The general approach is developed primarily in terms of RC transfer impedances, but applications to LC networks are also included.

MIT. 12:047

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON THE SCATTERING OF RADIO WAVES BY TURBULENT FLUCTUATIONS OF THE ATMOSPHERE, by F. Villars and V. F. Weisskopf. July 25, 1955 [8]p. incl. illus. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and [Air Force] Office of Scientific Research under [DA 36-039-sc-64637]) AD 94458 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 1232-1239, Oct. 1955.

This paper presents a theoretical analysis of the mechanism that enables transmission of vhf-signals over distances of the order of 10^3 km. It is found that turbulent mixing, operating at the lower edge of the E layer (h = 80-90 km) produces fluctuations in electron density of sufficient intensity to account for the observed signals. The basic assumptions are the existence of a sufficiently strong gradient electron density (dN/dh cm^{-3}/km) and a reasonable level of turbulent activity.

MIT. 12:048

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SPECTRAL PROPERTIES OF FLUCATIVE

MIT. 12:049 - MIT. 12:051

CONSONANTS, by G. W. Hughes and M. Halle. Aug. 5, 1955 [5]p. incl. illus. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 100286 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 28: 303-310, Mar. 1956.

Energy density spectra of gated segments of fricative consonants were measured. The spectral data were used as a basis for developing objective identification criteria which yielded fair results when tested. As a further check gated segments of fricatives were presented for identification to a group of listeners and their responses evaluated in terms of the objective identification criteria. (Contractor's summary)

MIT. 12:049

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ANALYSIS OF SIGNALS AND NOISE IN LONGITUDINAL ELECTRON BEAMS, by H. A. Haus. Aug. 18, 1955, 64p. incl. diagrs. refs. (Technical rept. no. 306) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 123164 Unclassified

The theory of signal propagation in longitudinal one-dimensional electron beams is reviewed. The kinetic power theorem is proven and used for the characterization of longitudinal-beam microwave amplifiers in terms of matrices of lossless networks. The properties of noise in electron beams are studied. The two noise parameters, invariants with regard to lossless beam transformations, are derived from a simple theorem of matrix algebra. Equivalent noise impedances are defined. As a result, noise transformations in an electron beam can be handled by conventional impedance transformation methods. The noise theory is then applied to derive the expression for the minimum noise figure of longitudinal beam tubes. Applications to practical cases are discussed.

MIT. 12:050

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ACTION POTENTIALS FROM THE FROG COLLICULUS (Abstract), by A. M. Andrew. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637; and in part by the Illuminating Engineering Research Fund (U. S.)) Unclassified

Presented at meeting of the Physiol. Soc., Dundee (Scotland), Sept. 23-24, 1955.

Micro electrodes in the colliculi (optic lobes) of pithed frogs were used to record unit action potentials from cells, in response to stimulation of the contralateral eye with light. The layer of the colliculus from which responses were obtained appears to he 0.5 mm, or, less below the surface. From a particular recording site, responses were evoked by light in a particular part of the visual field. The optimal position for a small light source could be determined with accuracy ranging from ± 5 to ± 15°. Usually both on-responses and off-responses were obtained from a recording site. Almost always the off-response was larger and had a lower threshold and shorter latency than the on-response. Typical latencies were 30 msec and 58 msec, respectively. No maintained response to steady illumination has been seen. Frequently an off-response consisted of an initial burst of activity followed by a train of impulses that sometimes lasted as long as 7 sec. Responses to a moving spot of light have been studied, using as stimulus the spot of a 2-inch cathode-ray tube moving at a selected speed from one stationary position on the screen to another. The cathode-ray tube could be placed in any position in the visual field and always faced the frog at a distance of 10 in. Some recording sites showed marked differences between the responses to movements at the same speed and along the same path but in opposite directions. The response to movement cannot be accounted for as a summation of on- and off-responses at points passed by the spot. A marked difference in the response to movement, depending on direction of travel, has been seen when the on- and off-responses were essentially the same at all points along the path of the spot. (Contractor's abstract)

MIT. 12:051

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CODING FOR NOISY CHANNELS (Abstract), by P. Elias. [1955] [15]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the Third London Symposium on Information Theory, London (England), Sept. 12-16, 1955.

Published in Proc. Third Symposium on Information Theory, Royal Institution, London (England) (Sept. 12-16, 1955), London, Butterworth's Scientific Publications, 1956, p. 61-76

This paper considers in detail the simplest kinds of noisy channels – binary channels with symmetric and independent errors. For these channels a strong version of the channel capacity theorem is proved, giving precise relations between channel capacity, rate of information transmission, decoding delay D, and error probability at the receiver. It is shown that Shannon's random message coding is essentially optimum for transmission rates reasonably near channel capacity. For low rates, however, it is possible to decrease error probability with increasing decoding delay more rapidly by design than by chance. Any

coding procedure requires codebook memories, or computers, or both, at transmitter and receiver. Random message codes require codebooks which grow exponentially in size with the decoding delay D. It is shown that random check symbol codes of various kinds can be constructed which perform just as well in terms of information rate and error probability, but which require a codebook increasing in size only linearly with D. This has not only practical but theoretical interest, since such a code is error-free. That is, the receiver can increase D and reduce error probability as much as it likes without consulting the transmitter. (Contractor's abstract)

MIT. 12:052

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STUDIES OF POPULATION RESPONSES IN THE PERIPHERAL AUDITORY NERVOUS SYSTEM (Abstract), by L. S. Frishkopf and W. A. Rosenblith. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637)
Unclassified

Presented at meeting of the Amer. Physiol. Soc., Tufts College, Medford, Mass., Sept. 6-9, 1955.

Electrical responses to auditory clicks were recorded at relatively microphonic-free locations near the round windows of anaesthetized cats. The average amplitude of N_1, the first neural component of this response, was determined in nine animals as a function of stimulus intensity over a range of 80 to 100 db. Amplitude variability was determined as a function of stimulus intensity for three animals over a similar range of stimulus intensity. In three other animals clicks were presented in a background of low intensity noise, and masked and unmasked amplitude growth functions determined. These studies were analyzed in relation to a threshold model for peripheral auditory units, a model in which threshold has a probability character. The results strongly suggest the existence of a fairly homogeneous population of sensitive units, responsive over a range of 30 to 40 db and consisting of 150 to 400 elements. (Contractor's abstract)

MIT. 12:053

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXAMPLE OF A STATISTICAL INVESTIGATION OF THE TEXT OF "EUGENE ONEGIN" ILLUSTRATING THE DEPENDENCE BETWEEN SAMPLES IN CHAIN, by A. A. Markov, tr. by M. Halle. Sept 5, 1955, 12p. incl. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36 039 sc-64637) AD 116075 Unclassified

Also published in Bull. Acad. Imperiale Sciences, St. Petersbourg, 1953, p. 153-162.

The investigation applies to a sequence of 20,000 Russian letters, not counting the "hard" and "soft" signs (ъ and ь), in Pushkins poem "Eugene Onegin," which sequence includes the entire first chapter and 16 stanzas of the second. This sequence provides us with 20,000 connected samples, each of which is either a vowel or consonant letter.

MIT. 12:054

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NEW METHOD FOR MEASURING THE ABSOLUTE VISCOSITY OF LIQUID HELIUM II, by H. H. Kolm and M. A. Herlin. Oct. 10, 1955 [7]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA36-039-sc-64637]) AD 103571
Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Also published in Phys. Rev., v. 102: 607-613, May 1, 1956.

A new type of static viscometer for use in liquid helium II was developed; its inner cylinder is suspended within a rigidly fixed, coaxial outer cylinder by a servomechanically controlled magnetic bearing of the type used by Beams and others in vacuum ultracentrifuges. The inner cylinder is accelerated electromagnetically; the absolute viscosity of the medium is determined from the deceleration observed when it is permitted to coast freely. Bearing friction is negligible, and there is no inherent lower limit to the speed of this measurement. Reproducible viscosity values were obtained in gaseous helium, but 1/TS-damping from thermomechanical flow induced by eddy current heating in the rotor was observed in liquid helium II. This effect was reduced considerably by elaborate precautions for isolating the apparatus from ground vibrations. At higher speeds, the anomalous behavior was observed, which eliminates the attempted "mutual friction" explanation. The absolute viscosity increased discontinuously to a higher value as the speed increased. The observation is reproducible qualitatively, but because of vibrations, not quantitatively. (Contractor's abstract)

MIT. 12:055

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ANALYSIS OF NOISE IN ELECTRON BEAMS, by F. N. H. Robinson and H. A. Haus. Oct. 15, 1955 [12]p. incl. illus. (In cooperation with Bell Telephone Labs., Inc., Murray Hill, N. J.) (Sponsored jointly by Signal Corps, Office of Naval Research, and

MIT. 12:056 - MIT. 12:059

Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 93751 Unclassified

Also published in Jour. Electronics, v. 4: 373-384, Jan. 1956.

A general discussion of noise in linear systems, where many modes carrying both positive and negative power can propagate, is given. Matrix notation is used and it is found that an arbitrary noise process can be represented by a process with independent excitation of each mode together with a lossless transducer. An expression for the noise figure depends only on the least noise content of a negative power mode in the fundamental representation of the noise process.

MIT. 12:056

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TOWARD SOME CIRCUITRY OF ETHICAL ROBOTS OR AN OBSERVATIONAL SCIENCE OF THE GENESIS OF SOCIAL EVALUATION IN THE MIND-LIKE BEHAVIOR OF ARTIFACTS, by W. S. McCulloch. Oct. 15, 1955 [10]p. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637], and Bell Telephone Lab., Inc.) AD 100285 Unclassified

Also published in Acta Biotheoretica, v. 11: 147-156, 1956.

Modern knowledge of servo systems and computing machines makes it possible to specify a circuit that can and will induce the rules and winning moves in a game like chess when they are given only ostensibly, that is, by playing against opponents who quit when illegal or losing moves are made. Such circuits enjoy a value social in the sense that it is shared by the players. (Contractor's abstract)

MIT. 12:057

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EFFECTS OF STRYCHNINE WITH SPECIAL REFERENCE TO SPINAL AFFERENT FIBERS, by P. D. Wall, W. S. McCulloch and others. [1955] [12]p. incl. illus. diagr. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36 039 sc 64637) AD 88790 Unclassified

Also published in Epilepsia, Series 3, v. 4: 29-40, Nov. 1955.

Some of the literature on the basic effects of strychnine is reviewed. Experiments carried out on cats show that strychnine does not affect the excitability of the motor horn cells of the spinal cord as tested by microelectrode stimulation within the cord. It is shown that the threshold of the fibers in the terminal arborization of final afferent fibers is raised. The shape of the early components of the dorsal root potentials is changed. Findings could be explained by an increase in the height of the individual action potentials in the terminal arbors under the influence of strychnine. Strychnine spikes traveling antidromically away from strychninized nuclei of Goll and Burdach were shown to emerge from lumbar dorsal roots. The significance of these findings is discussed. A critique of strychnine neuronography in the light of recent findings is presented. (Contractor's summary)

MIT. 12:058

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

APPLICATION OF SPACE-CHARGE THEORY TO THE DETERMINATION OF ELECTRON EMITTER PROPERTIES (Abstract), by W. B. Nottingham. Aug. 1955 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Mexico U., Mexico City, Aug. 29-31, 1955.

Published in Phys. Rev., v. 100: 964, Nov. 1, 1955.

Basic space-charge theory depends on the simultaneous solution of three equations. These equations are: (1) Poisson's, (2) Boltzmann's density relation, and (3) the equation of current continuity. The solution of these equations applicable to parallel-plane electrodes leads to methods that also serve for coaxial cylinders. Tubes have been constructed with oxide cathodes and a ratio of radii collector to emitter of 2.5. The emitter specifications to be evaluated and reported on include the "a" constant in amp/ m^2 and the work-factor ϕ in electron volts. These constants are useful in the simplified current density expression: $a \exp(-\phi/V_T)$. The temperature expressed as V_T is T/ 11600. Also, the Richardson constants A_R and ϕ_R and the temperature coefficient of the true work-function are determined. The analysis yields a value for the true work-function of the collector. (Contractor's abstract)

MIT. 12:059

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PRECISION OF MICROWAVE SPECTROGRAPHS (Abstract), by M. W. P. Strandberg and M. Peter. [1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36 039 sc 64637) Unclassified

Presented at meeting of the Amer. Phys. Soc., Mexico U., Mexico City, Aug. 19-31, 1955.

Published in Phys. Rev., v. 100: 963, Nov. 1, 1955.

Microwave molecular beam spectroscopes using either absorption or emission of radiation, or particle counting techniques, operate within the same realm of techniques. The ultimate frequency precision of each of these forms of beam spectroscopy is thus simply expressible in terms of common parameters. Then based on only the most general considerations the particle counting system has the highest probability of defining a point on the atomic or molecular resonance curve by the square root of ratio of the photon energy to the thermal noise energy kT. Practical considerations can shift this ratio many orders of magnitude either way. The microwave absorption spectroscope is unique in being able to operate without state selection and without beam flow. In this form of operation the resolution is less because of Doppler broadening. However, the over-all precision of an absorption spectrograph can be greatly increased over beam operation since the amount of active material, and hence power handling capability, can be greatly increased without the need of absurd flow handling capacity. (Contractor's abstract)

MIT. 12:060

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NETWORK SYNTHESIS FOR A PRESCRIBED IMPULSE RESPONSE, by R. A. Pucel. Nov. 2, 1955, 35p. incl. diagrs. (Technical rept. no. 305) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 122939 Unclassified

Two semigraphical methods are presented for the synthesis of a linear, finite, lumped-element network in which the desired response is prescribed in the time domain. The methods are based on the approximation of the real or the imaginary part of the associated system function. In the first method, the desired real or imaginary part function is approximated in the complex-frequency plane by a sequence of impulses along a contour parallel to and to the left of the imaginary axis. In the second method, this function is approximated along the imaginary axis by a rotational fraction whose zeros and whose behavior at infinity are initially prescribed. Simple methods are proposed for the evaluation of the error committed in the time domain. Examples illustrating the two methods are given. (Contractor's abstract)

MIT. 12:061

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PHASE STABILIZATION OF MICROWAVE OSCILLATORS, by M. W. P. Strandberg. Nov. 30, 1955, 1p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 109228 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 696, May 1956.

A circuit has been developed with which microwave oscillators may be phase-locked to weak but stable reference signals. The circuit was operated with S-band oscillators (707B klystron; 2C37 triode oscillator) and a 2K50 K-band klystron. It is possible to lock a microwave oscillator directly or through a cascade of such circuits to a quartz-stabilized oscillator. The statistical theory of random noise is used to obtain an analysis of the stabilizing effect of the circuit, and the power spectrum of the stabilized microwave source is calculated. The scheme can also be applied in divider operation. Modifications are discussed. A modified circuit that uses carrier-suppressed modulation of the reference signal has also been realized. In another circuit, the oscillator frequency is converted by means of a stable reference, and compared with a second reference that can be of low frequency and tunable. These latter circuits allow elimination of the excess noise introduced by crystal diodes. In the original straight dc circuit this noise cannot be eliminated, but calculation shows that its influence on the output power spectrum is very small. (Contractor's summary)

MIT. 12:062

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE CONCEPT OF THE ONE IN VOLTAGE TRANSFER SYNTHESIS, by P. M. Lewis, II. [1955] [4]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-2: 316-319, Dec. 1955 (Network Realization Issue).

The concept of the one is introduced and found to give a physical interpretation to the constant multiplier in voltage transfer synthesis. It places in evidence the constraints placed on the performance of physical systems by the configuration used in the synthesis. Several theorems are derived concerning the ultimate limits of performance obtainable when a given configuration is used to realize a given voltage transfer function. (Contractor's abstract)

MIT. 12:063

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE PHONEMES OF SHILHA (Abstract), by J. R. Applegate. [1955] 1 p. (Sponsored jointly by

MIT. 12:064 - MIT. 12:066

Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the Linguistic Soc. of Amer., Chicago, Ill., Dec. 29, 1955.

This paper presents a description of the phonology of Shilha, one of the major Berber dialects spoken in southwestern Morocco. This description is based on the analysis of the speech of several native speakers of the language. It is, primarily, a discussion of the phonemic structure of the language. Spectrographic data are used to illustrate certain features of the phonemic system which have been presented in different forms in other studies of the language and to support conclusions reached concerning these features. (Contractor's abstract)

MIT. 12:064

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE REPRESENTATION OF SOME PERIODIC STIMULI IN THE BIFREQUENCY PLANE (Abstract). by M. H. Goldstein, Jr. [Dec. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the Acoust. Soc. Amer., Brown U., Providence, R. I., Dec. 15-17, 1955.

Published in Jour. Acoust. Soc. Amer., v. 28: 153, Dec. 1956.

Recently attention has been focused on psychophysical experiments with nonsinusoidal stimuli of a periodic nature. These studies were concerned with the "residue," the "missing fundamental" and more generally with amplitude modulated signals, bursts of noise, and repeated clicks. The results were often in contradiction with Ohm's acoustic law according to which a complex stimulus is analyzed during the listening process into its sinusoidal (Fourier) components. It appeared therefore desirable to develop a mathematical transformation that would bring to light certain aspects of these stimuli that are of importance in determining psychophysical judgments. A bifrequency transform will be presented which is a function of two variables, both of which have the dimension of frequency. One variable relates closely to Fourier frequency, the other to the time-varying envelope of the signal. The shape of the bifrequency plot of a number of auditory stimuli will be illustrated, and the method of analyzing psychophysical experiments employing these stimuli will be described. In several instances the bifrequency method makes plausible psychophysical judgments that are not predicted from Ohm's law. (Contractor's abstract)

MIT. 12:065

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE TERMINAL ARBORIZATION OF THE CATS PYRAMIDAL TRACT DETERMINED BY A NEW TECHNIQUE, by P. D. Wall and W. S. McCulloch and others. [1955] [8]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 93753 Unclassified

Also published in Yale Jour. Biol. and Med., v. 28: 457-464, Dec. 1955-Feb. 1956.

A new technique is described which uses antidromic impulses generated in terminal arborizations by stimulating microelectrodes. The position of the stimulating microelectrode is determined for those points of stimulus which evoked a response recorded in a tract projecting into the stimulated area. The resolution of the technique is shown to be greatly superior to previous physiological methods which attempted to localize the ending of projection fibers. The technique is used to show the endings of the group I afferent fibers from the gastrocnemius muscle in the grey matter of the cord. The ending of the pyramidal tract in the cat is shown to be limited to a small region in the ventral part of the dorsal horn. Preliminary results on the monkey are also discussed. (Contractor's summary)

MIT. 12:066

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF INTERNAL OVER-ALL ROTATIONAL INTERACTIONS. II. HAMILTONIAN FOR THE NON-RIGID INTERNAL ROTOR, by D. Kivelson. Dec. 1955 [6]p. incl. diagrs. table, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 85770 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2230-2235, Dec. 1955.

An approximate Hamiltonian for a nonrigid internal rotor is derived. The potential energy was expanded in a Taylor's series in the displacement coordinates and in a Fourier series in the angle of internal rotation [illegible]. The Hamiltonian was transformed by a contact transformation, and a second-order Hamiltonian in which vibrations and rotations were separated was obtained. The Hamiltonian consists of terms which constitute the usual rigid internal rotational problem, of centrifugal distortion terms involving both over-all and internal angular momentum, and of terms that arise because of the repulsive nature of the barrier. These repulsive terms enter as a single term, $2JF_v(m|1 - \cos 3\alpha|m)$, in the expression for the

rotational transitions of symmetric rotors, where J is the total angular momentum quantum number and m is the pseudo-quantum number for internal rotation. The repulsive constant, F_v, is given by the relation

$$F_v = -\Sigma \tfrac{1}{2}\left[B_{xx}^{(i)} + B_{yy}^{(i)} \right] a_i^{(1)},$$

where $B_{xx}^{(i)}$ $B_{yy}^{(i)}$ is the derivative of the rigid rotor rotational constant with respect to the ith symmetry coordinate, and $a_i^{(1)}$ is one-half the displacement of the equilibrium position of the ith internal coordinate in going from $\theta = 0$ to $\theta = \pi/3$. The dependence of the barrier height upon the vibrational motion was also studied. (For Part I see item no. MIT. 11:047) (Contractor's abstract)

MIT. 12:067

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF INTERNAL OVER-ALL ROTATIONAL INTERACTIONS. III. NONRIGID ASYMMETRIC ROTORS, by D. Kivelson. Dec. 1955 [8]p. incl. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 85882
Unclassified

Also published in Jour. Chem. Phys., v. 23: 2236-2243, Dec. 1955.

The theory of the interactions of hindered internal rotation with over-all rotations is extended to include nonrigid asymmetric rotors. The interdependence of hindered internal rotation and vibrations and their effect upon the vibrational energy levels is considered. An approximate over-all internal rotational wave function is discussed. Since the general energy relation involves too many parameters to compute or to fit empirically, certain special cases are discussed. (Contractor's abstract, modified)

MIT. 12:068

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A TRAVEL AID FOR THE BLIND (Abstract), by C. M. Witcher. [Dec. 1955] 1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637)
Unclassified

Presented at meeting of the A. A. A. S., Atlanta, Ga., Dec. 26, 1955.

The meaning of the term "adequate travel aid for the blind" based on consideration of its required performance characteristics has been previously discussed by several workers. A set of such requirements has been tentatively accepted in this laboratory to serve as the basis for the design and construction of an actual model. These are summarized in the present paper. A description of the system design aspects of the model now under construction is given, with an analysis of how this system design attempts to meet the tentatively accepted requirements. In this analysis, the travel aid is conceived as a communication system, taking in information from the environment through which the blind user moves, and transmitting it to his brain through some sensory channel which can substitute for the visual one. From this point of view, the problem presents two aspects: A, to determine the minimum necessary information which must be extracted from the environment; and B, to devise means for the most efficient use of the chosen sensory channel for transmitting this information to the user's brain. The optical system employed in the present model is considered in some detail. The principle of step-down detection is briefly reviewed, after which an analysis of detector sensitivity requirements is given. A general relation is obtained expressing the received signal power in terms of the constants of the system and a factor, f, expressing the diffuse reflectivity of the surface being viewed by the system. A Fourier analysis of the received signal is given, leading to an expression for the power spectrum. This permits some conclusions to be drawn with regard to optimum amplifier design. (Contractor's abstract)

MIT. 12:069

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ACOUSTIC PROPERTIES OF STOP CONSONANTS, by M. Halle, G. W. Hughes, and J.-P. A. Radley. [1956] [10]p. incl. illus. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637, and National Science Foundation)
AD 129243 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 29: 107-116, Jan. 1957.

Results of a study of the two major cues for stop consonants are presented: the burst of the stop release and the transition of the formants in the adjacent vowel. Detailed energy density spectra of the bursts were prepared. The transitions were studied by means of sonagrams. Possible criteria for identification were developed and tested. In order to assess the efficacy of the two types of cue, preceptual tests were conducted with isolated segments that contained either stop bursts or vowel transitions alone. Common acoustical properties of bursts and formant transitions are noted; differences as well as similarities are discussed in the light of different varieties of pitch judgments. (Contractor's abstract)

MIT. 12:070 - MIT. 12:074

MIT. 12:070

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A FOURIER METHOD FOR TIME DOMAIN SYNTHESIS, by M. Strieby. [1956] [13]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at Symposium on Modern Network Synthesis, Polytechnic Inst. of Brooklyn, N. Y., Apr. 13-15, 1955.

Published in Proc. Symposium on Modern Network Synthesis, v. 5: 197-209, 1956.

The chief aspect of time domain synthesis which is considered here is that of approximating an impulse response. The specific objective is to find a function which approximates an arbitrary, transformable time function and of which the Laplace transform is a realizable function of frequency. One period of a Fourier series is used to approxmlate the desired time function. The series shows how many poles are needed in the network system function and gives one an idea of the error function to be expected. It can be adjusted to achieve a reasonable compromise hetween error and network complexity. From this a realizable system function is straightforwardly computed.

MIT. 12:071

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

GRAPHICAL METHODS FOR TRANSFORMING IMPEDANCES THROUGH LOSSLESS NETWORKS BY THE CAYLEY KLEIN DIAGRAM, by E. F. Bolinder. [1956] 13 [p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36 039-sc-64637) AD 122940 Unclassified

Also published in Acta Polytechnica No. 202, Electrical Engineering Series, v. 7: 1-13, 1956.

A method of Van Slooten for transforming reactances through lossless networks by means of the Cayley Klein diagram (also called "hyperbolic plane," "Cayley diagram" or "projective chart") is extended to be valid for transformations of arbitrary impedances. Its connection with the isometric circle method is studied and it is shown that in the latter method one of the centers of perspectivity of the former method is situated at the point corresponding to infinity in Euclidean space. (Contractor's abstract)

MIT. 12:072

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE GYRISTOR. A TOPOLOGICAL APPROACH TO ACTIVE CIRCUIT ANALYSIS (Abstract), by S. J. Mason. [1956] [1]p. (Technical rept. no. [illegible]) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Kirchhoff and Maxwell gave us topological inspection rules for evaluating the transmission of a linear bilateral branch network. A linear bilateral branch network is a connection of resistors in each of which the current is proportional to the difference of its two terminal potentials. The gyristor is a branch-like element whose current is proportional to the sum of its two terminal potentials. With (complex) resistors and gyristors one can model any lumped linear circuit, in general nonbilateral. The point is that the Kirchhoff-Maxwell rules carry over to such models without change of form, the only addition being a relatively simple algebraic sign rule for gyristors in the transmission expression. (Contractor's abstract)

MIT. 12:073

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

NEW METHODS OF DRIVING-POINT AND TRANSFER IMPEDANCE SYNTHESIS, by E. A. Guillemin. [1956] [26]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Presented at Symposium on Modern Network Synthesis, Polytechnic Inst. of Brooklyn, N. Y., Apr. 13-15, 1955.

Published in Proc. Symposium on Modern Network Synthesis, v. 5: 119-144, 1956.

Driving-point and transfer problems have certain common characteristics, so that a study of one of these is in one way or another helpful in the solution to the other problem. Regarding the driving-point problem a number of realization schemes are mentioned. Stress is put on procedures which avoid mutual inductive coupling, are straightforward, and are not very tedious algebraically and numerically. In suggesting various methods simplicity is stressed more than applicability.

MIT. 12:074

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

OPTIMUM DESIGN OF FINAL VALUE CONTROL

SYSTEMS, by R. C. Booton, Jr. [1956] [9]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637])
Unclassified

Presented at Symposium on Nonlinear Circuit Analysis, Polytechnic Inst. of Brooklyn, N. Y., Apr. 25-27, 1956.

Published in Proc. Symposium on Nonlinear Circuit Analysis, v. 6: 233-241, 1956.

This paper deals with the statistical optimization of nonlinear time-variable systems. Treated are final-value control systems in which the response is constrained in such a manner that earlier response values affect the final response.

MIT. 12:075

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PIECEWISE-LINEAR NETWORK ANALYSIS AND SYNTHESIS, by T. E. Stern. [1956] [31]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc 64637])
Unclassified

Presented at Symposium on Nonlinear Circuit Analysis, Polytechnic Inst. of Brooklyn, N. Y., Apr. 25-27, 1956.

Published in Proc. Symposium on Nonlinear Circuit Analysis, v. 6: 315-345, 1956.

This paper presents a general systematic approach to the problems of piecewise-linear resistive network analysis and synthesis. This unified approach considerably broadens the scope of current piecewise-linear synthesis, particularly as applied to diode network synthesis.

MIT. 12:076

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SENSORY AID DEFINES LIGHTS AND MARKS, by C. H. Hartig. [1956] [2 p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36 039 sc 64637) AD 122936 Unclassified

Also published in Electronics, v. 30: 162-163, Feb. 1, 1957.

This miniature device using cadmium sulfide photocell, diode and two transistors to actuate a magnetic earphone gives audible indication of printing, meter readings or location of maximum ambient light. The unit, including accessory lamp bulb, is powered by a 1.5 volt battery.

MIT. 12:077

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STUDY OF THE EXPONENTIAL LINE BY THE ISOMETRIC CIRCLE METHOD AND HYPERBOLIC GEOMETRY, by E. F. Bolinder. [1956] [21]p. incl. illus. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 129242
Unclassified

Also published in Acta Polytechnica, No. 214, Electrical Engineering Series, v. 7: 1-21, 1957.

The isometric circle method is used to study impedance transformations through lossless exponentially tapered transmission lines. By a simple inversion in the isometric circle of the direct transformation, followed by a reflection in the symmetry line of the two isometric circles, the ratio of the input impedance and the characteristic impedance at the input of the exponential line can be obtained from the ratio of the output impedance and the characteristic impedance at the output. The three different cases: transmission in the pass-band (elliptic case), cutoff (parabolic case), and below cutoff (hyperbolic case) are studied in the complex impedance plane, the complex reflection coefficient plane (Smith chart) and on the Riemann unit sphere. The use of non-Euclidean hyperbolic geometry is briefly outlined. Finally, the extension of the method to impedance transformations through lossy exponential lines is indicated.

MIT. 12:078

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TRANSMISSION AND REFLECTION OF WAVES BY NONUNIFORM ONE-DIMENSIONAL MEDIA, by S. J. Mason. [1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637)
Unclassified

The propagation of a wave in a one-dimensional medium is governed by the equation

$$z \frac{d}{dx}\left(\frac{1}{z}\frac{dE}{dx}\right) = s^2 E$$

where z is the wave impedance and s is the complex frequency. In this equation we assume that the wave velocity has been normalized to unity by a properly chosen deformation of the distance scale. Let z be a known function of x in the interval from 0 to x_1 and a constant in each of the two regions lying outside this interval. Now define

$$r(x) = \frac{1}{2}\frac{d}{dx} \log$$

MIT. 12:079 - MIT. 12:081

$$f_0(s, x) = 1$$

$$f_{k+1}(s, x) = \int_0^x f_k(-s, x')\, r(x') \exp(-2sx')\, dx'$$

In terms of these defined quantities the reflection coefficient R(s) of the nonuniform region is

$$R(s) = \frac{\sum f_{2k+1}(s, x_1)}{\sum f_{2k}(s, x_1)}$$

where the summations are taken over integer values of k from zero to infinity. The reflection coefficient gives the complex amplitude of the reflected wave when a unit amplitude wave traveling in the positive x direction is incident upon the nonuniform region lying between 0 and x_1. (Contractor's abstract)

MIT. 12:079

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ON ACOUSTICAL CUES FOR STOP CONSONANTS (Abstract), by M. Halle, G. W. Hughes, and J.-P. A. Radley. [Dec. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the Acoust. Soc. of Amer., Brown U., Providence, R. I., Dec. 15-17, 1955.

Published in Jour. Acoust. Soc. Amer., v. 28: 161, Jan. 1956.

A study has been conducted of the two major cues for stop consonants: the burst of the stop release and the transition of the formants in the adjacent vowels. Detailed frequency versus intensity spectra of the bursts were prepared, while the transitions were studied by means of Sonagraph records. Possible criteria for identification were developed and tested. In order to assess the efficacy of the two major types of cue, perceptual tests were conducted with isolated segments containing either stop bursts or vowel transitions alone. (Contractor's abstract)

MIT. 12:080

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORETICAL ASPECTS OF SOUND PROPAGATION IN LIQUID HELIUM (Abstract), by I. Tisza. [Dec. 1955] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the Acoust. Soc. of Amer., Brown U., Providence, R. I., Dec. 15-17, 1955.

Published in Jour. Acoust. Soc. Amer., v. 28: 150, Jan. 1956.

It is a characteristic feature of the low-temperature modification of liquid helium that temperature differences propagate in the form of waves instead of producing a dissipative heat conduction. In these thermal waves or "second sound," temperature variations play a role similar to pressure variations in first or ordinary sound. Although our understanding of the molecular mechanism behind these phenomena is still far from satisfactory, the experimental and theoretical study of the two sound waves has contributed significantly to the clarification of the situation. (Contractor's abstract)

MIT. 12:081

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TIME-DOMAIN SYNTHESIS BY MEANS OF TRIGONOMETRIC POLYNOMIAL APPROXIMATIONS, by M. Strieby. Jan. 5, 1956, 35p. incl. diagrs. refs. (Technical rept. no. 308) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 107542 Unclassified

The area of time-domain synthesis considered here is the process of finding the system function of a lumped-element, linear, passive, bilateral network whose impulse response approximates a prescribed function of time. Time-domain synthesis can be regarded as essentially equivalent to the design of a rotational delay-line approximant. Suppose e^{-sT^*} to be such an approximant. $H_p(s)$ is the Laplace transform of a suitably chosen semiperiodic (periodic for t greater than zero, and zero for t less than zero) trigonometric polynomial approximation of period T to the desired network impulse response that is also of duration T. Then the function $H_p(s)(1 - e^{-sT^*})$ is the desired rational system function. The first method of synthesis bases the choice of a rational delay-line approximant upon the particular impulse response that is being synthesized. Care must be taken in the selection to insure realizability of the resultant network and proper convergence of the impulse response. However, the method is straightforward and gives good results: a fairly accurate error prediction can easily be made, so that no trial and error procedure is needed. Several examples show that a close approximation to the desired impulse response is attainable with relative economy of network elements. The second of the many possible procedures based on the same underlying philosophy uses a rational delay line approximant which is independent of the function that is being synthesized. One example seems to show that this approach also produces satisfactory results. (Contractor's abstract)

MIT. 12:082

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TUBE LABORATORY MANUAL, by F. Rosenburg, ed. 2nd ed. Jan. 15, 1956, 132p. incl. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 95493 Unclassified

This manual was prepared as a guide for workers in the Tube Laboratory at M.I.T. with the view of making the book as useful as possible to those whose work in the laboratory involves vacuum devices. It includes: (1) chemical procedures; (2) electroplating; (3) heat treating and brazing; and (4) Tube Laboratory procedures. There are also 30 tables containing physical and chemical properties and other data regarding materials used in the laboratory. An index of materials is appended.

MIT. 12:083

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

PROPOSED COINCIDENCE SCHEME FOR THE ELIMINATION OF THE DOPPLER EFFECT, by P. L. Sagalyn. Jan. 31, 1956 [2]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039 sc-64637]) AD 103574 Unclassified

Also published in Phys. Rev., v. 102: 293-294, Apr. 1, 1956.

The coincidence technique of Bradley (Phys. Rev., v. 102: 293, Apr. 1, 1956) is adapted to the measurement of the wave lengths of emission spectra. The method can be used to improve spectroscopic determinations of such parameters as hyperfine-structure constants and isotope shifts. It also provides another method for the detection of radio-frequency resonance in the intermediate state.

MIT. 12:084

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A UNIFIED THEORY OF INFORMATION, by K. H. Powers. Feb. 1, 1956, 105p. incl. diagrs. refs (Technical rept. no. 311) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637 AD 99355 Unclassified

The probabilistic theory of information is extended to processes involving the most general probability distributions. A change of probability measure on an abstract space serves as the appropriate mathematical model for the fundamental information process. A unified definition for the amount of concomitant information, which takes the form of a functional of the a priori and a posteriori measures, is introduced. This definition is sufficiently general to be applied to a theory that includes both the discrete and continuous theories as special cases. The definition is applied in a study of the information associated with the realization of a stochastic process. For the evaluation of mutual information rates between stationarily correlated multivariate gaussian time series, the techniques of linear prediction are employed. A brief investigation is made of the problems of communications in the presence of noise and through linear networks. (Contractor's abstract)

MIT. 12:085

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FOURIER TRANSFORMS AND TAPERED TRANSMISSION LINES, by E. F. Bolinder. Feb. 8, 1956, 1p. incl. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 108763 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 557, Apr. 1956.

The non-linear differential (Riccati) equation for a tapered line is transformed into a first-order equation (for the reflection coefficient) which can be linearized. The solution is given as a Fourier integral of a function of the characteristic impedance.

MIT. 12:086

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

GETTING RID OF THE DOPPLER EFFECT (Abstract), by F. Bitter. Feb. 1956 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at Spectroscopy Symposium, Argonne National Lab., Lemont, Ill., Feb. 15-16, 1956.

A general survey was made of the significance of the Doppler effect in obscuring the interpretation of hyperfine structure data. A few of the more promising areas for further work on HFS were reviewed. Various experimental approaches to the problem were described and compared, and preliminary work with jet lamps was discussed. (Contractor's abstract)

MIT. 12:087 - MIT. 12:089

MIT. 12:087

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A HIGH-RESOLUTION ABSORPTION SPECTROSCOPE FOR THE STUDY OF RESONANCE LINES OF RADIOISOTOPES (Abstract), by J. E. R. Young. [Feb. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at Spectroscopy Symposium, Argonne National Lab., Lemont, Ill., Feb. 15-16, 1956.

A unique but simple high-resolution absorption spectroscope has been built for the study of the hyperfine structure of the 2537Å mercury lines. The Zeeman effect on a cooled Hg^{198} arc gives a variable wavelength source. The two circularly polarized components are divided into separate beams, traversing the same optical system, but detected separately; thus the source line scans the absorption spectrum in two directions simultaneously as the Zeeman field is varied. The light intensity from the source is monitored both before entering, and after leaving, the quartz absorption cell, by 1P28 photomultipliers. The resultant photocurrents are accurately compared on a dc bridge which gives a value directly proportional to the transmission through the cell. The six abundant stable isotopes are readily investigated, and owing to the sensitivity of the apparatus, which will detect approximately 10^{12} atoms of mercury vapor, it is possible to investigate radioisotopes of mercury. Techniques are under development to prepare very pure samples of radio-mercury in vapor form in order to investigate their hyperfine structure with this instrument. (Contractor's abstract)

MIT. 12:088

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MAGNETIC SCANNING OF THE MERCURY $^3S_1$ STATE (Abstract), by H. H. Plotkin. Feb. 1956 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at Spectroscopy Symposium, Argonne National Lab., Lemont, Ill., Feb. 15-16, 1956.

By means of an extension of the method of magnetic scanning the $^3S_1$ state of mercury was studied in samples of natural mercury, mercury enriched in the isotope Hg^{201}, and radioactive mercury produced by the bombardment of gold by deuterons. The atoms were excited into the metastable $^3P_0$ level through the absorption of 2537A radiation and subsequent collision with N_2 molecules. A variable wavelength source of 4047A radiation from a pure Hg^{198} lamp in a magnetic field was then used to excite selectively the hyperfine structure components of the 4047A line. The intensity of the re-emitted 5461A radiation was observed with a photomultiplier. The lines of the even isotopes were not resolved; all of the magnetic hyperfine structure components of Hg^{199} and Hg^{201} were separated and measured. The frequencies were found to be in good agreement with reported values. A tentative assignment of the new components which appeared in the radioactive sample results in a nuclear magnetic moment for Hg^{197} of $\mu_{197} = 1.055\mu_{199}$ and an isotope shift toward abnormally small effective nuclear radius. Other lines, presumably from an isomeric state of Hg^{197}, have not been identified (Contractor's abstract)

MIT. 12:089

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CENTRAL EFFECTS OF STRYCHNINE ON SPINAL AFFERENT FIBERS, by J. Y. Lettvin, W. S. McCulloch and others. [1955] [2]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637; also in part by the Teagle Foundation, National Science Foundation, and Bell-Telephone Labs., Inc.) Unclassified

Presented at 584th meeting of the Boston Soc. of Psychiatry and Neurology, May 19, 1955.

Published in Arch. Neurology and Psychiatry, v. 75: 323-324, Mar. 1956.

A stimulating microelectrode was placed in the ventral horn of a lumbar spinal segment in anesthetized curarized cats. Recordings were taken of the antidromic volley running in the group one fibers in the dorsal root and of the orthodromic volley running in the segment's ventral root. After intravenous strychnine no change was found in the threshold of the motor horn cells. The terminal arborizations of the afferent fibers showed an increase in threshold. It was shown that strychnine affects all components of the electrotonic dorsal root potentials. The earliest components believed to be due only to the passage of impulses in the primary afferent fibers were affected. In these respects, strychnine imitates post-tetanic potentiation of reflexes which is due to hyperpolarization of the stimulated fibers. No evidence could be found of a decrease of threshold of the motor-horn cells after strychnine. The nuclei of Goll and Burdach were locally strychninized and recordings were taken from the dorsal columns and lumbar dorsal roots. It was found that synchronized antidromic volleys generated in the strychninized areas ran down the dorsal columns and out of the dorsal roots. Five examples are known of strychnine failing to fire off central nerve cells, one example of transynaptic conduction of strychnine "spikes" has been shown in the sympathetic nervous system and also antidromic spike propagation in the dorsal columns. (Contractor's abstract, modified)

MIT. 12:090

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

EXCITABILITY CHANGES IN ANATOMICAL COMPONENTS OF THE MONOSYNAPTIC ARC, FOLLOWING TETANIC STIMULATION (Abstract), by A. R. Johnson, P. D. Wall and others. [1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637; Bell Telephone Labs., Inc., Teagle Foundation, and National Science Foundation) Unclassified

Presented at meeting of the Amer. Physiological Soc. and Federation of Amer. Societies for Exper. Biology, Atlantic City, N. J., Apr. 16-20, 1956.

Published in Fed. Proc., v. 15: 102, Mar. 1956.

Using unanesthetized, spinal, and decerebrate cats, we have exposed nerves from individual muscles. Most experiments were carried out using the nerves to gastrocnemius. All ventral roots in the lumbar enlargement were cut. The time course of post-tetanic potentiation of a monosynaptic reflex was measured. Next stimulating monopolar microelectrodes made of 15 micron OD sharpened glass-covered platinum wire were lowered through several stations into the lumbar enlargement. These electrodes were cut off and left in the cord and their location was later shown by histological examination. The change of excitability along the intramedullary fibers was tested by stimulating locally with the microelectrodes and recording the size of the antidromic spike traveling in the relevant sensory nerve. The excitability of tetanized group I fibers from gastrocnemius is decreased for a very prolonged time from the root entrance zone to the region of their endings in the ventral horn. Relations between this depression and the increase of the monosynaptic reflex will be discussed. The excitability of the terminations of nontetanized neighboring group I fibers is not affected during the prolonged period of depression. Motor horn cell excitability was tested by direct local stimulation and was found not to be changed during the long period of post-tetanic potentiation. (Contractor's abstract)

MIT. 12:091

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DRIVING-POINT IMPEDANCE FUNCTIONS OF ACTIVE NETWORKS, by N. DeClaris. Mar. 1956 12 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at I.R.E. National Convention, New York, Mar. 19-22, 1956.

Published in I.R.E. Convention Record, Pt. II: 26-37 1956.

A general theorem is presented that relates three arbitrary terminal-pairs of a linear circuit by means of network parameters – impedance or admittance functions. It is shown that this is a generalization of Thévinin's theorem, leading to considerable simplifications in the driving-point analysis of active networks. The class of active networks containing only one active element, or their equivalent, is considered in detail. Some properties of the driving-point impedance functions of such networks are stated in the form of existence theorems. Synthesis techniques for two particular types of active network configurations are presented and illustrated. (Contractor's abstract)

MIT. 12:092

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A PREDICTION THEORY APPROACH TO INFORMATION RATES, by K. H. Powers. [Mar. 1956] [8]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at I.R.E. National Convention, New York, Mar. 19-22, 1956.

Published in I.R.E. Convention Record, Pt. IV: 132-139, 1956.

Regarding a change of probability measure to be the fundamental information process, a unified definition for the amount of information resulting is introduced. This definition is sufficiently general to include as special cases both discrete and continuous theories. With the recognition of an intimate relationship between information theory and the prediction theory of Kolmogorov and Wiener, the techniques of linear prediction are employed to determine the rate at which one gaussian time function gives information about the past, present, and/or future of another similar function correlated with it. The results of this study are applied to the investigation of the processes by which information is lost in additive noisy channels as well as in linear filters and predictors. (Contractor's abstract)

MIT. 12:093

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A THEORY FOR THE EXPERIMENTAL DETERMINATION OF OPTIMUM NONLINEAR SYSTEMS, by A. G. Bose. Mar. 1956 [9 p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at I.R.E. National Convention, New York, Mar. 19-22, 1956.

MIT. 12:094 - MIT. 12:096

Published in I. R. E. Convention Record, Pt. 1V: 21-30, 1956.

Following the lines of the Wiener theory of experimental nonlinear system classification a theory is developed for the experimental determination of optimum time-invariant nonlinear filters. The filters are optimum in a weighted mean square sense in which the weighting function is at our disposal. An operator on the past of the input is defined in such a way that, in the experimental setup, we can take advantage of orthogonality to evaluate the classifying coefficients of the optimum system independently. This paper briefly describes the Wiener theory of nonlinear system classification and then discusses the theory and associated apparatus for the determination and synthesis of optimum nonlinear filters. (Contractor's abstract)

MIT. 12:094

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TWO INVARIANTS OF NOISY LINEAR AMPLIFIERS, by H. A. Haus and R. B. Adler. [Mar. 1956] [15]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at I. R. E. National Convention, New York, Mar. 19-22, 1956.

Published in I. R. E. Convention Record, Pt. II: 53-67, 1956.

This work concerns the single-frequency noise performance of linear, active two-terminal pair networks with internal noise generators. Two parameters of any active network, expressible in terms of its impedance matrix and open-circuit noise voltages, are found to be invariant when it is imbedded in any arbitrary, lossless (reciprocal or nonreciprocal) network to produce a new two-terminal-pair system. An important class of amplifiers can be brought, by means of lossless feedback, into a unilateral form in which the open-circuit input and output impedance are guaranteed to have positive real parts. One simple interpretation of the invariants is that they determine, for this class of amplifiers, the minimum value of the expression $M = (F - 1)/(1 - 1/G)$ attainable by means of proper end-loading of the unilateralized amplifier, where F is the spot noise figure, and G is the available gain. It is shown further that the same minimum value for M can be reached, but not improved upon, by proper end-loading of the amplifier in a nonunilateral and unconditionally stable circuit connection. These results, and some others demonstrating the invariance properties of M, suggest that the quantity M be adopted, instead of the noise figure F, as a quantitative measure of amplifier noise performance. (Contractor's abstract)

MIT. 12:095

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

WAVEFORM OF ELECTRICAL RESPONSES IN THE AUDITORY NERVOUS SYSTEM AS A FUNCTION OF THE ONSET CHARACTERISTICS OF THE STIMULUS (Abstract), by N. Y. S. Kiang and M. H. Goldstein [Jr.] [Mar. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at meeting of the Eastern Psychological Soc., Atlantic City, N. J., Mar. 23-24, 1956.

Responses to acoustic stimulation were recorded electrically at two locations, cochlea and cortex in the cat's auditory pathway. Under certain stimulus conditions, the potentials generally used as indicators of eighth nerve activity become undetectable while cortical responses remain essentially unchanged. An interpretation in terms of single unit activity is offered. (Contractor's abstract)

MIT. 12:096

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A PROBABILITY APPROACH TO CERTAIN NEUROELECTRIC PHENOMENA, by L. S. Frishkopf. Mar. 1, 1956, 74p. incl. illus. diagrs. refs. (Technical rept. no. 307) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 107077 Unclassified

When an acoustic click is presented to the ear of an anesthetized cat, an electrode, placed near the round window of the cochlea, detects a superposition of microphonic and neural components. The first neural component (N_1) represents a sum of action potentials of first-order auditory neurons. We have studied the N_1 response amplitude as a function of click intensity and observed that this "intensity function" characteristically exhibits a two-stage growth. This behavior suggests that the contributing neural elements might be usefully classified as "sensitive" or "insensitive." A model is developed in which properties of "neural units" are defined: units obey the all-or-nothing principle; the threshold of a unit is a fluctuating parameter describable by a probability density function. Populations of statistically independent identical units are postulated. The model is related to the data by defining an intensity function that depends linearly on the number of units in each population that respond. The results of two experiments are compared with the predictions of the model. First, we have studied the amplitude variability of N_1 as a function of stimulus intensity. Second, we have investigated the effect of a continuous noise background on the amplitude of the N_1 response to a click

("masking" of N_1). In both cases the data and the predictions of the model are in good agreement over the first interval of amplitude growth (the sensitive range). Over the insensitive interval the data are inconclusive. The size of the sensitive population and the characteristic rate of threshold fluctuations of a sensitive unit are estimated. It is concluded that (a) a relatively homogeneous population of neural units, characterized hy rapidly fluctuating thresholds, is responsible for the initial component of growth of the intensity function; and (b) that over the remaining interval of the intensity function a single-population hypothesis will not account for the data within the framework of the model. (Contractor's abstract)

MIT. 12:097

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF INTERNAL OVER-ALL ROTATIONAL INTERACTIONS. IV. STARK EFFECT IN NONRIGID INTERNAL ROTORS, by D. Kivelson. [Mar. 5, 1956] [2]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 129244 Unclassified

Also published in Jour. Chem. Phys., v. 26: 215-216, Jan. 1957.

When a uniform electric field is applied to a nonrigid internal rotor, the "Stark pattern" of the energy levels is dependent upon the torsional motion. This dependence enters as a centrifugal distortion interaction and by means of the so-called "repulsive effect" of the potential barrier to internal rotation. These effects are small but observable and require that appropriate corrections be made in order to obtain an accurate and meaningful dipole moment from Stark effect measurements. The theory of the Stark effect in vibrating internal rotors has been formulated in this article with particular emphasis on its application to a molecule of C_{3v} symmetry such as CH_3SiH_3. Krongelb and Strandberg have observed this effect in CH_3SiH_3. (Contractor's abstract)

MIT. 12:098

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SOME APPLICATIONS OF FOURIER TRANSFORMS IN ELECTRICAL ENGINEERING AND THEIR INTER RELATIONSHIPS, by E. F. Bolinder. Mar. 15, 1956, 1p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039 sc-64637]) AD 103575 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 820, June 1956.

The visual pictures associated with Fourier transforms are discussed to relate diffraction to tapered lines, tapered lines to directional couplers, directional couplers to distributed amplifiers, transversal filters and gratings. The chain is continued through electron beams deflection systems and optical slits.

MIT. 12:099

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

VIBRATION-INTERNAL ROTATION INTERACTIONS IN MOLECULES CONTAINING A SYMMETRIC TOP GROUP, by P. R. Swan, Jr. and M. W. P. Strandberg. Mar. 22, 1956 [46]p. incl. diagrs. tables, refs. (Technical rept. no. 313) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Also published in Jour. Molecular Spectroscopy, v. 1: 333-378, Dec. 1957.

The vibration-internal rotation interactions in molecules that contain a single symmetric top are studied by means of a model consisting of two internally rigid groups that are allowed to vibrate as well as rotate relative to each other. The matrix mechanical Hamiltonian for the model is obtained and the diagonalization of the corresponding secular determinant that contains large off-diagonal terms is accomplished. An expression for the $J = 0 \rightarrow 1$, $\Delta K = 0$ transition is obtained. Numerical calculations are carried out for the case of methyl alcohol in order to compare the theory with the observed spectrum. A qualitative fit is found, the major contributions being the in-plane vibrations of the two rigid groups. The lack of detailed agreement is attributed to the neglect of those vibrations which distort the methyl group, and to insufficient knowledge concerning the infrared spectrum of the molecule. (Contractor's abstract)

MIT. 12:100

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THE CRYOTRON - A SUPERCONDUCTIVE COMPUTER COMPONENT, by D. A. Buck. [1956] [12]p. incl. diagrs. tables. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637] Unclassified

Published in Proc. Inst. Radio Engineers, v. 44: 482-493, Apr. 1956.

The study of nonlinearities in nature suitable for computer use has led to the cryotron, a device based on the destruction of superconductivity by a magnetic field. The cryotron, in its simplest form, consists of

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a straight piece of wire about one in. long with a single-layer control winding wound over it. Current in the control winding creates a magnetic field which causes the central wire to change from its superconducting state to its normal state. The device has current gain, that is, a small current can control a larger current; it has power gain so that cryotrons can be interconnected in logical networks as active elements. The device is also small, easily fabricated, and dissipates very little power.

MIT. 12:101

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

HYPERFINE STRUCTURE BY COINCIDENCE TECHNIQUES, by L. C. Bradley, III. [1956] [1]p. incl. diagr. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 103580 Unclassified

Published in Phys. Rev., v. 102: 293, Apr. 1, 1956.

The method is based on the work of Brannen, et al. (C. A., v. 49, 12123d). A low-resolution spectrograph admits to 1 photomultiplier only right-circularly polarized light of wave length λ_1; to the other, only right-circularly polarized light of wave length λ_2. A magnetic field is applied in the direction of observation. There will be only accidental coincidences, unless a radio-frequency field causes transitions in the intermediate level between the sublevels M = ± 1/2. Thus, a rise in the coincidence rate indicates the resonant frequency. It is clear that similar, but less pronounced, effects will occur if the intermediate level possesses hyperfine-structure sublevels, between which transitions are similarly induced. A level of an ionized atom can be studied by this technique. Metastable or ground states are not accessible to this technique. (C. A., 1956:11105a)

MIT. 12:102

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MAXIMUM EFFICIENCY OF FOUR TERMINAL NETWORKS, by E. F. Bolinder. Apr. 9, 1956, 1p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 108349 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 941, July 1956.

Mathis and Altschuler have respectively (Proc. I.R.E., v. 43: 229-230, Feb. 1955 and Proc. I.R.E., v. 43: 1016, Aug. 1955) shown geometric constructions for finding the input impedance Z_a (reflection coefficient Γ_a) and the maximum efficiency η_{max} of an arbitrary two-part network which is terminated in its conjugate-image impedance match. In this paper simple geometric explanations are given for these constructions. Diagrams are presented to show division of a hyperbolic distance into two equal parts, displacement of a hyperbolic distance along a straight line, and the use of the butterfly figure for determining Γ_a and η_{max}.

MIT. 12:103

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

CURRENT PUBLICATIONS ON ACOUSTICS, by F. A. Firestone. [May 1956] [3]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 103573 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 28: 509-511, May 1956.

Two book reviews are given (1) Ultrasonic Engineering, by A. E. Crawford, reviewed by R. B. Lindsay, Brown U. and, (2) Manual of Phonology, by C. F. Hockett, reviewed by M. Halle, M.I.T., Research Lab. of Electronics.

MIT. 12:104

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A THEORY OF NONLINEAR SYSTEMS, by A. G. Bose. May 15, 1956, 58p. incl. diagrs. (Technical rept. no. 309) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 134905 Unclassified

The Wiener theory of nonlinear system characterization is described and some of its important concepts are discussed. Following these lines, a theory is developed for the experimental determination of optimum time-invariant nonlinear systems. The systems are optimum in a weighted mean-square sense in which the weighting function is at our disposal. The design of nonlinear systems is regarded as the problem of mapping the function space of the past of the input onto a line that corresponds to the amplitude of the filter output. By choosing a series expansion for this mapping operation that partitions the function space into nonoverlapping cells, an orthogonal representation for nonlinear systems is obtained that leads to convenient apparatus for the determination of optimum systems. General methods are described for applying this theory to the determination of systems that have a performance superior to that of given linear or nonlinear systems. A criterion is established relative to which two systems are defined as "nearly equivalent" and the approximation of nonlinear systems by linear and simple nonlinear systems is discussed. The theory is extended to include the problem of

multiple nonlinear prediction and apparatus for the determination of optimum predictors is indicated. (Contractor's abstract)

MIT. 12:105

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RECORDING MAGNETIC-RESONANCE SPECTROMETER, by M. W. P. Strandberg, M. Tinkham and others. Apr. 3, 1956, rev. May 16, 1956 [10]p. incl. illus. refs. (Technical rept. no. 304) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 115169 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 596-605, Aug. 1956.

Apparatus especially designed for studying electron paramagnetic resonance is described and discussed. A magnet of novel yokeless design is presented. Field stabilization and modulation procedure is considered. The microwave sample cavity is analyzed to determine conditions for optimum operation. The klystron stabilization problem is examined. Appropriate lumped circuits for low-frequency operation are described. The signal amplification and presentation system is treated in detail.

MIT. 12:106

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MULTIPLE-GROUND CODING IN ITERATIVE SWITCHING CIRCUITS, by J. B. O'Loughlin. June 1956, 62p. incl. illus. tables. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637] AD 102325 Unclassified

The general theory of iterative switching circuits is presented, and the use of the flow table, state diagram, and cell diagram is introduced in the analysis, coding, and synthesis of the typical cell, the basic building block in iterative circuit design. Several examples of single-ground and multiple-ground coding are given, and their relative merits and disadvantages are discussed. A new multiple-ground code is introduced which results in the synthesis of a typical cell less complicated and more economical than its single-ground equivalent. The characteristics and properties of this new code are discussed, and several examples are given.

MIT. 12:107

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORETICAL LIMITATIONS ON THE NOISE PERFORMANCE OF LINEAR AMPLIFIERS (Abstract), by H. A. Haus and R. B. Adler. [June 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the Congrès International "Tubes Hyperfréquences," Paris (France), May 29-June 2, 1956.

This work concerns the single-frequency noise performance of linear, active, two terminal-pair networks with internal noise generators. It is shown that an adequate measure of noise performance of an amplifier must include, beside the noise figure F, the available power gain G of the amplifier. The new proposed measure is: $M = (F - 1)/(1 - 1/G)$. The significance of M shows up when the amplifier is imbedded in an arbitrary lossless network in such a way that a new two terminal-pair amplifier is obtained. This transformation leaves invariant the eigenvalues of a matrix N that is formed from the open-circuit noise voltages and the impedance elements of the amplifier. The minimum value of the noise measure M that can be achieved by such a lossless transformation is given by one of the eigenvalues of the N matrix. An important class of amplifiers can be brought, by means of lossless feedback, into a unilateral form in which the open-circuit input and output impedances have positive real parts. One way of achieving the minimum value of M is to properly mismatch the input of the amplifier in its unilateral form. Some properties of the noise measure M are presented that further recommend its use, instead of the noise figure F, as a quantitative measure of amplifier noise performance. (Contractor's abstract)

MIT. 12:108

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

TUNED CIRCUITS CONTAINING NEGATIVE RESISTANCE, by J. Gross. [1955] [5]p. incl. diagrs. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 106116 Unclassified

Also published in Jour. Appl. Phys., v. 27: 603-607, June 1956.

A negative resistance connected to a "suitable" resonant circuit (a current-controlled negative resistance connected to a series-tuned circuit, or a voltage-controlled negative conductance connected to a parallel-tuned circuit) constitutes an almost-harmonic oscillator. In this paper the "unsuitable" connections (a current-controlled negative resistance connected to a parallel-tuned circuit, or a voltage-controlled negative conductance connected to a series-tuned circuit) are analyzed qualitatively in terms of variables leading to a single-valued phase plane. Physical considerations, expressed in a jump condition, serve to connect different regions of analyticity of the differential

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equattons of lhe circuit tn this plane. The "unsuttable" connections cannot sustain almost-harmonic oscillattons, and their theorettcally possible relaxatton oscillations are unstable; they yteld bistable ctrcuits. (Contractor's abstract)

MIT. 12:109

Massachusetts Inst. of Tech. Research Lab. of Electrontcs, Cambridge.

THE SYNTHESIS OF VOLTAGE TRANSFER FUNCTIONS, by P. M. Lewis, II. June 7, 1956, 105p. incl. diagrs. refs. (Technical rept. no. 314) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 133936 Unclassified

The synthesis of voltage transfer functions (E_2/E_1), in lhe form of linear, lumped, finite, passtve, bilateral networks, containing no ideal transformers or mutual coupling, is considered. The basic realizability conditions are derived and realization procedures are developed based on these conditions, showing them to be both necessary and sufficient. This particular class of networks places constraints on the allowable values of the constant multiplier in the voltage transfer function and on the positions of the transmtssion zeros in the case of grounded networks. In order to study these constraints, a new concept — the concept of the one — is introduced. This concept gives a certain physical significance to the constant multiplier which allows the basic realizability conditions to be derived in a simple fashion. These conditions are: (1) the maximum gain obtainable from a given pole-zero plot independent of configuration; (2) the maximum gain obtainable from a give pole-zero plot for a given complexity of the network configuration; (3) the maximum gain obtainable from a given pole-zero plot for a realization in terms of a symmetrical network; and (4) the general conditions under which a grounded (three-terminal) realization of any transfer function is possible Various synthesis procedures are developed based on these realizability conditions: (1) a general lattice synthesis in the two element and three element cases; (2) a general method of realizing grounded symmetrical networks, by first realizing a lattice and then unbalancing it; and (3) a general realization procedure yielding any allowable gain in both the two element and the three-element cases. (Contractor's abstract)

MIT. 12:110

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MOTIONS OF IONS AND ELECTRONS, by W. P. Allis. June 13, 1956, 100p. incl. diagrs. tables, refs. (Technical rept. no. 299) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 125502 Unclassified

This report reviews the mathematical methods applicable to ionized gases. In Part I the motion of an individual electron or ion under a Lorentz force, tncluding the effects of magnetic gradients, is studted. In Part II, with the tntroductton of collistons, thts ts no longer posstble, but we can still follow the motion of an average particle. For high values of E/p, the behavtor of a swarm of parttcles ts remarkably close to the motton of the average parttcle, but for lower values of E/p other methods must be used. In Part III the Boltzmann equatton ts applied to a "Lorentzian gas," that is, to force electrons in a gas. In Part IV the equation is transformed to an integral form, the Boltzmann transport equation, so that it will be applicable to ions. The transport equation is solved exactly for the case of particles with a constant mean free time, which corresponds to the polarization force between an ion and a molecule. The consideratton of Coulomb interacltons in Part V introduces a force of so much longer range that an electron interacts simultaneously wtth a large number N of electrons and ions. The basic assumption of Boltzmann theory is then isolated, and one must use the Fokker-Planck equation, the relation of which to the Boltzmann transport equation is shown. The coefficients of the Fokker-Planck equation are derived by the method of the Rosenbluth potentials. (Contractor's abstract)

MIT. 12:111

Massachusetts Insl. of Tech. Research Lab. of Electronics, Cambridge.

PIECEWISE-LINEAR NETWORK THEORY, by T. E. Stern. June 15, 1956, 76p. incl. diagrs. refs. (Technical rept. no. 315) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 200729 Unclassified

A systematic approach to the problems of analysis and synthesis of piecewise-linear systems that do not contain memory is presented. These systems provide a link between the general studies of nonlinear systems, examplified by the work of Wiener, Zadeh, and others, and the needs of the practical circuit designer. In the area of analysis, straightforward procedures are developed for handling resistive piecewise-linear networks. The methods are based upon an algebra of inequalities. Examples of applications to analysis are given. In the area of synthesis, techniques are developed by using diode networks for the construction of general piecewise-linear driving point functions, as well as generators of piecewise-linear voltage transfer functions of several variables. Some of the properties of nonlinear resistive networks, in general, and diode networks, in particular, are discussed. Applications of the inequality algebra to the synthesis problem are also considered. Two forms of the transfer synthesis problem are treated, arbitrary function synthesis. Examples of the practical application of the techniques that are discussed to the construction of generators of functions of one and two variables are given. (Contractor's abstract)

MIT. 12:112

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

IMPEDANCE AND POLARIZATION RATIO TRANSFORMATIONS BY A GRAPHICAL METHOD USING THE ISOMETRIC CIRCLES, by E. F. Bolinder. [1956] [5]p. incl. diagrs. (Sponsored jointly Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 115170 Unclassified

Also published in I. R. E. Trans. on Microwave Theory and Techniques, v. MIT-4: 176-180, July 1956.

The isometric circles for the direct and inverse linear fractional transformations can be used for transformations of impedances and polarization ratios. In the loxodromic case an inversion is performed in the isometric circle of the direct transformation, followed by a reflection in the symmetry line of the two circles, and a rotation around the origin of the isometric circle of the inverse transformation. In the nonloxodromic case only the first two operations have to be applied. Three illustrative examples are given: the first shows the transformation of the right half of the complex impedance plane into the unit circle (Smith Chart); the second gives a circular geometric proof of the Weissfloch transformer theorem; the third shows an example of cascading lossless, two terminal-pair networks. (Contractor's abstract)

MIT. 12:113

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MORPHOPHONEMIC CHANGE IN SIOUAN (Abstract), by G. H. Matthews. July 1956 [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc 64637, and National Science Foundation) Unclassified

Presented at meeting of the Linguistic Soc. of Amer., Ann Arbor, Mich., July 27-28, 1956.

A morphophoneme which occurs in the Siouan languages consists of from two to four allomorphophones, depending on the language. The correspondences of these allomorphophones, vowels, among both those languages which have retained the morphophoneme and those which have lost it, are different from the correspondences of the several vowels when they occur in the same environment but not as part of the morphophoneme. This infers that instead of a morphophoneme, another vowel phoneme must be reconstructured in Proto-Siouan. However, this reconstructed phoneme occurs only in a very restricted, morphologically described environment. In addition, it alters the Proto Siouan vowel from the typical Siouan one shared by most of the daughter languages. Those daughter languages differing from the typical Siouan system do so in an entirely different manner. (Contractor's abstract)

MIT. 12:114

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A NOTE ON THE MAXIMUM FLOW THROUGH A NETWORK, by P. Elias, A. Feinstein, and C. E. Shannon. July 11, 1956 [3]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 127653 Unclassified

Also published in I. R. E. Trans. of Professional Group on Information Theory, v. IT-2: 117-119, Dec. 1956.

This note discusses the problem of maximizing the rate of flow from one terminal to another, through a network which consists of a number of branches, each of which has a limited capacity. The main result is a theorem: The maximum possible flow from left to right through a network is equal to the minimum value among all simple cut-sets. This theorem is applied to solve a more general problem, in which a number of input nodes and a number of output nodes are used.

MIT. 12:115

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY AND APPLICATIONS OF FLOW GRAPHS, by C. S. Lorens. July 15, 1956, 114p. incl. diagrs. refs. (Technical rept. no. 317) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 158736 Unclassified

Three objectives were undertaken: (1) the development of a basic theory of flow graphs; (2) the extension of its known application to electrical networks; and (3) the formulation of the natural relation between flow graphs and the properties of discrete statistical systems. Part I deals with the first two objectives. Much of the linear theory of flow graphs parallels linear equation theory in such a manner that considerable meaning is given to many classical operations of formulation, inversion, and reduction. Part I covers additive functional systems; inversion; electrical network formulation; mathematical determinants; partitions and expansions of a determinant; rank, positive definite, eigenvalues, and eigenvectors; group multiplication; and transcendental equations. Part II deals with the third objective. The pictorial representation of a discrete statistical system specifies its properties. With flow graphs these properties are conveniently calculated and interpreted directly from the representative graph. The material of Part II covers recurrent events, transient systems, stationary state distributions, sensitivity and variation, generating

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functions channel capacity, and information structure. (Contractor's abstract, modified)

MIT. 12:116

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MAGNETIC MOMENTS AND HYPERFINE-STRUCTURE ANOMALIES OF Cs^{133}, Cs^{134}, Cs^{135}, and Cs^{137}, by H. H. Stroke, V. Jaccarino and others. July 26, 1956 [14]p. incl. diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 127652 Unclassified

Also published in Phys. Rev., v. 105: 590-603, Jan. 15, 1957.

The atomic-beam magnetic-resonance method was used to measure the nuclear gyromagnetic ratios and hyperfine-structure separations of the radioactive isotopes Cs^{134}, Cs^{135}, and Cs^{137}. A surface ionization detector was used. The hyperfine-structure separations were obtained by direct $\Delta F = \pm 1$ transitions near zero field. The values of $\Delta\nu$ found for the three isotopes are:

$\Delta\nu\ (Cs^{134}) = 10473.626 \pm 0.015$ mc/sec,
$\Delta\nu\ (Cs^{135}) = 9724.023 \pm 0.015$ mc/sec,
$\Delta\nu\ (Cs^{137}) = 10115.527 \pm 0.015$ mc/sec.

Pairs of transition belonging to the two different F-states, but involving the same m_F values, constitute frequency doublets separated by $2g_I\mu_o H$. From measurements of the difference frequencies of these doublets for pairs of isotopes in fields in the vicinity of 9000 gauss, the following g-value ratios were obtained:

$g_I(Cs^{135})/g_I(Cs^{133}) = 1.05820 \pm 0.00008$,
$g_I(Cs^{137})/g_I(Cs^{135}) = 1.04005 \pm 0.00008$,
$g_I(Cs^{134})/g_I(Cs^{133}) = 1.01447 \pm 0.00029$.

The hfs anomalies arising from the variation of the electron wave function over the finite distribution of nuclear magnetization were calculated from these measurements. The values found for these anomalies, defined by $\epsilon_2 - \epsilon_1 = [g_1\nu_2(2I_1 + 1)]/[g_2\nu_1 \times (2I_2 + 1)] - 1$, are:

$\epsilon(Cs^{133})\ \epsilon(Cs^{135}) = +0.057 \pm 0.009\%$,
$\epsilon(Cs^{135})\ \epsilon(Cs^{137}) = -0.020 \pm 0.009\%$,
$\epsilon(Cs^{133})\ \epsilon)Cs^{134}) = +0.169 \pm 0.030\%$.

The theory of Bohr and Weisskopf on the hfs anomalies was applied to these nuclei; the calculations are based primarily on a single-particle model with varying distributions of spin and orbital contribution to the nuclear moment. An apparent magic number effect in the anomalies was observed. (Contractor's abstract)

MIT. 12:117

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE CONDUCTIVITY OF AN IONIZED DECAYING PLASMA AT LOW-PRESSURES, by A. L. Gilardini and S. C. Brown. July 27, 1956 [6]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 127599 Unclassified

Also published in Phys. Rev., v. 105: 25-30, Jan. 1, 1957.

Margenau's analysis for the microwave conductivity of an infinite decaying plasma in a uniform field is extended to the case of a bounded plasma in a slightly nonuniform file. It is shown that, if we assume a power expansion for the electron-collision frequency as a function of energy, the conductivity at low pressures can be computed as a function of time and position when the spatial and time variations of the density and energy moments of the electron-distribution function are known. An approximate method, based on a convenient integration of Boltzmann equation is given to compute these quantities, when inelastic collisions can be neglected. The steady-state conductivity in the late afterglow of a diffusion-controlled decaying plasma is thus explicitly determined for two experimental conditions: a plasma filling a cubic quartz bottle centered in a parallelpiped microwave cavity and a plasma filling a quartz tube of square cross section in a wave guide. The limit for the validity of the theory set by the appearance of inelastic collisions at high electric fields is investigated.

MIT. 12:118

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE DETERMINATION OF THE PROBABILITY OF COLLISION OF ELECTRONS IN NEON, by A. L. Gilardini and S. C. Brown. July 27, 1956 [4]p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 127651 Unclassified

Also published in Phys. Rev., v. 105: 31-34, Jan. 1, 1957.

The theory for computing the microwave conductivity of a plasma discussed in the previous paper (Phys. Rev., v. 105: 25-30, Jan. 1, 1957) can be used for determining the collision probability for momentum transfer of slow electrons when the conductivity ratio of a plasma is measured as a function of the applied field. The conditions required for having a pressure independent conductivity ratio and steady state electron energy for a given field are investigated. The convenience of using two independent fields for

measuring the conductivity and changing the electron energy is shown. Conductivity ratios measured in the afterglow of a pulsed discharge in a microwave resonant cavity are given for neon and neon contaminated with argon. The collision probability for momentum transfer is neon computed from these data as a function of the electron velocity joins Ramsauer's and Kollath's measurements for higher electron velocities.

MIT. 12:119

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ABSORPTION OF SOUND IN LIQUID HELIUM II, by W. M. Whitney. Aug. 15, 1956 [4]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 127600 Unclassified

Also published in Phys. Rev., v. 105: 38-41, Jan. 1, 1957.

The coefficient of absorption of sound in liquid helium has been measured at a frequency of 11.8 mc/sec in the temperature range from 0.2°K to 1°K, at vapor pressure, and at 8.0, 13, and 18.3 atmospheres. Careful measurements above 0.9°K at vapor pressure reveal that the two sharp maxima observed by Chase and Herlin at the top of their absorption curve were an instrumental effect. Preliminary results at the higher pressures indicate that, if allowance is made for the pressure variation of the density and the velocity of sound, the attenuation decreases exponentially with pressure at temperatures just below 1°K. (Contractor's abstract)

MIT. 12:120

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FLUCTUATIONS AND IRREVERSIBLE THERMODYNAMICS, by L. Tisza and I. Manning. [Aug. 16, 1956] 11 p. incl. refs. (Technical rept. no. 235) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 135144 Unclassified

Also published in Phys. Rev., v. 105: 1695-1705, Mar. 15, 1957.

The time dependent theory of fluctuations is based on a combined application of the phenomenological theory of dissipation and the stochastic theory of random processes. The traditional method of joining these theories into a uniform scheme proceeds by adding a random perturbation to the differential equation of the phenomenological kinetic theory (the Langevin equation in case of Brownian motion). In the present approach the problem is considered as an essentially statistical one. The role of the differential equation is to fix the form of the distribution function over the manifold of fluctuation paths in function space. The solutions of the equation constitute the most probable region in function space, and the fluctuations appear with their appropriate probabilities. The connection between the phenomenological equation and the distribution function is stipulated by means of a postulate, the essential ingredient of which is the auxilliary function recently introduced by Onsager and Machlup. This postulate is joined to the standard assumptions of the phenomenological and the stochastic theories for the derivation of the entire time-dependent fluctuation theory. The calculation of fluctuations is carried out in the temporal and the spectral descriptions. The relation of the two schemes is discussed along with the scope and limitations of the theory.

MIT. 12:121

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

VOLTAGE-TUNED RC ACTIVE FILTERS USING JUNCTION DIODES AND TRANSISTORS (Abstract), by C. R. Hurtig. [Aug. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

The use of forward-biased junction diodes as the resistive parameters of RC active filters results in a voltage-tuneable filter whose complex natural frequency is a linear function, within 2 per cent, of the control voltage over a range of ten-to-one. Two examples are shown — an oscillator and a narrow-bandwidth amplifier. The fundamental limitations to linearity of the frequency control characteristic are discussed. The short-time stability of the magnitude of the complex natural frequency is limited by resistance modulation of the diodes by excess semiconductor noise to a few parts in ten thousand. The long-time stability is mainly determined by the temperature dependence (approximately -0.34 per cent per degree Centigrade) of the incremental resistance of the junction diodes. A design concept for the use of passive networks with transistor amplifiers which results in networks compatible with transistor impedances obtained with bias-stabilized connections is discussed. These networks are the reversed equivalent of those commonly used in vacuum tube circuitry. (Contractor's abstract)

MIT. 12:122

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THEORY OF HYPERFINE STRUCTURE II, by C. Schwartz. [Aug. 31, 1956] 11 p. incl. diagrs. tables. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 128823 Unclassified

MIT. 12:123 - MIT. 12:124

Also published tn Phys. Rev., v. 105: 173-183, Jan. 1, 1957.

Numerical values for the 1-electron integrals of tnterest in the analysts of atomtc hyperfine structure have been calculated by using screened relativistic wave functions. Ratios of these tntegrals, representing the relativistic correction factors of Casimtr, are given to replace the older values which neglected shielding effects. The most marked changes occur tn the studies of the octopole tnteraction and hfs anomalies tn p-states. The calculated 1-electron magnetic dipole integral, when compared with the expertmental ratio. dipole hfs/nuclear moment, makes it posstble to deduce the magnitude of atomic polarization (Sternheimer) effects. In the doublet p-states that were studied, the polarization terms seem to be almost entirely of the sort discussed in an earlier paper: excitation of s-electrons. In a general discussion of polarization calculations, some explanation is given of the large correction factors for the fine structure, dipole, and quadrupole hyperfine structure that were calculated by Sternhetmer (the radial redtstribution of charge terms). It ts also suggested that large polarization corrections may be needed for the octopole interaction. (For Part I see item no. MIT. 11:061) (Contractor's abstract)

MIT. 12:123

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FINAL-VALUE CONTROL SYSTEMS, by R. C. Booton, Jr. [Sept. 1956] [3]p. (Sponsored jointly by Signal Corps, Offtce of Naval Research, and Air Force Office of Sctenttfic Research under DA 36-039-sc-64637) Unclassified

Presented at 1956 Symposium on Information Theory, M.I.T., Sept. 10-12, 1956.

Published in I.R.E. Trans. on Information Theory, v. IT-2: 173-175, Sept. 1956.

A final-value system controls a response variable over a time interval with the objective of minimizing some measure of the difference between a desired value and the value of the response at the final time of the interval. The ensemble of situations is considered in which the system input and the desired response are random variables that are statistically related. The response variable is constrained because of the physical limitations of the element being controlled. Earlier considerations (1) of the problem has shown that any situation in which the response is the result of a linear (possibly time variable) operation on a variable that is constrained to be less in magnitude than some allowable value can be conferred to a maximum velocity constraint situation by consideration of an extrapolated response that is velocity constrained and which equals the actual response at the final time. Earlier results (1) based upon a quasi-linearization interpretation of the optimum mean-square-error linear system with a velocity constraint suggest that a system consisting of a predictor followed by a simple nonlinear feedback system should be approximately the optimum system. The present paper discusses the optimum design problem with an arbttrary error criterion and an arbitrary ensemble of input functtons. The discussion ts restricted to the velocity constraint situation and for mathematical stmplicity the continuous time variable ts replaced by a discrete set of time values. Chotce of the system operator to mtnimize the measure of error ts shown to lead to a result that can be described in words as follows: "At each step in time the system can move the response from tts old position to a new position that can be selected from a range of values determined by the old response and by the allowable amount of movement (determined, of course, by the magnitude of the allowable velocity). For each allowable value of the new response the conditional error measure, conditional both on the input values already received and on the assumption that in the future the system will perform in an optimum manner, is computed." (Contractor's abstract)

MIT. 12:124

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambrtdge.

A RADAR DETECTION PHILOSOPHY, by W. M. Siebert. [1956] [18]p. incl. illus. (Sponsored jotntly by Signal Corps, Office of Naval Research, and Air Force Office of Sctentiftc Research under [DA 36-039-sc-64637]) AD 127078 Unclassified

Also published tn I.R.E. Trans. on Information Theory, v. IT-2: 204-221, Sept. 1956.

This paper is an attempt to present a short, unified discussion of the radar detection, parameter estimation, and multiple-signal resolution problems — mostly from a philosophical rather than a detailed mathematical point of view. The purpose is, hopefully, to make it possible in at least some limited sense to reason back from appropriate measures of desired radar performance to specifications of the necessary values of the related radar parameters. Specifically four measures of performance quality are considered: (1) the reliability of detection, (2) the accuracy with which target parameters can be esttmated; (3) the extent to which such estimates can be made without ambiguity; and (4) the degree to which two or more different target echoes can be separated or resolved. It is argued that the radar synthesis problem can be split into two more-or-less independent phases. First, adjust such parameters as those appearing in the radar equation so that the received signal energy is sufficiently large for the degree of reliability of detection desired. The required value of energy is almost entirely independent of the character of the received echo signal waveform. The second phase is, then, to select the waveform in such a way that accuracy, ambiguity, and resolution requirements are met. The limitations on what can be achieved in terms of these three quality measures are discussed in relation to an uncertainty principle. For

purposes of illustration several novel waveforms havtng unusual and useful properties are described. (Contractor's abstract)

MIT. 12:125

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A THEOREM CONCERNING NOISE FIGURES, by A. G. Bose and S. D. Pezaris. [1956] [5]p. incl. diagrs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-3: 190-196, Sept. 1956.

A theorem is formulated and proved which determines the greatest lower bound of the single-frequency noise figure of a general system consisting of n amplifying devices and passive coupling elements. According to the theorem, this lower bound is equal to the noise figure of an optimum system using a selected one of these amplifying devices. (Contractor's abstract)

MIT. 12:126

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

BASIC DATA OF ELECTRICAL DISCHARGE, by S. C. Brown and W. P. Allis. Sept. 1, 1956, 103p. incl. diagrs. tables, refs. (Technical rept. no. 283; 3rd ed.) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 49438 Unclassified

This report contains basic data on: (1) potential excitation and ionization energies of atoms in electron volts; (2) probabilities of the collision of electrons and ions; (3) surface phenomena including emissions and conversions; (4) motions, velocities and energies of electrons and ions; (5) production and decay of ioniza tion; (6) high-frequency and direct-current breakdown and time lags; (7) electron energies; and (8) cathode phenomena such as cathode fall and sputtering.

MIT. 12:127

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

NUCLEAR RESONANCE SPECTRA OF HYDRO-CARBONS: THE FREE ELECTRON MODEL, by J. S. Waugh and R. W. Fessenden. Sept. 4, 1956 [4]p. incl diagrs. tables, refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc 64637) AD 128824 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 846-849, Feb. 20, 1957.

The classical free electron model of Pople is used to predict the high resolution nuclear resonance spectra of some hydrocarbons. The modifications necessary to describe the spectra of simple substituted benzenes are discussed. Some previous measurements by other workers of the spectra of condensed aromatic substances are repeated somewhat more precisely, and agree only very crudely with the simple free electron theory. The spectra of two 1.4-polymethylenebenzenes are predicted and support the fundamental ideas of Pople. The spectrum of 2, 2-paracyclophane is also reported. (Contractor's abstract)

MIT. 12:128

Massachusetts Inst of Tech. Research Lab. of Electronics, Cambridge.

CHARACTERIZATION OF PROBABILITY DISTRIBUTIONS FOR EXCESS PHYSICAL NOISES, by J. Hilibrand. Sept. 7, 1956, 51p. incl. illus. diagrs. tables, refs. (Technical rept. no. 276) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 149545 Unclassified

Theoretical and experimental techniques are described for charactsrizing the probability distributions of certain excess physical noises by their moments. Theoretical methods are presented for applying this "moments technique" in the time domain to random-pulse noise, and in the frequency domain to any random functions for which the momsnts exist. The frequency-domain techniqus is used for a theoretical study of the approach to a gaussian distribution of random-pulss noise that is band-limited by RC cutoffs at low and high frequencies is examined by using the time-domain technique. It is found that the approach of noise distributions to gaussian is govsrned by ths "memory" of the filter system rather than simply by its band-width. An experimsntal systsm is described for measuring the first four moments of notses in the 0.2 cps - 10 kc range. It is concluded that experimental measurements of moments are mors dsairable than direct probability denstty msasursments when the goals are: (a) to categorize broadly the form of continuous noise distributton by a small number of parameters, and/or (b) when a minimum investment of time and equipmsnt is desired. Measuremsnts on 1/f noise in germantum diodes confirm (within experimental error) that the first probabtlity dtstribution of this notse is gaussian in nature. Some effects of limited system bandwidth are illustrated by measurements on the distinctly nongaussian "avalanche" noise in silicon junction diodes. (Contractor's abstract)

MIT. 12:129 - MIT. 12:132

MIT. 12:129

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THE PARAMAGNETIC RESONANCE SPECTRUM OF AMMONIUM CHROMIUM ALUM, by C. F. Davis, Jr. and M. W. P. Strandberg. [Sept. 11, 1956] [9]p. incl. diagrs. tables, refs. [Technical rept. no. 242] (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 128825 Unclassified

Also published in Phys. Rev., v. 105: 447-455, Jan. 15, 1957.

A detailed solution of the fine-structure splitting of the ground state of the chromium ion is given. This solution assumes an electric field of cubic symmetry with a small trigonal distortion and the residual spin-orbit coupling superposed. The effect of a magnetic field at an arbitrary orientation is calculated. Absorption positions and relative intensities are calculated and checked with experiment. Lines of character predominantly $\Delta S_z = 2, 3$ are shown to have sufficient $\Delta S_z = 1$ character to give the experimentally determined intensities. So-called "forbidden transitions" are accounted for quantitatively by this detailed calculation. Shapes of absorption peaks are Lorentzian for dilute specimens and Gaussian for full-strength alum. A small variation of trigonal Stark field from one paramagnetic ion to another is sufficient to account for the observed line width. (Contractor's abstract)

MIT. 12:130

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FIELD HOMOGENEITY AND POLE DISTRIBUTION, by J. D. Bjorken and F. Bitter. [June 25, 1956; rev. Sept. 14, 1956] [4]p. incl. diagrs. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 122934 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 1005-1008, Dec. 1956.

The design of a magnet for producing a uniform field is described. The magnet model used in the calculations is that of cylindrical cores surrounded by rims. The positions of the central pole faces and rims can be adjusted independently. A calculation, based on the assumption that the pole pieces are uniformly magnetized, shows that, for a certain positioning of the cores and rims, the z^2 and z^4 correction terms to H_z can be simultaneously canceled. Practical limitations to uniformity that result from a slight asymmetry in the geometry and from the effect of nonuniformity in magnetization because of domain structure in the iron also are discussed. (Contractor's abstract)

MIT. 12:131

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

BARRIER THEORY OF THE PHOTOCONDUCTIVITY OF LEAD SULFIDE, by J. C. Slater. [1956] [14]p. incl. diagrs. tables. [Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637] Unclassified

Published in Phys. Rev., v. 103: 1631-1644, Sept. 15, 1956.

The barrier theory of the infrared photoconductivity of PbS films is discussed, according to which the high resistance of the films arises from n-p-n barriers at the surfaces between the crystallites forming the films, the barriers being formed in the oxidizing process used in preparing the films. Under the action of light, electron hole pairs are formed, these carriers become trapped in the n- and p-type regions, respectively, the resulting charge density lowers the barriers, and hence the conductivity is increased. This theory is worked out quantitatively, and compared with experimental results of Mahlman on films of the type actually used as sensitive photoconductors. The theory shows good qualitative and quantitative agreement with experiment in numerous respects, including the explanation of the dark conductivity of the films and its dependence on temperature, the photoconductivity as a function of irradiance and temperature, the time constants involved in the rise or decay of the photoconductivity, and the short-wave limit of the photoconductivity. In working out the theory of the barrier model, we use the properties of the bulk material as determined by Petritz and Scanlon, and the properties of the films are found to be consistent with our knowledge of the behavior of the bulk material. (Contractor's abstract)

MIT. 12:132

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

INTERFERENCE REJECTION IN FM RECEIVERS, by E. J. Baghdady. Sept. 24, 1956, 106p. incl. diagrs. tables, refs. (Technical rept. no. 252) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 145017 Unclassified

A new role is suggested for the amplitude limiter in FM receivers. By spreading out the spectrum which is necessary for the reproduction of the FM disturbance that is caused by the interference, the limiter makes it possible for a filter to reject an important portion of this spectrum without substantially affecting the spectrum that carries the message modulation. The conditions for the success of this operation are analyzed in terms of an ideal limiter followed by an idealized filter. The variation of the required

minimum extent of linearity in the discriminator characteristic with the limiter bandwidth is determined. This is followed by a study of the effect upon the interference of a repeated cycle of amplitude limiting and spectrum filtering. The cascading of several narrowband limiters is found to be an invaluable scheme for enhancing the capture capabilities of an FM receiver. (Contractor's abstract)

MIT. 12:133

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

FLUCTUATIONS IN NEURAL THRESHOLDS AND RELATED PROBABILITY MODELS IN THE NERVOUS SYSTEM, by L. S. Frishkopf and W. A. Rosenblith. [Oct. 1956] [16]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the Symposium on Information Theory in Health Physics and Radiobiology (Health Physics Div.), Oak Ridge National Lab., Gatlinburg, Tenn., Oct. 19-30, 1956.

Published in Symposium on Information Theory in Biology, 1958, p. 153-168.

Over the past 25 years at least half a dozen independent investigations of the responsivity of nerve tissue have led to the conclusion that the threshold of a resting neuron fluctuates in time. This conclusion is based on the study of sensory and motor fibers, of monosynaptic arcs and neuromuscular junctions. If not a property of all nerve tissue, threshold fluctuation is a valid concept in many specific parts of the nervous system. An attempt will be made to review these studies, to find common elements among them and to specify differences. In particular it will be useful to describe the fluctuating threshold in terms of a probability distribution rather than in a deterministic way. The degree of threshold correlation among neurons of a given "pool" or population will be considered for several systems, based on available data and on theoretical considerations. Likely sources of threshold fluctuation leading to both correlated and uncorrelated variations will be discussed. A number of mathematical models based on such a probability description of neural thresholds have been developed. These models attempt to derive the response characteristics of large ensembles of neural elements from postulated properties of the thresholds of single units and of threshold interaction among several units. Each model is specific to a certain area of experimentation; common to all of them is the probability description of threshold behavior. Several of these models will be discussed and evaluated. (Contractor's abstract)

MIT. 12:134

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

STATISTICAL THEORIES OF RADAR SYNTHESIS, by W. M. Siebert. [1956] 10p. incl. illus. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 135148 Unclassified

Also published in Proc. National Electronics Conference, Chicago, Ill., v. 12, Oct. 1-3, 1956.

The behavior of a simple model is analyzed to determine those attributes which influence the performance with respect to various quality measures. Specifically detection reliability is shown to depend almost exclusively on the received signal energy and to be essentially independent of the transmitted waveform. On the other hand questions of accuracy, ambiguity, and resolution are determined almost entirely by the waveform and can in particular be only slightly influenced by the receiver design. The treatment is based in large part on the a posteriori probability approach of Woodward with special emphasis on the limitation imposed on simultaneous range and velocity measurements by a fundamental uncertainty principle. (Contractor's abstract)

MIT. 12:135

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

AN ELECTRONIC METHOD FOR DETECTING EVOKED RESPONSES OF THE BRAIN AND FOR REPRODUCING THEIR AVERAGE WAVEFORMS, by J. S. Barlow. Oct. 15, 1956 [4]p. incl. illus. (In cooperation with Mass. General Hospital, Boston.) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 139557 Unclassified

Also published in Electroencephalography and Clin. Neurophysiology Jour., v. 9: 340-343, May 1957.

An electronic method is described for detecting evoked responses of the brain and for reproducing their average waveforms. The electronic equipment utilizes a magnetic delay drum, an integrator, a timer (automatic recycling device), and a gating and storage unit. Stimuli and brain potentials are recorded simultaneously on magnetic tape from a conventional electroencephalograph and the averages of evoked responses are obtained as the tapes are played back repeatedly. By means of the magnetic drum, the stimulus artefacts can be delayed in time (+) with respect to the brain potentials. For a given setting of the magnetic drum (i.e., a given displacement of stimuli in time) the instantaneous voltage of the brain potentials corresponding to each of the stimuli is noted. An average of all such samples is obtained by a Miller integrator.

MIT. 12:136 - MIT. 12:139

and the result written out on an Esterline-Angus graphic milliammeter. The setting of the magnetic drum is then automatically changed to a new delay, the tape played through again, a new average obtained, and so on. The resulting plot of averages against the delay τ then gives the average evoked response for the particular number of stimuli chosen.

MIT. 12:136

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

RELATIONS BETWEEN AUDITORY PSYCHOPHYSICS AND AUDITORY ELECTROPHYSIOLOGY, by W. A. Rosenblith. [Oct. 15, 1956] [8]p. incl. refs. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 144177 Unclassified

Also published in Trans. New York Acad. Sciences, v. 19: 650-657, May 1957.

A brief review is presented of instrumentation problems and advances in instrumentation and techniques. Recent significant advances in the physiology and in particular the neurophysiology of audition are enumerated. Six areas of study in auditory psychophysics are reviewed. Major conceptual trends that have influenced research workers in audition are cited. Future trends in the field are predicted.

MIT. 12:137

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

DETECTION THEORY AND PSYCHOPHYSICS, by T. Marill. Oct. 30, 1956, 72p. incl. illus. tables, refs. (Technical rept. no. 319) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 141583 Unclassified

Traditional psychophysical models and Tanner and Swets' model are critically examined. Some of the weaknesses of these models are found to be eliminable by a more sophisticated analysis in terms of detection theory. Accordingly, psychophysical methods are reexamined, and the two-category forced-choice technique is found to be particularly advantageous on theoretical grounds. Application of detection theory to the problem of auditory masking with gaussian noise as measured by this forced-choice technique leads to the mathematical derivation of the theoretical ("ideal detector") psychophysical function for this situation. Experiments using the forced-choice method with auditory signals masked by broadband gaussian noise are reported. The aim of these experiments is to determine the extent to which and the manner in which subjects differ from the "ideal detector" of detection theory. It is found that, except for being approximately 13 db less sensitive, subjects behave very much like the ideal detector – that is, in accordance with the mathematical predictions – when the signals are pure tones. Results with signals consisting of two-component tones require a somewhat enlarged model; such a model is developed. (Contractor's abstract)

MIT. 12:138

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

A LOOK AT COMMUNICATION SYSTEMS OF THE FUTURE (Abstract), by R. M. Fano. [Nov. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at the New England Radio Electronics meeting, Boston, Mass., Nov. 15-16, 1956.

It has been shown that, contrary to earlier belief, the reliability of a communication system disturbed by noise can be made as perfect as desired for a fixed bandwidth, fixed signal power, and fixed transmission rate; noise sets and inherent limit to the transmission rate at which perfect reliability can be obtained but not to the degree of reliability. It has been shown further that our present utilization of communication channels is in many cases grossly inefficient. Possible future system developments will be discussed in the light of these results, together with some of the theoretical and practical problems that must still be faced in their connection. (Contractor's abstract)

MIT. 12:139

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROWAVE DETERMINATIONS OF THE FREQUENCY OF IONIZATION AND THE COEFFICIENT OF FREE DIFFUSION IN HYDROGEN (Abstract), by M. P. Madan, S. J. Buchsbaum, and E. Gordon. [1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) Unclassified

Presented at 9th annual Gaseous Electronics Conference, Westinghouse Research Labs., Pittsburgh, Pa., Oct. 31-Nov. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II. v. 2: 87, Jan. 30, 1957.

Microwave breakdown experiments yield, apart from other parameters, the ratio ν_i / D, in which ν_i is the ionization frequency and D_- is the coefficient of free diffusion for electrons. This paper describes a method for a direct determination of ν_i and D_-, utilizing an additional experimental parameter tp, where p is the pressure and t is the time for the build-up of electron density. In addition, the steady-state

breakdown fields can also be predicted. The experiment has been performed, using two TM_{010}-mode resonant cavities of different sizes. The results have been compared with the theory of Allis and Brown. By properly accounting for the space-charge effect and the nonuniformity of the electric field, the results are in substantial agreement with the theory. (Contractor's abstract)

MIT. 12:140

Massachusetts Inst. of Tech. [Research Lab. of Electronics] Cambridge.

THE TECHNICAL FEASIBILITY OF TRANSLATING LANGUAGES BY MACHINE, by V. H. Yngve. [1956] [6]p. (Sponsored jointly by Signal Corps, Office of Naval Research, Air Force Office of Scientific Research, and National Science Foundation under [DA 36-039-sc-64637]) Unclassified

Published in Elec. Eng., v. 75: 1-6, Nov. 1956.

Language translations now can be implemented by general-purpose digital computers or, more economically, by using special-purpose machines. Either word-by-word or more accurate sentence-by-sentence translations are considerably faster and cheaper than man-made ones.

MIT. 12:141

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

ELECTROPHYSIOLOGICAL EVIDENCE FOR AUDITORY SENSITIZATION, by J. R. Hughes and W. A. Rosenblith. Nov. 9, 1956 [6]p. incl. illus. table. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) AD 133272 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 29: 275-280, Feb. 1957.

This study was designed to investigate the properties of the first neural response (N_1) to tone-pips; the responses were recorded from the round window of the cat. Amplitude, latency, and adaptation (equilibration) curves were studied. The major part of the investigation was concerned with the effect of low-tone exposure on the amplitude of the N_1-response to tone pips. After a relatively intense exposure, the amplitude of the N_1 response, compared with the pre-exposure level, shows an initial subnormality (decreased response), a sensitization (increased response), and then a second subnormality. Sensitization was found when the exposure tone was the same, higher and lower in frequency than the basic frequency of the test tone pip. Exposure to low-frequency noise gives rise to a monotonic recovery process, i.e., a subnormality without subsequent sensitization. Contralateral effects were not detected. This sensitization of the N_1- response is compared with related psychophysical data and may be regarded as an example of post-tetanic potentiation. (Contractor's abstract)

MIT. 12:142

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

IMPEDANCE CHARACTERISTICS OF METAL MICROELECTRODES (Abstract), by R. C. Gesteland. [Sept. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Office of Scientific Research under DA 36-039-sc-64637; and in part by National Science Foundation, Bell Telephone Labs., Inc., and Offner Electronics, Inc.) Unclassified

Presented at 8th annual meeting of the Amer. Physiol. Soc., Rochester U., N. Y., Sept. 4-7, 1956.

Published in Amer. Jour. Physiol., v. 187: 601, Dec. 1956.

Warburg's law that the impedance of a metal-electrolyte boundary varies inversely with the square root of frequency applies to a limited set of cases, few (if any) of which occur in biological science. Empirically, one can fit the behavior of most smooth-metal microelectrodes in body fluids with inverse power laws over a wide frequency range. The data presented show that these laws vary with polarizing current for the two components of impedance. The self-noise of the electrode is shown to be an index to the real component of impedance. Recording through the electrodes puts restrictions on the associated amplifier. These restrictions are discussed. (Contractor's abstract)

MIT. 12:143

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

MICROINHOMOGENEITIES IN MAGNETIC FIELDS, by H. H. Brown, Jr. and F. Bitter. [Sept. 4, 1956; rev. Oct. 5, 1956] [4]p. incl. diagrs. tables. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under [DA 36-039-sc-64637]) Unclassified

Published in Rev. Scient. Instruments, v. 27: 1009-1012, Dec. 1956.

Small variations in the fields of magnets, caused by structures or domains in the pole faces, were investigated by moving a small coil in a circular path. It was found that for a given pole face the variations in the field were all about the same size, and decreased exponentially from the pole face. None of the materials tested as pole faces produced strikingly better fields than another. (Contractor's abstract)

MIT. 12:144 - MPP. 01:001

MIT. 12:144

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

SOME SYNAPTIC EFFECTS IN MOTONEURONS (Abstract), by J. Y. Lettvin, W. S. McCulloch, and W. Pitts. [Sept. 1956] [1]p. (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637; and in part by Bell Telephone Labs., Inc., National Science Foundation, and Offner Electronics, Inc.) Unclassified

Presented at 8th annual meeting of the Amer. Physiol. Soc., Rochester U., N. Y., Sept. 4-7, 1956.

Published in Amer. Jour. Physiol., v. 187: 614, Dec. 1956.

Using intracellular micropipettes we have found in the cat a class of lumbar motoneurons in which the height of the antidromic response is affected systematically by orthodromic volleys. In particular, a facilitatory synaptic potential decreases the overshoot of the antidromic spike and shortens the latency of the so-called "b" spike with respect to the "a" spike. The phenomenon bears a marked resemblance to the diminution of overshoot in single muscle fibre spikes during the end-plate potential. (Contractor's abstract)

MIT. 12:145

Massachusetts Inst. of Tech. Research Lab. of Electronics, Cambridge.

THERMIONIC EMISSION, by W. B. Nottingham. Dec. 10, 1956, 178p. incl. diagrs. refs. (Technical rept. no. 321) (Sponsored jointly by Signal Corps, Office of Naval Research, and Air Force Office of Scientific Research under DA 36-039-sc-64637) AD 126182 Unclassified

This report makes a study of the more fundamental aspects of the experimental and the theoretical investigations of the phenomenon of electron emission from heated conductors. The study describes the following four surface classifications of transmission emitters and critically reviews important investigations yielding relevant information about them: (1) clean homogeneous surfaces; (2) clean heterogeneous surfaces; (3) simple composite surfaces; and (4) complex surfaces. A detailed analysis of the present state of our understanding with respect to both theory and experiment is included.

MAS. 01:001

Massachusetts U. Dept. of Chemistry, Amherst.

A NEW SYNTHESIS OF DIBENZYLS AND POLYNUCLEAR HYDROCARBONS, by L. A. Carpino. Apr. 29, 1957, 2p. (AFOSR-TN-56-601) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)114 and Research Corp., N. Y.) AD 115027 Unclassified

Also published in Chem. and Indus. (London), No. 6: 172, Feb. 9, 1957.

A method of synthesis of dibenzyls is described. The production of R= $COOMe_3$ is undertaken for the second part. The purpose is a more general method than that of Hall, Lesslie and Turner for the synthesis of dihydrophenanthrenes and related dihydroaromatics.

Mathematisches Institut der Universitaet, Freiburg (Germany). see Freiburg U. Inst. for Mathematics (Germany).

MAU. 01:001

Maudsley Hospital, London (Great Britain).

HYPOTHALAMUS, HYPOPHYSICS, AND THYROID GLAND (Abstract), by G. W. Harris. [1956] [21]p. incl. refs. [AF 61(514)953] Unclassified

Presented at the 20th International Physiological Congress, Brussels (Belgium), July 30-Aug. 4, 1956.

Abstract published in 20th International Physiological Congress. 1. Abstracts of Reviews, 1956, p. 508-528.

A review is presented of investigation into the relationship between the central nervous system and the thyroid gland. The following items are considered: (1) evidence that the central nervous system influences thyroid activity, (2) the mechanism whereby the central nervous system influences thyroid activity, (3) the hypothalamus and thyroid activity, and (4) relation of experimental data to Graves' disease. There are 68 references of international scope offered covering a time period from 1835 to 1956.

MPP. 01:001

[Max-Planck-Institut für Physik der Stratosphare, Hechingen (Germany)]

COMPARISON OF LOW GAS DENSITY FLOW VISUALIZATION TECHNIQUES, by W. B. Kunkel. Mar. 7, 1956 [12]p. (AFOSR-TN-56-426) (AF 61-(514)911) AD 96508 Unclassified

Various techniques being developed for gas-flow visualization are based on density-dependent properties other than the variation of the refractive index. They include: (1) the true absorption of suitable electromagnetic radiation; (2) the scattering and apparent absorption of electrons; and (3) the emission of electromagnetic radiation. The UV absorption technique suffers from instrumental difficulties and limited sensitivity. The afterglow techniques are easily realized and are effective for demonstration purposes.

but are not satisfactory for quantitative work. The use of an electron-beam density probe is recommended for quantitative dynamic investigations. Such a probe can be designed to scan all sizes of gas streams, and to operate with great accuracy and high sensitivity over a very wide range of gas densities.

MPS. 01:001

Max-Planck-Institut für Strömungsforschung, Göttingen (Germany).

THE OSCILLATING LIFTING SURFACE IN THE RANGE OF SUBSONIC FLOW, by H. G. Kuessner. [Final rept.] Sept. 15, 1953, 24p. incl. refs. (AF 61(514)428) AD 30783 (also AD 32129) Unclassified

The two-dimensional linearized problem of the oscillating lifting surface at Mach numbers $0 < \beta < 1$ is generally solved in the simplest way by definite integrals with elliptic coordinates. It is a suited generalization of the known solution for $\beta = 0$. While there the characteristic function satisfies the Laplace differential equation, here it must satisfy the wave equation. The result is compared with two solutions by Timman and van de Vooren and by E. Reissner and their identity is proved. Approximate solutions for very high and very low frequencies are given. (Contractor's abstract)

MPS. 02:001

Max-Planck-Institut für Strömungsforschung, Göttingen (Germany).

[DETERMINATION OF VELOCITY ALONG THIN, DOME-SHAPED PROFILES IN GENERALIZED POTENTIAL FLOW] Zur Geschwindigkeitsbestimmung an gewölbten, dünnen Profilen in allgemeiner Potentialströmung, by H. Krüger. Sept. 28, 1953, 16p. incl. diagrs. tables. (Rept. no. 1) (AF 61(514)-429) AD 21789 Unclassified

The connection between tangential and normal velocity along a thin profile in two-dimensional potential flow is treated generally and in particular for profiles whose mean line is an arc of a circle. An iteration process for velocity determination along thin profiles is derived and tested out. Tables are presented of form constants for profiles whose mean line is an arc of a circle.

MPS. 02:002

Max Planck-Institut für Strömungsforschung, Göttingen (Germany).

INVESTIGATION OF SURFACE VELOCITY AND PRESSURE DISTRIBUTION ALONG CASCADED PROFILES. PART I. VELOCITY DISTRIBUTION AT A HIGHLY CAMBERED SINGLE PROFILE, by H. Krüger. Sept. 28, 1953 [32] p. incl. diagrs. tables. (Rept. no. 1) [AFOSR-TN-54-80, Pt. 1] (AF 61(514)429) AD 21789 Unclassified

Consideration is given to a procedure for the calculation of the distribution of circulation about thin airfoils of any shape in generalized potential flow. This procedure is based on the simple relationship between circulation and normal velocity around circular-arc profiles, and permits formulation of the differences in shape between circular-arc profiles, and a given wing. It may be applied numerically and semigraphically. Tabular data are presented for the form constants of the circular profiles. A sample calculation is given, illustrating the fast convergence in spite of the unfavorable choice of the approximate profile.

MPS. 02:003

Max-Planck-Institute für Stromungsforschung, Göttingen (Germany).

INVESTIGATION OF SURFACE VELOCITY AND PRESSURE DISTRIBUTION ALONG CASCADE PROFILES. PART 2. A METHOD FOR VELOCITY CALCULATION AT THIN, CAMBERED CASCADE PROFILES, by H. Krüger. Feb. 27, 1954, 60p. illus. tables. (Rept. no. 2) ([AF]OSR-TN-54-80, Pt. 2) (AF 61(514)429) AD 30063 Unclassified

Vortex distributions are presented which at cascades of straight lines induce normal velocities of constant, linear, and parabolic courses over the blade length. They correspond to Birnbaum-Clauert vortex distributions at a plate, and may serve to determine velocities at thin profiles provided they can be approximated by a third-order equation. The distributions were computed by a conformal representation of the lattice of straight lines on the unit circle. The distributions for constant and linear normal velocity distributions are given in closed form, and for square normal velocity distribution, the distribution is obtained numerically by means of the Poisson integral. The vortex diagrams are used to determine velocity distributions at: (1) profiles in a straight cascade, (2) resting circular lattices flown through by a vortex and source flow originating at the center, and (3) blades of rotating circular lattices. Velocity distributions are calculated for each of these cases. (ASTIA abstract)

MPS. 02:004

Max-Planck-Institut für Strömungsforschung, Göttingen (Germany).

INVESTIGATION OF SURFACE VELOCITY AND PRESSURE DISTRIBUTION ALONG CASCADE PROFILES. PART 3. VELOCITY DISTRIBUTION ON A RADIAL CASCADE, by H. Krüger. Feb. 10, 1955, 43p. incl. diagrs. tables. (Rept. no. 3) [AFOSR-TN-54-80, Pt. 3] (AF 61(514)429) AD 70781 Unclassified

The circular cascade, with n = 6, 12, and 24 straight

MPS. 02:005 - MUF. 01:001

lined blades of 150-mm length, was transformed by conformal mapping into a rectilinear cascade, the stagger, solidity, and profile shape of which follow from the circular cascade geometry. This mapping was used to find the velocity distributions and blade circulations caused by an inflow from a source or vortex in the center of the cascade.

MPS. 02:005

Max-Planck-Institut für Strömungsforschung, Göttingen (Germany).

INVESTIGATION OF SURFACE VELOCITY AND PRESSURE DISTRIBUTION ALONG CASCADE PROFILES, by H. Krüger. Final rept. Apr. 29, 1955, 52p. incl. illus. diagrs. [AFOSR-TR-55-16] (AF 61-(514)429) AD 66708 Unclassified

A review is given of previously reported theoretical investigations of a highly cambered single profile, a rectilinear staggered cascade of cambered profiles, and a circular cascade of rectilinear radial and staggered blades. Equipment is described for testing the performance of plane flow through a circular cascade. A comparison is given between the theoretical and experimental results for prssure distributions.

MED. 01:001

Méditerranéen de Recherches Thermodynamiques, Nice (France).

RESEARCH ON THE STUDY OF THE CONDITIONS SURROUNDING A BODY MOVING AT THE HIGH SPEEDS IN THE IONOSPHERE, by [F. M. Devienne]. Technical rept. Mar. 1, 1955 - Feb. 29, 1956 [39]p. incl. illus. tables. (AFOSR-TR-56-24) (AF 61(514)-818) AD 89497 Unclassified

The objectives were to study the energy exchange between a moving body and air at pressures corresponding to those of the ionosphere, and to measure the stagnation pressure. Experiments were conducted in a vacuum-tight tank 150 cm id in the pressure range 0.15 to 1 μ of Hg by means of an apparatus consisting of 2 duralumin arms capable of revolving at speeds up to 300 m/s. Temperature increase was measured easily and accurately by specially installed thermocouples for metal plate models 6 mm x 6 mm x 0.1 mm, which were fastened to one arm. Stagnation pressure was measured by micro-ionization gauges set at the end of the other arm; accurate measurement was difficult, and measurements could not be made above 150 m/s because of filament breakage. Incomplete results indicated that for temperature rise for a Ag plate in air the coefficient of accommodation is reduced when the pressure increases; and is also reduced when the speed increases, and the lower the pressure, the greater the decrease. Stagnation pressure measurements did not permit a definite conclusion as to whether the distribution of molecular velocities follows the Maxwellian law. It seemed, however, that the stagnation pressure was slightly lower than the theoretical value.

MET. 01:001

Metalectro Corp. [Bladensburg] Md.

A STUDY OF INCORPORATION OF HIGH ENERGY SUBSTANCES IN CONVENTIONAL TYPE FUEL MATERIALS BY PHYSICAL INCLUSION, by D. Horvitz, F. R. Benson and others. Final technical rept. Aug. 23, 1955 - Mar. 31, 1956. Apr. 1956, 36p. incl. tables, refs. (AFOSR-TR-56-17) (AF 18-(600)1558) AD 87518 Unclassified

Efforts were directed toward synthesizing, when necessary, compounds suitable as intermolecular entrapping agents. The entrapment of H inter- and intramolecularly was investigated. The process of physical inclusion was evaluated as a means of producing improved propellant systems. Preliminary experiments in which N was physically included in quinol indicated that the equipment and techniques were satisfactory. Agitating by shaking the solutions during the inclusion process resulted in a complete and rapid entrapment of the gas. Successful attempts were made to introduce more than one molecule of N per available cavity in quinol by using higher pressures. H could not be physically included in quinol at pressures up to 1000 psi; the α-quinol structure was recovered. Mixtures of N and H at total pressures up to 1460 psi showed no evidence of H inclusion; only N was entrapped by the quinol. Experiments in which MeOH was used as the solvent and blocking agent in the presence of H at a pressure of 2500 psi likewise showed no evidence of H inclusion. Small amounts of N were included in 2,2,4-trimethyl-4-p-hydroxyphenylchroman and in hexamethylenetetramine; H could not be included. Neither N nor H was included in p-phenylenediamine, tetramethylpyrazine, and tris-(hydroxymethyl)aminomethane. H was not included in pentaerythritol, camphene, and abietic acid. Copolymerizations of divinylbenzene and diallyl maleate were conducted in N and in H at pressures up to 8000 psi. No definite evidence was obtained of any gas entrapment. Diallyl maleate was polymerized by itself under N at 8000 psi; no evidence of entrapment of N was found.

MUF. 01:001

Miami U., Coral Gables, Fla.

FIXED POINT PROPERTY FOR THE SPACE OF SUBSETS OF AN ABSOLUTE RETRACT, by W. L. Strother and C. E. Capel. July 1955, 1p. (Rept. no. 2) ([AF]OSR-TN-55-244) (AF 18(600)1449) Unclassified

Presented at meeting of the Amer. Math. Soc., Ann Arbor, Mich., Aug. 30-Sept. 3, 1955.

The mathematical question asked by Wojdyslawski (Fundamenta Mathematica, v. 32: 184-194, 1939),

"If X is a CAR* (= retract of a cube), is the space of closed subsets S(X) a CAR*?," has been answered in the affirmative by Strother (Fixed Points, Fixed Sets, and M-Retracts, Duke Math. Jour.) for the special case in which X is a Peano Continuum. This result is used in the present study to prove that if X is a CAR*, then S(X) has the fixed point property.

MUF. 01:002

Miami U., Coral Gables, Fla.

A SPACE OF SUBSETS HAVING THE FIXED POINT PROPERTY, by W. L. Strother and C. E. Capel. Aug. 1955, 5p. (Rept. no. 3) ([AF]CSR-TN-55-268) (AF 18(600)1449) AD 111085 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 707-708, Aug. 1956.

The object of this paper is to prove that if X is a CAR* then S(X) has the fixed point property. First it will be shown that if T is a Tychonoff cube this S(T) has the fixed point property. If the space X is a CAR*, it is a retract of some cube T and hence S(X) is a retract of S(T). Thus the fixed point property in S(X) follows from that in S(T).

MUF. 01:003

Miami U., Coral Gables, Fla.

KNASTER CONTINUA (Abstract), by W. L. Strother and C. E. Capel. Nov. 14, 1955 [1]p. (Rept. no. 5) [AFOSR-TN-55-452] (AF 18(600)1449) Unclassified

Presented at meeting of the Amer. Math. Soc., Knoxville, Tenn., Nov. 18, 1955.

Published in Bull. Amer. Math. Soc., v. 62: 33, Jan. 1956.

Let X denote a compact connected metric space. An M-arc in X is a point connected multi-valued function F:I → X. Utilizing Kelly's results on (Hyperspaces of Continuum, Trans., v. 52; 1943), indecomposable continua can be characterized as follows: A compact metric space X is indecomposable if and only if there is a pair of connected closed sets A and B in X such that for every M-arc F:I → X joining A and B there is a point a in I such that F(a) is the whole space X. Also X is a Knaster space (every subcontinua is indecomposable) if and only if M-arcs in X are unique. (Contractor's abstract)

MUF. 01:004

Miami U., Coral Gables, Fla.

A NEW PROOF OF A FIXED-POINT THEOREM OF WALLACE (Abstract), by W. L. Strother and C. E. Capel. Nov. 14, 1955 [1]p. (Rept. no. [4])

[AFOSR-TN-55-453] (AF 18(600)1449) Unclassified

Presented at meeting of the Amer. Math. Soc., Knoxville, Tenn., Nov. 18, 1955.

Published in Bull. Amer. Math. Soc., v. 62: 33, Jan. 1956.

A. D. Wallace (Bull. Amer. Math. Soc., v. 47: 757-760, 1941) has shown that if T is a tree (in a combinatorial sense) and F is a continuous, multi-valued function on T to itself, such that the image of each point is connected, then F has a fixed point. Using L. E. Ward's characterization of a tree in terms of a partially ordered space (A Note on Dendrites and Trees, Proc. Amer. Math. Soc., v. 5: 992-994, Dec. 1954), an order theoretic version of Wallace's theorem is given. (Contractor's abstract)

MUF. 01:005

Miami U. [Coral Gables] Fla.

TRACES FOR MULTIVALUED FUNCTIONS, by C. E. Capel and W. L. Strother. July 1955, 7p. (Rept. no. 4) (AFOSR-TN-[56]-82) (AF 18(600)1449) AD 81535 Unclassified

A continuous multivalued function F: X → Y is shown to have a trace which is a continuous singled-valued function f: X → Y such that $f(x) \in F(x)$ for all x in X, when Y has a continuous partial order in which the image of each point under F has a first element. The assumption that the multivalued function is continuous is essential. The terminology is as follows: Let S(X) denote the space of nonnull, closed subsets of a compact Hausdorff space X. If $\mathbf{A} \subset S(X)$, then a continuous function s: F: $\mathbf{A} \rightarrow X$ is a selection on $\mathbf{A}$ if $s(A) \in A$, for A in $\mathbf{A}$. The idea of Michael (Trans. Amer. Math. Soc., v. 71: 152-182, 1951) that there is a selection on S(X) if X is linearly ordered in a continuous sense is extended to finding selections on subsets of S(X) when X has a continuous partial order. Then for a suitable space X, such as an n-cell or Tychonoff cube, a continuous multivalued function F: X → X, with restrictions on the image of a point such as point-convex, has a trace and hence a fixed point.

MUF. 01:006

Miami U. [Coral Gables] Fla.

COUNTEREXAMPLE TO A THEOREM OF HAMILTON, by C. E. Capel and W. L. Strother. Aug. 25, 1956, 2p. (Rept. no. 7) (AFOSR-TN-56-400) (AF 18(600)1449) AD 96058 Unclassified

Also published in Duke Math. Jour., v. 24: 57, Mar. 1957.

The following appears in a paper of O. H. Hamilton (A Fixed-Point Theorem for Upper Semicontinuous

MUO. 01:001 - MIC. 01:001

Transformations on n-Cells for Which the Images of Points are Nonacyclic Continua, Duke Math. Jour., v. 14: 689-693, 1947): Theorem. If I_n is a topological n-cell, T is a continuous multivalued transformation of I_n into a subset of itself such that for each point P of I_n, T(P) is the boundary of a topological n-cell and M_1, M_2, and M_3 are the subsets of I_n consisting of the points P which are respectively in the interior of T(P), and in the exterior of T(P), then (a) M_2 is nonvacuous and closed, (b) M_1 M_2 and M_2 M_3 are each closed, and (c) M_1 and M_3 are each open with respect to I_n. If M_1 and M_3 are each nonvacuous, then M_2 separates M_1 from M_3 in I_n. The following is an example of a continuous multivalued transformation T of a 2-cell I_2 into itself, with the image of each point being a 1-sphere, such that M_2 is null and M_1 is a single point. Using polar coordinates in the plane,

let $I_2 = \{(r, \theta) \mid 0 \leq r \leq 1\}$. For $0 \leq s \leq 1$, define

$$T(s, 0) = \left\{ (r, \theta) \;\middle|\; \begin{array}{l} [\, r = 1 \text{ or } r = 1 - s) \text{ and } s \leq \theta \leq 2\pi - s] \\ \text{or} \\ [\, 1 - s \leq r \leq 1 \text{ and } (\theta = s \text{ or } \theta = 2\pi - s)] \end{array} \right\}.$$

For $0 \leq s \leq 1$ and $0 = \theta = 2\pi$, define $T(s, \theta)$ to be the set $T(s, 0)$ rotated through the angle θ. In the proof of the above theorem, 2 auxiliary functions S and W are defined on I_n into itself, where S(P) is T(P), together with its interior and W(P) is the closure of $I_n - S(P)$. It is presumed that W(P) was meant to be T(P) together with the intersection of the exterior of T(P) with I_n. The difficulty lies in the statement that S and W are continuous, which is false. (Contractor's abstract)

MUO. 01:001

Miami U., Oxford, Ohio.

A "STANDARD" SAMPLE-HOLDER FOR X-RAY DIFFRACTION EXPOSURES AND ITS ABSORPTION CORRECTIONS, by H. L. Ritter. Sept. 1955 [12]p. incl. dtagrs. tables. (Rept. no. 1) ([AF]OSR-TN-55-297) (AF 18(600)485) AD 100173 Unclassified

The choice of a standard sample holder for liquids for x ray diffraction exposures and its absorption corrections are described. The absorption corrections, for a sample contained inside a cylindrical tube of annular cross section, are: (1) $A_{a,ac}$, the correction for diffraction in the annular tube and partially absorbed in the annulus and in the core; (2) $A_{c,ac}$, the correction for diffraction in the core and partially absorbed in the annulus and in the core; and (3) $A_{c,c}$, the correction for diffraction in the core and absorption in the core only (naked sample). The correction depends upon: (1) the diffraction angle (θ); (2) the radius of the tube; (3) the wall thickness of the tube; (4) the absorption coefficient of the sample; and (5) the absorption coefficient of the sample-holder material. Efforts to eliminate the necessity of applying a correction for the container by the use of a crystalline holder were not successful. The metric equivalent of the analytical procedure appeared to be more efficient than either the graphical or analytical method for computing the corrections. In an attempt to reduce the number of parameters involved in computing correction tables, standard experimental conditions were chosen, such as the use of only Mo-Kα radiation and a Pyrex-glass sample holder. The absorption coefficient was fixed and the number of parameters was reduced to 4. An attempt was then made to standardize the geometry of the sample tube itself. By fixing these parameters, the absorption becomes a variable function only of θ and the absorption coefficient of the sample. A procedure is given for the computation of absorption corrections for encased diffracters. Numerical values of these corrections were computed for the standard holder.

Michigan U., Ann Arbor.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:110-PRI. 11:112.

MIC. 01:001

Michigan U. Engineering Research Inst., Ann Arbor.

INTERACTION OF A SIDE JET WITH A SUPERSONIC MAIN STREAM, by M. V. Morkovin, C. A. Pierce, Jr., and C. E. Craven. Sept. 1952, 34p. incl. illus. diagrs. tables, refs. (Engineering Research bull. no. 35) [AF 33(038)19747] Unclassified

An experimental investigation was conducted in the University of Michigan supersonic wind tunnel (Ann Arbor) to explore the main characteristics of the flow and pressure field generated by a supersonic jet directed at 90° to the body into the 1.90-Mach-number tunnel stream. In particular, a study was made of the spreading characteristics of the jet and its gross effect on the normal force, drag, and moment of the cone-cylinder body, from which the jet issued. The phenomenon was investigated as a function of pressure ratio, P_0/P_s (jet stagnation pressure to tunnel static pressure), angle of attack of the body, and jet-nozzle geometry. Within a relatively short distance from the exit, the normal jet was turned in the direction parallel to the free stream even at pressure ratios of over 50. Simultaneously, it spread in all directions, mixing violently with the free stream. Optical evidence suggests that fringes of the jet are in contact with the cylinder. This may have practical implications for the use of hot side-control jets on bodies. The interaction resulted in regions of both high and low pressure over the body. The normal force on the body was decreased below the nominal jet side-thrust value, and the drag was increased above the no-jet value. A moment which depends on the geometry, particularly the length of the body, was generated about the nominal center of gravity of the body. (Contractor's abstract)

MIC. 01:002

Michigan U. Engineering Research Inst., Ann Arbor.

WING-BODY INTERFERENCE. PART II. EXPERIMENTAL INVESTIGATIONS OF CYLINDRICAL MODEL, by H. E. Bailey and R. E. Phinney. Final rept. Feb. 1954, 62p. incl. illus. refs. (Rept. no. 1937-2-F) [AFOSR-TN-54-77] (AF 33(038)19747) AD 28069
Unclassifted

Expertmental results obtained from a model consisting of a cylindrtcal body and 2 half wings were compared with the theoretical results of J. N. Neilson (Supersonic Wing Body Interference, Ph. D. thests, Calif. Inst. Tech., 1951) and with the results obtained in AD 25324. The Reynolds number for the tests based on a 2-in.-diam body was 7×10^5, which corresponds to an actual 2-ft-diam mtssile flying at M = 1.9 at an altttude of 90,000 ft or to a 2-in.-diam mtssile flying at M = 1.9 at 37,000 ft. Expertmental results agreed with the values predicted by lineartzed theory as long as only those portions of the body upstream of the Mach helix from the juncture of the body and the wing trailing edge were considered. Beyond the trailing edge, the theory is no longer valid, and only the experimental results are applicable. The agreement betwsen theory and expertment was improved by shifting the axial position at which the shock jumps were predtcted by linearized theory to the position which was indicated by simple shock-wave theory. Experimental results tndicated that a decrease in thickness of the turbulent boundary layer on the body caused a slight decrease in the viscous effects near the wing leading edge and consequently better agreement between expertment and theory. The character of the body boundary layer, that is, whether it is laminar or turbulent, may exert a strong influence on the shape of the body pressure profiles. The effect of a gap between wing and body appeared to be small on such integrated quantities as total lift and total drag on the body, although the pressure profiles on the body tn the vtctnity of the gap were radtcally altered because of the presence of wing-tip vortices at the inboard edge of the wing. (For Part I see item no. MIC. 01:004)

MIC. 01:003

Michigan U. Engineering Research Inst., Ann Arbor.

WING-BODY INTERFERENCE. PART III. EXPERIMENTAL INVESTIGATION OF BODY SIMULATOR PLATE, by H. E. Bailey and R. E. Phinney. Final rept. Feb. 1954, 47p. incl. illus. (Rept. no. 1937-3-F) [AFOSR-TN-54-78] (AF 33(038)19747) AD 28070
Unclassifted

Results of tssts at M = 1.9 are presented of a model which consists of a body simulator plate and a wing which could be placed next to the body simulator plate. The body plate may be moved parallel to itself so as to produce a gap between the wing and body plate. The wing angle of attack may be varied continuously over a range of ± 12°. The dthedral angle between the wing and the body plate may be varied. The experimental pressures measured on the wtng and on the body simulator plate agreed wtth the pressures prsdtcted by simple shock-wave and Prandtl-Meyer flow theory. The flow appeared to be conical for values of x (the distance aft of the leading edge of the wing) greater than 1. For values of x less than 1 the flow was not conical, and the full theorettcally predtcted pressure jump did not occur. There was some upstream propagation of the pressure dtsturbance which ortginated at the leading edge of the wing, with the amount of upstream propagation tncreasing for increasing x. For posttive angles of attack of the wing, the Prandtl-Meyer flow at the leading edge was preceded by a weak compression shock wave whtch appeared to be a continuation of the shock wave generated on the under side of the wing. The expertmental results obtained with a -8° angle of attack of the wing and a dihedral angle of 135° agreed with the linear theory of Lagerstrom and Van Dyke (Douglas Report 5M 3432, June 1949). The agreement between theory and expertment was good when the angle of attack of the wing was +8° and the dihedral angle 45°. For the cases (1) angle of attack of the wing +8° and dihedral angle 135° and (2) angle of attack of the wing -8° and dihedral angle 45°, the agreement between linearized theory and experiment was poor.

MIC. 01:004

Michigan U. Engineering Research Inst., Ann Arbor.

WING-BODY INTERFERENCE. PART I. THEORETICAL INVESTIGATION, by H. E. Bailey and R. E. Phinney. Final rept. Jan. 1954, 18p. incl. diagrs (Rept. no. 1937-1-F) (AF 33(038)19747) AD 25324
Unclassifted

The effect of viscostty on wing-body tnterference at supersonic speeds ts considered. A theoretical analysis is made tn whtch an inviscid flow ts assumed, and the differenttal equations of motion are lineartzed. The problem ts reduced to a combination of simpler wtng-body problems tn which: (1) the body-alone potential is obtained; (2) a ftctitious wing potential ts obtained which cancels the velocities induced tn the wing plane by the body-alone potential; and (3) an interference potential ts obtained whtch cancels the velocttties tnduced on the cylindrical body by the wing potential, but which does not tnduce any velocities in the wing plane. The solution obtained ts to be used tn combinatton with the solutions of J. N. Nielsen and W. C. Pitts (NACA Technical note no. 2677, Apr. 1952) and J. N. Nielsen, (California Inst. Tech., Ph. D. thesis, 1951) to obtain the pressure distribution on a cylindrical body as a result of the presence of a flat surface wing for any combination of body and wing angles of attack. The solution is valid only forward of the trailing edge of the wing.

MIC. 02:001 - MIC. 03:001

MIC. 02:001

Michigan U. Engineering Research Inst., Ann Arbor.

ZERO DIVISORS AND COMMUTATIVITY OF RINGS, by J. E. McLaughlin and [I.] A. Rosenberg. July 1952, 17p. refs. (Technical rept. no. 1) (AF 18(600)-130) Unclassified

Published in Proc. Amer. Math. Soc., v. 4: 203-212, June 1953.

A study is made of the effect of the structure of the set of zero divisors on the associativity and commutativity of an alternative ring. A ring satisfies the alternative law if the $(x, y, z) = (xy)z - x(yz)$ is an alternating function of its arguments. In the case of a finite associative ring this problem has been studied by Herstein (A Proof of a Conjecture of Vandiver, Proc. Amer. Math. Soc., v. 1: 370-371, 1950). The theory of the radical of an alternative ring has been presented by Smiley (The Radical of an Alternative Ring, Ann. Math., v. 49: 702-709, 1948), and his definition will be used throughout this study. By the center of an alternative ring A, it is meant the set C of all elements c such that $(c, A, A) = (c, A) = 0$. Here $(x, y) = xy - yx$ is the commutator of x and y. If an alternative ring properly contains its center and all its zero divisors lie in the center, it will be shown that the set of zero divisors forms an ideal. Accordingly, the alternative Zorn rings (Kaplansky, I., Semisimple Alternative rings, Portugal. Math., v. 10: 37-50, 1951) are first studied where the set of left zero divisors forms a proper left ideal. Such a ring is a division ring modulo its radical, and, conversely, in a Zorn ring which is a division ring modulo its radical the set of left divisors forms a left ideal. In Section 3, it is assumed that all the zero divisors of an alternative ring lie in the center and then give sufficient conditions for the ring to be commutative and associative. In particular, this turns out to be the case for an algebraic algebra over an algebraically closed or finite field. In the next section, it is assumed only that the nilpotent elements lie in the center but here deal only with algebraic algebras. Under suitable hypotheses on the base field, it is again time that the algebra is associative and commutative. In the last section, the results are extended to real Banach algebras, replacing the concept of zero divisor by that of topological zero divisor. In particular, it is shown that a real Banach algebra with all its topological zero divisors in the center is the quaternions or commutative. (Contractor's abstract)

MIC. 02:002

Michigan U. Engineering Research Inst., Ann Arbor.

[INVESTIGATION IN THE THEORY OF SIMPLE RINGS], by I. A. Rosenberg. Final rept. Oct. 1952, 2p. (AF 18(600)130) Unclassified

The first main line of investigation dealt with the following rings: Let M be a vector space of dimension λ, $\chi \geq \chi_0$, over a division ring D which contains at most χ elements. If L is the ring of all linear transformations on M, it is known that all 2-sided ideals of L are of the form $F_\chi = \{a / \dim Ma < \chi'\}$. Thus, F_χ is a maximal 2-sided ideal, and so the ring $A = L - F_\chi$ is a simple ring. A has a unit, but no minimal ideal. By the general Jacobson structure theory, it is known that A is primitive and so admits faithful irreducible modules. It was the aim of the study to classify these. First attention was focussed on the commutings ring of endomorphisms E, however, it proved impossible to decide any question about it. The following questions were considered: (1) is E algebraic over D? (2) are all E's isomorphic? and (3) what is the transcendence degree of E over D? The next step was to consider under what conditions 2 irreducible right modules of A were isomorphic. As is well known, any irreducible right module can be thought of as A/J, where J is a maximal right ideal. It is then possible to prove that A/J is isomorphic to A/1 if and only if there is an a in A such that $aJ \subset I$, a not in 1. Thus, there certainly cannot be more irreducible modules isomorphic to a given one than there are elements in the ring A. But it can be seen that the ring A has $\leq \exp \chi$ elements. ($\exp \chi$ is written for 2^χ.) So, given one irreducible module, there cannot be more than $\exp \chi$ ones isomorphic to it. Next the maximal right ideals in A were counted. This was accomplished by returning to the ring L and picking a basis B of M. The Boolean algebra P(B) of subsets of B is known to possess $\exp \exp \chi$ distinct maximal ideals containing the ideal of all subsets of power $\leq \chi$. It can be shown that these lead to $\exp \exp \chi$ distinct maximal right ideals of L containing F_χ, and so to $\exp \exp \chi$ distinct maximal right ideals of A. Thus, there are exactly $\exp \exp \chi$ distinct irreducible modules for A.

MIC. 03:001

Michigan U. Engineering Research Inst., Ann Arbor.

ELECTRON DIFFRACTION INVESTIGATION OF PHOTOCONDUCTIVE CRYSTALLINE LEAD SULFIDE SURFACES, by L. O. Brockway and M. S. Wasserman Wasserman. Quarterly rept. no. , Dec. 5, 1952 - Mar. 5, 1953. July 1953, 17p. incl. diagrs. table, refs. [AFOSR-TN-55-19] (AF 18(600)175) AD 18174 Unclassified

The examination by electron diffraction and microscopy of chemically precipitated films of high and low photosensitivity has shown that both films have resolved lead sulfide crystallites of the order of 0.1-μ diameter along with some irregular agglomerates of 2 to 3μ. The agglomerates form a nearly continuous framework in the high-sensitivity films, but appear in a much lower concentration on the surface of the low-sensitivity films. This is the first indication of a structural difference between films of different sensitivities. The characterization of the oxidized phase in these films requires the preparation of films especially mounted for transmission diffraction photographs. Condensed films of lead sulfide about 0.15μ thick can

now be controlled in particle size between 0.01 and 0.1μ by altering the temperature of the substrate between 200° and 350°C. Preferred orientations in the lead sulfide occur to a small degree on glass under heat treatment, and are far more pronounced on selected single-crystal substrates. No extra phase has been identified in films condensed and heated at 10^{-4} mm pressure, although extra diffraction rings appear under conditions not favoring the larger particle sizes. That they disappear on heating for 3 minutes at 350°C, or longer at 300°C, makes the formation of an oxysulfate on the surface of the lead sulfide an unlikely explanation of the extra rings. (Contractor's abstract)

MIC. 04:001

Michigan U. Engineering Research Inst., Ann Arbor.

AN EXPERIMENTAL INVESTIGATION OF THE STABILITY OF AXIALLY SYMMETRIC POISEUILLE FLOW, by R. J. Leite. Final rept. Nov. 1955, 82p. incl. illus. diagrs. refs. (Rept. no. 2072-2-F) ([AF]OSR-TR-56-2) (AF 18(600)350) AD 87670 Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Also published in Jour. Fluid Mech., v. 5: 81-96, Jan. 1959.

Results of an experimental investigation of the stability of Poiseuille flow are compared with the predictions of a recent unpublished mathematical analysis of the problem by G. M. Corcos and J. R. Sellars. A review of this theory is presented. The experiments were conducted in a lucite pipe 1.25 in. in diameter and 73 ft long. The air was supplied from a high-pressure tank, passed through a settling chamber, and discharged through the pipe to the atmosphere. A theodolite was used to align and level the pipe. All measurements were made with a hot-wire anemometer. The attainment of undisturbed laminar flow for all flow rates up to about R = 20,000, the maximum capacity of the system, was achieved with no difficulty, but the procurement of axially symmetric, fully developed velocity profiles was difficult. Results of the hot-wire measurements indicate that axially symmetric, fully laminar flow in a pipe is stable to small disturbances, whether they are axially symmetric or not, up to R = 13,000. Experimental values of rate of decay and of speed of propagation of the disturbances are in satisfactory agreement with theoretical predictions. Some dependence of the propagation speed of the disturbance on radial position was noted, although the theory does not postulate such a relationship. Instability and transition to turbulent flow are excited when the disturbance exceeds a given amplitude.

MIC. 05:001

Michigan U. Engineering Research Inst., Ann Arbor.

A SEQUENCE EXPERIMENT FOR THE STUDY OF THE RECIPROCITY LAW FAILURE AT LOW INTENSITIES (Abstract), by J. H. Enns, R. L. Martin, and E. Katz. Feb. 10, 1955, 1p. [AFOSR-TN-55-39] [AF 18(600)750] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 33, Mar. 17, 1955.

The concept that the reciprocity law failure at low intensities results from disintegration of the latent image in its initial stages of formation has been supported experimentally by Webb and Evans in their publication of the sequence exposure curves, and theoretically by Katz. In principle the sequence experiment consists of exposing a photographic emulsion in part to high- and in part to low-intensity radiation, wherein the ratio of the two exposures and their sequence may be varied. An instrument will be described, which has recently been built in this laboratory and designed especially to record automatically sequence exposure data. An exposure is made on a 4 x 10" plate, each plate receiving 384 - 4 x 5mm squares uniformly exposed for densitometry measurements. Provision is also made to record plate calibration data. A few preliminary curves will be shown. (Contractor's abstract)

MIC. 05:002

Michigan U. Engineering Research Inst., Ann Arbor.

RESULTS OF INVESTIGATION OF LOW-INTENSITY RECIPROCITY LAW FAILURE, by R. L. Martin. Aug. 1956, 141p. incl. illus. diagrs. tables, refs. (Rept. no. 2158-5-T) [AFOSR-TR-56-39] (AF 18-(600)750) AD 96787 Unclassified

The physical properties of the photographic emulsion, the nature of the photographic latent image, the Mott and Gurney (Proc. Royal Soc. (London), v. A164: 151, 1938) theory of latent-image formation, and a simple model used by Webb (Jour. Opt. Soc. Amer., v. 40: 3, 1950) to calculate an effective electron trap depth are described. The single-trap depth model predicts a simple, isodense, low-intensity rlf (reciprocity law failure) curve whose slope rapidly approaches -1 with decreasing intensity exposure. A quantitative theory of the mechanism of latent-image formation proposed by Katz (Jour. Chem. Phys., v. 17: 1132, 1949) predicts noninteger low-intensity rlf slopes when an exponential distribution of trap depths is assumed. Pure AgBr emulsions were used for experiments of rlf vs grain size to avoid difficulties arising from the correlation between iodide content and grain size. The rlf slopes from 5 pure AgBr emulsions, whose average grain size ranged from about 0.2 to 5.0 sq μ, demonstrated a definite increase in slope with average grain size of emulsion used when developed with internal developer and a similar, but less marked, tendency with surface development. The effect was stronger when higher temperatures of storage and exposure

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were used. A simple model assuming 2 discrete trap depths provided low-intensity rlf curves of considerable structure which were qualitatively similar to experimental curves.

MIC. 05:003

Michigan U. Engineering Research Inst., Ann Arbor.

AN INVESTIGATION IN THE ZONE THEORY OF THE ENERGY OF ELECTRONS IN METALS, by G. B. Spence. Aug. 1956, 112p. incl. illus. diagrs. tables, refs. (Rept. no. 2158-7-T) [AFOSR-TR-56-40] (AF 18(600)750) AD 96788 Unclassified

The zone theory of electron energy bands was used in determining the phase boundaries of those alloys agreeing with the Hume-Rothery electron concentration rules. Studies showed that an energy gap cannot exist for some zones because of shape degeneracy. Shape degeneracies exist in the zones which cannot be constructed from an integral number of mappings of the unit cell of the reciprocal lattice of the alloy structure. They also exist in the zones of the γ-brass and β-Mn structures. The electron energy surfaces in some large zones are not qualitatively similar to the simple surfaces in the first zone of the conduction electrons of the noble metals. Two- and 3-dimensional problems are constructed from two 1-dimensional Schrödinger equations with potentials of 1 and 2 cosine terms, respectively. The 2-dimensional energy contours illustrate some of the complexities of the electron energies which occur in the large zones. For typical phase boundary problems, the density of states N, of the first phase is greater than the density of states N_2 of the second phase until some point beyond the peak in N_1. For such problems the total electron energy U_1 of the first phase, instead of increasing relative to U_2 as the zone is filled beyond the peak in N_1, continues to decrease relative to U_2 until that energy is reached at which the total number of electrons are equal in the 2 phases. The positions of the phase boundaries cannot be accurately predicted theoretically from the electron concentration corresponding to the peak in the density of states. (ASTIA abstract)

MIC. 06:001

Michigan U. [Engineering Research Inst.] Ann Arbor.

LUMINOSITY GENERATED BY SHOCK WAVES, by R. N. Hollyer, Jr., A. C. Hunting and others. Sept. 22, 1953 [3]p. [AF 18(600)983] Unclassified

Published in Nature, v. 171: 395-397, Feb 28, 1953.

Experimental investigations are reported of luminosity in nitrogen and in argon gases in the expansion chamber of a shock tube on release of hydrogen under several atmospheres of pressure; the luminosity is observed when the shock wave, produced by rupture of a diaphragm covering the compression chamber, is reflected from a plate at the end of the expansion chamber. Wave-speed photography of the region near the reflecting plate shows the luminosity to be confined initially to the region between the reflecting plate and the reflected shock until the shock meets the cold front originally dividing the gases on either side of the burst diaphragm. The luminous region thereafter is limited by the end plate and by the expansion wave generated at the meeting of the reflected shock and the interface. The photographs show a roughly triangular region with a duration in time of 1500-3000 μsec depending on shock strength and nature of the gas. Spectroscopic examination in preliminary tests with N and A showed merely the D lines of Na and the g line of Ca. Use of Kr and Xe in the expansion chamber to obtain stronger shocks and correspondingly higher temperatures permitted comparison of intensity of the g line of neutral Ca and the H and K lines of Ca II with increase in temperature. The g line alone is present in weaker shocks while for stronger shocks the H and K lines increase with the g line even decreasing, showing the luminosity of the gases behind the shocks to be purely a temperature phenomenon. Observations of spectral lines of metals and of the carrier gas with changes in temperature are described and discussed.

MIC. 06:002

Michigan U. Engineering Research Inst., Ann Arbor.

RADIATION FROM A STRONG SHOCK FRONT IN KRYPTON, by E. B. Turner. July 1955, 8p. incl. illus. diagr. (Rept. no. 2189-1-T) ([AF]OSR-TN-55-184) (AF 18(600)983) AD 68420 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Also published in Phys. Rev., v. 99: 633, July 15, 1955.

Petschek (Phys. Rev., v. 84: 614A, 1951) observed that a very strong shock front in argon is usually seen as a bright luminous line. It is shown from wave-speed photographs in krypton, obtained with a revolving drum camera at an angle to the shock tube, that the luminosity is homogeneous across the front and not a wall effect. Another series of wave-speed photographs was made with a wedge interference filter placed in front of a horizontal slit on the shock tube. These showed mainly line radiation, but the lines were not those of krypton. A spectrum was obtained by rotating the film drum at such a speed that the image of the shock front was stationary on the film. The Swan bands of carbon, which arise from organic vapors, as well as the lines of calcium and sodium were observed. The sharp luminous front is apparently the result of inelastic collisions between these vapors and krypton atoms in the zone where translational equilibrium is not yet established. (Contractor's abstract)

MIC. 06:003

Michigan U. Engineering Research Inst., Ann Arbor.

THE PRODUCTION OF VERY HIGH TEMPERATURES IN THE SHOCK TUBE WITH AN APPLICATION TO THE STUDY OF SPECTRAL LINE BROADENING, by E. B. Turner. May 1956, 170p. incl. illus. diagrs. tables, refs. (Rept. no. 2189-2-T) (AFOSR-TN-56-150) (AF 18(600)983) AD 86309 Unclassified

A small rectangular shock tube has been constructed expressly for the production of very strong shock waves in the rare gases. The tube is vacuum tight and driver gas pressures of up to 100 atm can be used. Wave-speed photographs of shock waves in the tube were made with a revolving drum camera for a large range of initial pressure ratios and the primary shock velocities were found to be considerably less than the theoretical values. The interaction of the reflected shock with the interface was studied both experimentally and theoretically. The delay time for ionization was studied in Xe, and an explanation was found for the shock front appearing as a thin luminous line. Spectra were taken of the shock-tube luminosity and such features as lines of metallic impurities, recombination continuum, and Stark broadening of the rare-gas lines were observed. It was found that intense Balmer lines of H can be produced behind the reflected shock at the end of the tube of adding about 1% H to Ne. Time-resolved spectra were made of H_β and the conditions of temperature, ion density etc., were calculated from the measured shock velocity. Comparison with the Holtsmark theory for first-order Stark broadening showed the experimental profiles to be about 20% wider. (Contractor's abstract)

MIC. 06:004

Michigan U. [Engineering Research Inst.] Ann Arbor.

SPECTRAL LINE PROFILES IN THE LUMINOUS SHOCK TUBE (Abstract), by E. B. Turner. [1956] [1]p. [AF 18(600)983] Unclassified

Presented at meeting of the Amer. Phys. Soc., Pasadena, Calif., Mar. 19-21, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 361, Nov. 23, 1956.

Although several investigators have observed the spectra of luminosity behind very strong shock waves, none have previously obtained quantitative data on spectral line shapes. Spectral observations were made at the end of the shock tube where the temperatures are somewhat higher than behind the primary shock wave. This has made necessary a theoretical and experimental explanation of the hydrodynamic processes at the end of the tube, namely, the interaction of the reflected shock with the interface. A revolving drum camera was used with a spectrograph to obtain time-resolved spectra of the luminosity. A new film calibration method was devised to eliminate the difficulties with reciprocity law failure, and the intensity profiles derived therefrom are fairly accurate. Shock waves were produced in neon, to which about 1% hydrogen was added. Profiles of the H_β line of hydrogen were obtained and found to be slightly wider than predicted by the Holtsmark theory, but in better agreement with the recent Kolb theory. The conditions behind the first reflected shock, as calculated from the primary shock velocity which was measured with a wave-speed camera, were approximately: T = 12000°K, ion density = 1.5×10^{16} ions/cc. (Contractor's abstract)

MIC. 07:001

Michigan U. Engineering Research Inst., Ann Arbor.

COMBUSTION WITH OZONE-MODIFICATION OF FLAME SPEEDS C_2 HYDROCARBON-AIR MIXTURES, by M. E. Gluckstein, R. B. Morrison, and T. B. Khammash. Aug. 1, 1955, 10p. incl. illus. diagrs. table. (Rept. no. 2279-1-T) ([AF]OSR-TN-55-227) (AF 18(600)1186) AD 69771 Unclassified

The effect of ozonized air on the combustion of ethane, ethylene, and acetylene in a Bunsen burner is studied. Research was conducted to determine: (1) whether ozone introduced into a combustor would produce significant alterations in the combustion processes; and (2) the magnitude and direction of any changes. Data were obtained with ozone (O_3) concentrations of about 1% by weight. To determine if the partial ozonization of the combustion air would have any effect on combustion, the flame speeds for the mixture burning with and without ozone were determined experimentally. Flame speed is defined as the velocity of the unburned gas normal to the flame front. Ozone analysis was made by iodometric titration for O_3. When ozone was added or eliminated, the flames changed from button-shape to cone shape or vice versa. The behavior of ethane was the reverse of ethylene and acetylene, indicating that the flame speeds of ethylene and acetylene decreased when ozone was present, while that of ethane increased. The addition or removal of ozone from a stable flame often induced oscillations, blowoff, or flashback. Rich flames were more susceptible to instabilities than lean flames. (Contractor's abstract)

MIC. 08:001

Michigan U. Engineering Research Inst., Ann Arbor.

CONSIDERATIONS FOR THE ATTAINMENT OF A STANDING DETONATION WAVE, by J. Rutkowski and J. A. Nicholls. Sept. 1955, 24p. incl. illus. diagrs. (Rept. no. 2284-5-T) ([AF]OSR-TN-55-216) (AF 18-(600)1199) AD 73703 Unclassified

Presented at the Gas Dynamics Symposium on Aerothermochemistry, Northwestern U., Evanston, Ill., Aug. 22-24, 1955.

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Also published in Proc. Gas Dynamics Symposium on Aerothermochemistry, Evanston, Ill., Northwestern U. (Aug. 22-24, 1955), 1956, p. 243-253.

Experimenial studies of detonation waves have hitherto been confined to unsteady 1-dimensional flow and normal wave conditions. The significant information deduced is rather limited owing to the singularity of the wave formation. The extension of the experimental work to the inclusion of standing detonation waves, stabilized in a channel, would immeasurably add to a better understanding of this complex phenomenon, in terms of the wave structure and wave stability. Experimental considerations of stabilizing and maintaining a detonation wave in a duct are described. These include particularly the supersonic flow of a combustible gaseous mixture over a wedge. The experimental requirement of generating the relatively high Mach numbers (M = 4.5 and higher) and the proper pressures and temperatures for the gaseous mixture at the test section are rather severe and demanding in apparatus. The practical requirements and limitations for a blow-down wind tunnel system are discussed. The theoretical considerations include a discussion of the steady 2-dimensional supersonic flow over a wedge wherein a stabilized nondiabatic wave is generated, with energy addition at the wave front. The idealized conservation equations for nonadiabatic waves lead to the polar diagram, which describes the various regimes of steady supersonic flow with oblique waves. The possible solutions and the flow conditions behind the stabilized wave are considered and are discussed in terms of initial flow conditions, energy release, and wedge angle. A graphical solution for the nonadiabatic wave polar is presented which permits a simple construction of the diagram. (Contractor's summary)

MIC. 09:001

Michigan U. Engineering Research Inst., Ann Arbor.

COMBUSTION STUDIES WITH A 12000-CURIE COLD SOURCE, by S. W. Churchill, A. Weir, Jr. and others. Dec. 1955, 53p. incl. illus. diagrs. tables, refs. (Rept. no. 2288-6-T) (AFOSR-TN-56-17) (AF 18(600)-1218) AD 90142 Unclassified

The effect of nuclear radiation from Au-198 and Au-199 on propane-air flames at low pressures was investigated experimentally. The source had an initial strength of 15,270 curies. Both the preflame mixture and the flame zone were irradiated. The number of ion pairs produced by β radiation greatly exceeded that produced by γ radiation. The rate of propagation of Bunsen flames was increased up to 50% by irradiation. The emission due to CH, C_2, and OH was measured at a series of elevations through a flat flame, and CH rotational temperatures were computed. The emission at 4315 Å owing to CH was increased up to 33%, and the emission at 5165 Å owing to C_2 was increased up to 150% with the source at a level of 1500 curies. The emission owing to OH was not affected significantly. Increases in CH rotational temperature up to 100% were calculated for a source level of 1500 curies. The maxima in the emission owing to C_2 and OH were observed to occur at an earlier stage than the maximum in emission owing to CH in the irradiated flames. (Contractor's abstract)

MIC. 10:001

Michigan U. Engineering Research Inst., Ann Arbor.

HEAT AND MOMENTUM TRANSFER FROM THE WALL OF A POROUS TUBE, by S. W. Churchill and H. E. Stubbs. Final rept. Mar. 1957, 71p. incl. diagrs. table, refs. (Rept. no. 2323-9-F) (AFOSR-TR-56-58) (AF 18(600)1335) AD 115001 Unclassified

Heat and momentum transfer from the wall of a porous tube to a fluid stream flowing in the tube were investigated analytically and experimentally. The investigation was limited to conditions where the main stream in the tube was turbulent and where a secondary flow, small relative to the primary, passed inwards or outwards through the porous wall. This small flow through the wall modified the usual velocity field in the tube and consequently the heat and momentum flux from the wall. In the analytical part of the investigation, the equations of motion of the fluid are simplified by approximations and suppositions about the distribution of turbulence to give an equation amenable to computation. From the latter equation temperature and velocity profiles for the tube are obtained as a function of the flow through the wall, and from these, values are derived for the friction coefficient of the flow and for the Nusselt modulus. The experimental work was designed primarily to determine the limitations of the analysis and was confined to circumstances in which the flow through the wall of the tube was inward. A re-interpretation of the experimental data of other investigators covering the case of flow outward through the wall is, however, given. The experiments indicate that the analysis is substantially correct when flow inward from the wall has a velocity less than .001 of the bulk velocity of the main stream and for a somewhat greater range of velocity when the flow is outward. For inward flow with a velocity of .001 of the main stream velocity, the heat and momentum transfer rates are reduced by about 13% from their values when there is no flow through the wall. For greater inward flow, little additional change takes place. (Contractor's abstract)

MIC. 11:001

Michigan U. Engineering Research Inst., Ann Arbor.

REVERSIBLE PROPERTIES OF FERROMAGNETS, [Parts I and III], by D. M. Grimes. Dec 1956, 56p. incl. diagrs., refs. (Technical rept. no. 1) (AFOSR-TN 56-464) (AF 18(603)8) AD 97082 Unclassified

Part III presented at the Conference on Magnetism, Boston, Mass., Oct. 18, 1956.

Part I also published in Jour. Phys. Chem. Solids, v. 3: 141-152, 1957.

Part I. Using a statistical model, equations are developed for the variation of the reversible susceptibility both parallel with and normal to the biasing magnetization as a function of the magnetization assuming that the susceptibility arises by domain rotation. The results are contrasted with previous results based upon domain-wall motion. It is concluded that the theory points out a new technique for the separation of the origins of the susceptibility. Equations are also given for the expected variation of the differential magnetostriction with magnetization both parallel with and normal to the field and for both domain wall motion and domain rotation. Quantitative results depend upon the fraction of the moments oriented in each direction. A function describing this distribution is discussed. An expression is given for the susceptibility matrix arising from domain rotation as a function of magnetization. Part II to be published as TN-57-209. Part III. Theory which was developed in Part I is compared with experimental data of Part II in relation to the separation of magnetization mechanisms by a new technique, the measurement and comparison of the parallel and transverse reversible susceptibilities. Theoretical curves are shown for the variation with magnetization of the wall-motional and domain-rotational susceptibilities and differential magnetostrictions. Applicability of theory is shown by susceptibility data charted for 3 ferrite samples considered to be of compositions $Ni_{.1682}Co_{.2992}Zn_{.5326}Fe_2O_4$, $Mg_{.97}Fe_{.03}Fe_2O_4$, and $Ni_{.3800}Fe_{.1282}Co_{.0330}Zn_{.4588}Fe_2O_4$. Theory and published data for Permalloy 45 are compared for magnetostriction.

MIC. 12:001

Michigan U. [Engineering Research Inst.] Ann Arbor.

SOME FEATURES OF BOUNDARY LAYERS AND TRANSITION TO TURBULENT FLOW, by A. M. Kuethe. [1956] [10]p. incl. diagrs. [AF 18(603)34] Unclassified

Published in Jour. Aeronaut. Sciences v. 23: 444-452, 506, May 1956.

A brief review of the status of knowledge of laminar and turbulent boundary layers and of transition is given. Some new experimental results on transition in Poiseuille flow in a tube are reported. One set shows transition excited by the annular wake behind a ring airfoil. Another shows oscillograms of velocity fluctuations in the flow for several imposed disturbance amplitudes. These demonstrate successive stages in the breakdown of the flow. (Contractor's summary)

MIC. 13:001

Michigan U. Engineering Research Inst., Ann Arbor.

THE LOGIC OF AUTOMATA, by A. W. Burks and H. Wang. Dec. 1956, 60p. incl. diagrs. refs. (Rept. no. 2512-2-F) (AFOSR-TN-56-539) (AF 18(603)72) AD 110358 Unclassified

Also published in Jour. Assoc. Computing Machinery, v. 4: 193-297, Apr. 1957.

Classes of automata are distinguished as fixed and growing, deterministic and probabilistic. Methods are presented for analyzing and synthesizing fixed, deterministic automata by 4 kinds of state tables. By use of these tables a decision procedure is obtained for determining whether or not 2 automaton junctions behave the same. Matrix theory is applied to some of the state tables, and theorems are proved about the resulting matrices and a corresponding normal form automaton. Finally, fixed, deterministic automaton nets are analyzed in terms of cycles. (Contractor's abstract)

MIN. 01:001

Minnesota U., Minneapolis.

HOLLOW BEAMS IN ELECTROSTATIC FIELDS, by L. A. Harris. May 1955 [25]p. incl. diagrs. (Technical note no. HB-2N) ([AF]OSR-TN-55-157) (AF 18(600)1169) AD 64523 Unclassified

Trajectories are calculated for the inner and outer edges of tubular electron beams in radial electrostatic fields. The beams are assumed to be of zero thickness initially and to have uniform axial velocity. Special cases considered include that of a beam inside a single drift tube and a beam between coaxial drift tubes. Both diverging and converging beams are treated in strong and weak radial fields. It is shown that strong radial fields effectively reduce the space-charge spread, at the same time deflecting the beam. Calculated results for a particular beam are presented as an example for each of these cases. (Contractor's abstract)

MIN. 01:002

Minnesota U., Minneapolis.

RESEARCH ON HOLLOW DENSE ELECTRON BEAMS, by L. A. Harris. Sept. 1955 [49]p. incl. diagrs. refs. (Technical rept. no. HB-2R) ([AF]-OSR-TR-55-27) (AF 18(600)1169) AD 77047 Unclassified

Research on the problems of producing and focusing hollow, dense, electron beams is described. Some properties of magnetically shielded systems are derived, and a new arrangement is proposed. A design method for a toroidal electron gun to act as a beam source is outlined and discussed. The behavior of hollow beams in radial electrostatic fields is summarized briefly, and the applications are noted. A method for the design and calculation of magnetic circuits applicable to these systems is presented, and

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some modifications are proposed. Finally, there is a discussion of a possible magnetron-type beam source, and a beam viewer. (Contractor's abstract)

MIN. 02:001

Minnesota U., Minneapolis.

SOME CONDITIONAL PROBABILITY DISTRIBUTION FUNCTIONS, by G. E. Baxter. Oct. 1, 1956, 16p. (Technical rept. no. 1) (AFOSR-TN-56-483) (AF 18-(603)30) AD 97367 Unclassified

Two identities are derived which give the generating functions of the probabilities $P\{S_n < a, S_1 > 0, \ldots, S_n > 0\}$ and $P\{S_n \cdot a, S_1 \geq 0, \ldots, S_n \geq 0\}$ in terms of the distribution function of S_k, $k = 1, 2, \ldots$. The case where k becomes a continuous parameter t is considered, also, with the set of partial sums replaced by a separable stochastic process $\{x(t), 0 \cdot t < \infty\}$ with stationary, independent increments and $x(0) = 0$. The results are two theorems and proofs with examples of limiting and non-limiting cases in Section 5.

MIN. 02:002

Minnesota U., Minneapolis.

DIFFERENTIAL EQUATIONS INVOLVING A PARAMETRIC FUNCTION, by R. H. Cameron. [1956] [7]p. (Technical rept. no. 2) [AFOSR-TN-56-487] (AF 18(603)30) AD 110301 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 834-840, Oct. 1957.

The conditions are sought for the function $f(t, u)$ under which the differential system $dz/dt + f[t, y(t) + z(t)] = 0$ with $z(0) = 0$ has a solution $z(t)$ on the unit interval I for almost all choices of the function y in the space C. The transformation $z(t) = x(t) - y(t)$ gives the equivalent nonlinear integral equation $y(t) = x(t) + \int_0^t f[s, x(s)]\, ds$ with f such that there is a solution $x \in C$ for almost every y in C.

MIN. 03:001

Minnesota U., Minneapolis.

SAMPLE LENGTH EFFECT ON PERMEABILITY MEASUREMENT (Abstract), by S. P. Yu, D. Cheu and others. [1956] [1]p. [AFOSR TN 56 433] (AF 18(603)113) AD 96516 Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 23-24, 1956.

Also published in Bull. Amer. Phys. Soc., Series II, v. 1: 322, Nov. 23, 1956.

A sample-length effect has been observed in the initial permeability measurement of finely powdered Fe_2O_3 and paraffin mixtures. The peaking of the loss angles at sample lengths equal to multiples of quarter wavelength can not be accounted for by higher order modes or dimensional resonance. Calculation reveals that the loss angle is sensitive to non-ideal termination of the transmission line and the error in the location of voltage minimum at these lengths. For optimum accuracy a one-eighth wave-length sample should be used even though the "exact" method is employed. (Contractor's abstract)

MIN. 04:001

Minnesota U. Dept. of Aeronautical Engineering, Minneapolis.

ON REAL UNICURSAL CURVES, by T. Riabokin. Oct. 1952, 124p. incl. diagrs. refs. Final tech. rept. (Research rept. no. 86) (AF 18(600)329) Unclassified

Algebraic curves of degree n were investigated by topological methods for real curves with n(n-2) real points of inflection, as well as for the existence of real unicursal curves and the general methods of obtaining equations for such curves. It was proved that for any positive integer n there exists a curve of degree n which has n(n-2) real inflection points. A method was found of constructing such curves and a method of writing the equations of such curves. It was proved that for any positive integer n there exists a curve of degree n which has $\frac{(n-1)}{2}(n-2)$ real singular points. General methods were found for obtaining equations of real unicursal curves and for construction of such curves. A brief discussion of the relationship between these unicursal curves and Lissajous figures concludes the report. (Contractor's abstract, modified)

MIN. 05:001

Minnesota U. [Dept. of Aeronautical Engineering] Minneapolis.

FLAME STABILIZATION ON BLUFF BODIES AT VARIABLE PRESSURES, by C.-C. Chang, C.-T. Hsu, and D. G. DeCoursin. [1956] [15]p. diagrs. refs. (AF 18(600)1456) Unclassified

Published in Proc. Fifth Biennial Technical Conference, Minnesota U., Minneapolis (Research rept. no. 137) Oct. 1956, p. 31-41.

The achievement of stable combustion in ramjets and turbojet afterburners is essential to the further development of air breathing jet propulsion. In solving this problem, extensive research is particularly required on the physical and chemical processes involved in stabilizing flames on bluff bodies. Recent investigations have greatly improved the understanding of the general mechanism of flame stabilization, however, most of this work has been carried out at atmospheric pressure. For ramjets flying at different

altitudes the static pressure in the combustion chamber may vary over a wide range. At present, little reliable information is available on flame stabilization at very low pressures. In order to simulate combustion at different altitudes and to carry out related basic research on this problem, the Combustion Research Lab. was recently established at the University of Minnesota under the sponsorship of the Air Force Office of Scientific Research. Work was begun in Sept. 1955, and construction of the major components of the facility has been completed. Work is now in progress on the calibration of the tunnels and construction of instrumentation so that research programs can be carried out in the near future. The present report consists of two parts: (A) a general review of recent literature on flame stabilization at atmospheric pressure; and (B) the combustion research facilities in the new lab. (Contractor's summary)

MIN. 06:001

Minnesota U. [Dept. of Mathematics] Minneapolis.

NONLINEAR VOLTERRA FUNCTIONAL EQUATIONS AND LINEAR PARABOLIC DIFFERENTIAL SYSTEMS, by R. H. Cameron. Sept. 26, 1955 [64]p. refs. (Technical note no. 1) ([AF]OSR-TN-55-378) (AF 18-(600)1144) AD 92002 Unclassified

Also published in Jour. Analyse Math. (Jerusalem), v. 5: 136-182, 1956/57.

Theorems are obtained relating existence theorems (almost everywhere type) for solution of nonlinear Volterra functional equations, values of Wiener integrals, and minimality theorems for positive solutions of linear parabolic differential systems. An existence theorem for the latter systems is also obtained. (Contractor's abstract)

MIN. 06:002

Minnesota U. [Dept. of Mathematics] Minneapolis.

INVESTIGATION OF BOUNDARY VALUE PROBLEMS AND FUNCTIONAL EQUATIONS, by R. H. Cameron. Technical rept. June 20-Aug. 19, 1954 and June 20-Aug. 19, 1955 [2]p. [AFOSR-TR-55-29] (AF 18-(600)1144) AD 75992 Unclassified

It is stated that results have been obtained in the following mathematical studies: (a) the solution of boundary-value problems and functional equations in terms of Wiener integrals; (b) the uniqueness and properties of solutions obtained in (a); (c) the relationship between results on the transformation of Wiener integrals, and the study of expectations of random processes; and (d) the general parabolic equation in two variables from the above viewpoint. No findings are presented in this report.

MIN. 06:003

Minnesota U. [Dept. of Mathematics] Minneapolis.

THE GENERAL LINEAR PARABOLIC EQUATION IN TWO VARIABLES, by R. H. Cameron. Jan. 31, 1956 [3]p. (Technical note no. 2) (AFOSR-TN-56-67) (AF 18(600)1144) AD 81059 Unclassified

It is the objective of this mathematical study to point out that the differential system:
(1a) $\frac{\partial H}{\partial t} = A(t,u)\frac{\partial^2 H}{\partial u2} + B(t,u)\frac{\partial H}{\partial u} + E(t,u)H$;
(1b) $H(O,u) = \alpha(u)$ can, under reasonable conditions, be transformed into the system; (2a) $\frac{\partial G}{\partial t} = \frac{\partial^2 G}{\partial \xi^2} +$ $\upsilon(t,\xi)G$; and (2b) $G(O,\xi) = \sigma(\xi)$ which has been studied by Cameron, Tingley and others (The Generalized Heat Flow Equation and a Corresponding Poisson Formula, Ann. Math., v. 59: 434-462, 1954). Thus, the existence, uniqueness, and minimality theorems obtained by Cameron and others for 2a and 2b can be made applicable to 1a and 1b.

MIN. 07:001

Minnesota U. Heat Transfer Lab., Minneapolis.

DIFFUSION EFFECTS IN A BINARY ISOTHERMAL BOUNDARY LAYER, by E. R. G. Eckert and P. J. Schneider. Nov. 1955, 15p. incl. diagrs. table. (Technical rept. no. 5) ([AF]OSR-TN-55-258) (AF 18(600)1226) AD 100059 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 384-387, Apr. 1956.

Improvements are made in the calculations by Smith (Jour. Aeronaut. Sciences, v. 21: 154-162, 1954) of the effects of molecular diffusion in a laminar boundary layer for cases of zero and finite heat transfer to porous flat plates. The results are presented for the isothermal case only, although the improvements are applicable to the heat-transfer case. Similarity solutions are obtained for plane longitudinal flow over a flat porous plate with normal injection of a fluid whose variable properties are widely different from those of the main stream. Variation of properties with mixture temperature and concentration are evaluated from results of molecular theory. Boundary-layer calculations are performed by the method of successive approximation for hydrogen injection into an air boundary layer under isothermal conditions. Calculated skin-friction coefficients are compared with corresponding values for the case of constant-property diffusion.

MIN. 07:002

Minnesota U. Heat Transfer Lab., Minneapolis.

FLOW EQUATIONS FOR MULTICOMPONENT FLUID SYSTEMS. PART I. GENERAL EQUATIONS.

MIN. 07:003 - MIN. 07:005

PART II. BINARY BOUNDARY LAYER EQUATIONS, by N. A. Hall. Aug. 22, 1955, 33p. (Technical rept. no. 2) [AFOSR-TN-55-333] (AF 18(600)1226) AD 70114 Unclassified

Part I. The general flow equations for a multicomponent compressible Newtonian fluid are developed. In the development of these equations, it is assumed that: (1) the fluid medium is isotropic; (2) the medium is single phase and locally homogeneous, i.e., no relaxation phenomena occur; (3) no external force acts upon any component; (4) transport phenomena are linearly dependent on property gradients; (5) differences between the kinetic energy of motion of the several components are negligible, i.e., diffusion velocities are small in absolute magnitude. Mass continuity and diffusion motion, entropy, the stress tensor, and heat and diffusion flow are considered and the set of equations obtained are simplified for application to binary systems. In Part II these general flow equations are applied to 2-dimensional steady laminar flow over a flat plate, with or without pressure gradient along the surface, and the boundary-layer equations are developed critically.

MIN. 07:003

Minnesota U. Heat Transfer Lab., Minneapolis.

MASS TRANSFER COOLING IN A LAMINAR BOUNDARY LAYER WITH CONSTANT FLUID PROPERTIES, by J. P. Hartnett and E. R. G. Eckert. Oct. 1955 [50]p. incl. diagrs. refs. (Technical rept. no. 4) [AFOSR-TN-55-375] (AF 18(600)1226) AD 77048 Unclassified

A study was made of the prediction of the heat transfer skin friction, and required coolant flows for transpiration-cooled high-speed aircraft surface or turbine blades. A preliminary examination is made of the laminar boundary-layer equations of momentum, diffusion, and energy for the case when the properties of the gas diffusing through the wall are identical with the properties of the free stream fluid. Simultaneous mass and heat-transfer solutions from the literature were supplemented by new calculations, where required, and are presented for the case of the flat plate and the plane stagnation flow. Solutions of the energy equations are also presented for the case of boundary-layer suction over a range of suction values for both the flat-plate and the plane stagnation flow. An evaluation of the recovery factor shows its sensitivity to both fluid injection and suction. With this information, the heat-transfer results can be applied to high velocities where viscous dissipation is important. (ASTIA abstract)

MIN. 07:004

Minnesota U. Heat Transfer Lab., Minneapolis.

TRANSPORT PROPERTIES FOR BINARY GAS MIXTURES, by W. O. Carlson and P. J. Schneider. Jan. 1956 [46]p. incl. diagrs. tables, refs. (Technical rept. no. 7) ([AF]OSR-TN-56-45) (AF 18-(600)1226) AD 80557 Unclassified

The diffusion process associated with two-component flow over flat plates has been found from recent studies to have a marked effect on the boundary-layer development. This effect is particularly pronounced when the properties of the diffusing foreign gas are widely different from the properties of the free stream. Since the thermal and dynamical properties affect the flow, there is a definite need for accurate information on the variation of these transport properties with both temperature and diffusing gas concentration. A review has been made of the various methods available for calculating these properties, and methods have been developed and suggested which lend themselves to rapid calculation without an excessive loss in accuracy. Expressions for the following binary mixture properties are included: density, constant-pressure specific heat, thermal conductivity, binary diffusion coefficient, and thermal diffusion factor. (Contractor's abstract)

MIN. 07:005

Minnesota U. [Heat Transfer Lab.] Minneapolis

MEASUREMENT OF RECOVERY FACTORS AND HEAT TRANSFER COEFFICIENTS WITH TRANSPIRATION COOLING IN A TURBULENT BOUNDARY LAYER AT M = 3.0 USING AIR AND HELIUM AS COOLANTS, by B. M. Leadon and C. J. Scott. Feb. 1956 [32]p. incl. illus. diagrs. (Research rept. no. 126) (AFOSR-TN-56-94) (AF 18(600)1226) AD 82502 Unclassified

Presented at meeting of the Amer. Phys. Soc., Pasadena, Calif., Mar. 19-21, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 365, Nov. 23, 1956.

Turbulent-recovery-factor and heat-transfer measurements have been made on a porous wall section at a nominal Mach number of 3.0 and a Reynolds number of approximately 10^6, using both air and He as the transpired gas. Measured heat-transfer coefficients correlate well with the compressible theory of Rubesin (An Analytical Estimation of the Effect of Transpiration Cooling on the Heat Transfer and Skin Friction Characteristics of a Compressible, Turbulent Boundary Layer Skin Friction and Heat Transfer, Jour. Aeronaut. Sciences, v. 21: 6, 1954) for air, and qualitatively with simple film theory for either coolant, indicating that the heat transfer from a turbulent-boundary layer can be reduced by transpiration cooling to well below that of the uncooled boundary layer at the same Reynolds number. The simple film theory (Heat, Mass, and Momentum Transfer for Flow over a Flat Plate with Blowing or Suction, by H. S. Mickley and others. NACA Technical rept. no. TN 3208, July 1954) is extended to apply to binary boundary layers with any concentration of foreign gas at the wall. (Contractor's abstract)

MIN. 07:006

Minnesota U. Heat Transfer Lab., Minneapolis.

MASS TRANSFER COOLING OF A LAMINAR AIR BOUNDARY LAYER BY INJECTION OF A LIGHT-WEIGHT GAS, by E. R. G. Eckert, P. J. Schneider, and F. Koehler. Apr. 1956 [25]p. incl. diagrs. (Technical rept. no. 8) ([AF]OSR-TN-56-136) (AF 18(600)1226) AD 86014 Unclassified

Calculations are presented for mass transfer cooling of a laminar air boundary layer by injection of H. All properties in the binary boundary layer are considered to vary with both local mixture concentration and temperature. Results in the form of boundary-layer velocity, concentration, and temperature profiles are given for a particular free-stream air temperature of 392°F, a free stream Mach number of 12, a surface-to-free-stream temperature ratio of 6, and surface concentrations of 0, 0.2, 0.4, 0.6, 0.8, and 0.9. The injection rate and skin friction are presented as a function of the surface concentration. (Contractor's abstract)

MIN. 07:007

Minnesota U. [Heat Transfer Lab.] Minneapolis.

TRANSPIRATION COOLING EXPERIMENTS AND TURBULENT BOUNDARY LAYER SEPARATION AT M = 3, by B. M. Leadon and C. J. Scott. [1956] [11]p. incl. illus. diagrs. (AF 18(600)1226) Unclassified

Published in Proc. Fifth Biennial Technical Conference, Minnesota U., Minneapolis (Research rept. no. 137) Oct. 1956, p. 15-20.

Published in Jour. Aeronaut. Sciences, v. 23: 798-799, Aug. 1956.

Turbulent recovery factors and heat-transfer measurements have been made on a porous flat plate imbedded in the floor of a supersonic channel operating at a nominal Mach number of 3.0 and an average Reynolds number of approximately 4×10^6 using both air and helium as the transpired gas. Total pressure and concentration (in the latter case) profiles were obtained and, assuming a reasonable temperature profile, velocity profiles were computed. Measured recovery factors show a definite reduction with transpiration of air and a strong reduction with helium. Separation occurs at lower blowing rates for helium transpiration.

MIN. 07:008

Minnesota U. [Heat Transfer Lab.] Minneapolis.

THE MANGLER TRANSFORMATION AS APPLIED TO POROUS CONES AND HEMISPHERES, by C. J. Scott. Sept. 1956 [10]p. (Engineering memorandum no. 68) (AF 18(600)1226) Unclassified

The 2-dimensional laminar boundary-layer equations are given for a viscous, compressible, heat-conducting gas. It is pointed out that in axially symmetric flow about a body of revolution, the boundary-layer equations describing this flow differ from the 2-dimensional equations only in the equation of continuity. The boundary-layer equations for nonslender bodies in axial symmetric flow are presented, and the transformation relations desired are shown. The general expression of Mangler's transformation, which applies to any nonslender body of revolution, is developed. Mangler's transformation is then applied to conical flow and to flow about a hemisphere. The transformation relations at the stagnation point of a hemisphere and at the hemisphere-cylinder intersection ($\theta = \pi/2$) are shown.

MIN. 07:009

Minnesota U. [Heat Transfer Lab.] Minneapolis.

THEORETICAL STUDY OF MASS TRANSFER COOLING BY INJECTION OF A LIGHT WEIGHT GAS, by E. R. G. Eckert and P. J. Schneider. [1956] [1]p. (AF 18(600)1226) Unclassified

Published in Proc. Fifth Biennial Technical Conference, Minnesota U., Minneapolis (Research rept. no. 137) Oct. 1956, p. 14.

The use of mass-transfer cooling is being investigated as a means of protecting the surfaces of high-speed vehicles against the high-temperature effects of intense aerodynamic heating. Boundary-layer similarity solutions have been obtained for high-speed laminar isothermal flow of air over a flat plate with normal injection of hydrogen varying inversely with the square root of the distance from the leading edge. In this case the momentum and diffusion equations are coupled through dependence of the transport properties on local concentration in the binary boundary layer, and accordingly solutions must be obtained by iteration. The decreased mass at the surface and the diffusion process accompanying injection of a light gas serve to reduce the surface velocity gradient and thus the local skin friction coefficient. At an injection rate corresponding to $f_w = -0.3$ the reduction in c_f is nearly 85% for hydrogen and 40% for helium. Similar calculations are being performed for the general heat-transfer case with hydrogen injection and a free-stream temperature of 392°F, a free-stream Mach number of 12, and a wall-to free-stream temperature ratio of 6. A detailed study of laminar "couette flow" with mass transfer has been undertaken in order to use it as a rough guide in predicting equilibrium surface temperatures and selecting the most effective coolants. Preliminary calculations indicated that the couette-flow model is a fair approximation to exact binary layer results providing the injection rate is reasonably low.

MIN. 08:001 - MIN. 09:004

MIN. 08:001

Minnesota U. Inst. of Tech., Minneapolis.

NUCLEAR SPIN RESONANCE OF AQUEOUS SODIUM ION, by J. E. Wertz and O. Jardetzky. [1956] [3]p. (AF 18(603)17) Unclassified

Published in Jour. Chem. Phys., v. 25: 357-358, Aug. 1956

Nuclear spin resonance absorption of ionic sodium in aqueous solutions of inorganic salts has been studied in a field of 7030 gauss. Although the absorption line is observable directly on an oscilloscope, it was found convenient to record its derivative. The shape of the derivative was found to correspond very closely to that of a Gaussian curve. The line width between points of maximum slope for the 3 M NaCl standard was found to be about 32 gauss. Although this width is much greater than that for proton lines, it is much less than the 0.2-gauss width for Cl^{35} as the chloride ion, although Na^{23} and Cl^{35} have quadrupole moments of similar magnitude. (Contractor's abstract)

MIN. 08:002

Minnesota U. [Inst. of Tech.] Minneapolis.

THE COMPLEXING OF SODIUM ION WITH SOME COMMON METABOLITES, by O. Jardetzky and J. E. Wertz. [1956] [4]p. incl. diagrs. (AF 18(603)17) Unclassified

Published in Arch. Biochem. and Biophys., v. 65: 569-572, Dec. 1956.

Application of nuclear spin resonance to the study of ionic sodium in aqueous solutions strongly indicates that some metabolites such as lactate, pyruvate, and citrate form specific complexes with the sodium ion. When the resonance absorption of sodium was examined in the presence of organic anions, it was found to depend greatly on their nature. Applications of the nuclear spin resonance method to biochemical problems are not limited to the detection.

MIN. 09:001

Minnesota U. Rosemount [Aeronautical] Labs., Minneapolis.

THE MOMENTUM INTEGRAL RELATION FOR COMPRESSIBLE, CONICAL FLOW AND TRANSFORMATION OF RESULTS TO PLATE FLOW, by W. S. Bradfield. July 9, 1951, 30p. incl. diagrs. tables, refs. (Engineering memo. no. 3) (AF 18(600)384) Unclassified

A completely general expression for the momentum theorem is written in vector notation. An equally general definition of divergence is made such that specification of coordinate systems is unnecessary. Using these two basic tools, the momentum integral relation for local skin friction coefficient and momentum thickness is obtained for two cases. The first is steady, compressible, conical viscous flow; the second is steady, compressible, viscous flow over a flat plate. The Hantzsche-Wendt laminar boundary layer transformation of displacement thickness from cone to plate is then applied to complete the calculation. (Contractor's abstract)

MIN. 09:002

Minnesota U. Rosemount [Aeronautical] Labs., Minneapolis.

CHARACTERSITICS OF LAMINAR-AND TURBULENT-BOUNDARY LAYER AT SUPERSONIC VELOCITY, by W. S. Bradfield, D. G. DeCoursin, and C. B. Blumer. July 1952 [152]p. incl. illus. diagrs. refs. (Research rept. no. 83) (AF 18(600)384) U25573; ATI-172620 Unclassified

The design, development, and application are described for a balance system suitable for direct measurement of viscous shearing stress in conical supersonic flow. Skin friction coefficients were measured from about free stream M = 3.0 to 5 and Re = 1.4 to 11 million. Momentum loss in the laminar and turbulent boundary layer on an exact duplicate of the balance system model was measured at an intermediate free system M = 3.47 and Re = 0.45 to 22 million. These results were used as a check against balance-system results. Reasonable agreement was observed. The experimental results compared with flat plate theory. In the interest of effecting an experimental comparison of flat plate results with cone flow measurements, experiments were conducted in the laminar boundary layer on a flat plate. These measurements are compared with the present cone flow results and with the results of previous investigators. Transition was measured on conical models in blowdown and continuous wind tunnels by application of the pitot-tube traverse method.

MIN. 09:003

Minnesota U. Rosemount [Aeronautical] Labs., Minneapolis.

THE BAROMETER AND THE MANOMETER IN PRESSURE MEASUREMENTS, by J. J. Sheppard, Jr. Jan. 30, 1953. 53p. incl. diagrs. tables, refs. (Engineering memo. no. 24) [AF 13(600)384] AD 17892 Unclassified

A brief discussion of the construction, calibration, and maintenance is presented for each instrument considered, and a detailed discussion of the sources of error and their corrections are given.

MIN. 09:004

Minnesota U. Rosemount [Aeronautical] Labs., Minneapolis.

THE STAGNATION STREAMLINE ASSOCIATED WITH

CERTAIN TWO-DIMENSIONAL BODIES IN SHEAR FLOW OF A PERFECT LIQUID NEAR A WALL, by B. M. Leadon. June 10, 1953, 20p. incl. illus. (Research rept. no 93) (AF 18(600)384) AD 20937 Unclassified

For several cases of closed bodies composed on sources and sinks and axially horizontal doublets in shear flow, the stagnation streamline is found to diverge away from the wall and toward higher velocities when no wall is present. In the case of that class of closed bodies generated by a distribution of sources and sinks on a line parallel to a straight wall, it is proved for 2-dimensional flows that the stagnation point occurs between the line of singularities and the wall. The cases of a circular cylinder near a wall and far from a wall in linear shear flow are compared to show that a stagnation point occurs on the body farther from the wall than its center but still inclined upward and toward higher shear flow velocities, respectively. If a vortex is required to describe the probe shape, it can cause a downward stagnation streamline inclination, and therefore a negative position error for the probe. Accompanying this would be a stagnation point on the wall. (ASTIA abstract)

MIN. 09:005

Minnesota U. Rosemount Aeronautical Labs., Minneapolis

THE EFFECT OF LEADING EDGE BLUNTNESS ON MOMENTUM LOSS MEASUREMENTS IN A LAMINAR SUPERSONIC BOUNDARY LAYER, by W. S. Bradfield, D. G. DeCoursin, and C. B. Blumer. Sept. 1953, 19p. illus. (Research rept. no. 96) (AF 18(600)384) AD 21496 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 21: 373-382, 398, June 1954.

An experimental investigation was made to ascertain the effect of leading-edge bluntness on momentum-loss measurements in the laminar boundary layer of a flat plate. Measurements were made in a wind tunnel with an asymmetric channel operating continuously at M = 3.05 (free stream). The test section was 1.75 in. wide by 2.0 in. high. The leading edge of the flat plate was hollow ground to provide additional sharpness and to avoid a strong attached shock wave on the lower side of the model. Leading edge thicknesses of 0.3, 5.9, and 11.7 mils were used. The data indicated that the effect of leading edge bluntness is an important consideration. The ratio of the leading edge thickness to theoretical values of boundary layer displacement thickness at the measuring station appeared to be a criterion of the magnitude of this effect. The blunting effect was demonstrated to be separate from the effects of heat transfer and pitot tube size. The effect on the total measured momentum loss appeared to be generally stronger than that on local measurements of viscous shear at the plate surface. The presence of a detached shockwave at the plate leading edge was considered responsible for the discrepancy between theoretically predicted and measured momentum losses. Comparable experiments on a 15° cone showed little effect of tip blunting on measurements in the laminar boundary layer.

MIN. 09:006

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

A CHARACTERISTICS ANALYSIS OF THE FLOW ABOUT A BLUNT LEADING EDGE, by C. J. Scott. Nov. 1953, 24p. incl. diagrs. refs. (Engineering memo. no 26) [AF 18(600)384] AD 25533 Unclassified

An application of the method of characteristics to the flow about a blunt leading edge is presented. Qualitative results are obtained by considering the steady, two-dimensional, rotational inviscid flow behind a curved, detached, shock wave. The plate boundary layer was not considered. An explanation of the flow conditions downstream from the leading edge is presented on the basis of characteristics analysis. The results of the analysis show that large velocity and pressure gradients are present near the leading edge. These gradients are shown to be damped as the flow proceeds downstream. An envelope of compression wavelets coalesces to form a secondary shock wave downstream of the detached shock wave. The secondary shock results from the centrifugal forces which produce an over-expansion of the flow around the curved leading edge. The effect of the presence of the detached shock on the flow conditions far downstream from the leading edge is confined, for all practical purposes, to a region adjacent to the plate surface approximately six-leading-edge thicknesses high. Fluid elements in streamlines above this height undergo changes in total pressure which are less than 1%. (Contractor's abstract)

MIN. 09:007

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

THE EFFECT OF CONE TIP BLUNTING ON THE SUPERSONIC CONICAL LAMINAR BOUNDARY LAYER, by C. B. Blumer, W. S. Bradfield, and C. J. Scott. Mar. 1954, 15p. illus. diagrs. refs. (Engineering memo no. 29) (AFOSR-TN 54-83) (AF 18(600)384) AD 34618 Unclassified

An experimental investigation was conducted to determine the effect of cone tip blunting on the supersonic, laminar, conical boundary layer as indicated by pitot tube surveys. Tests were conducted at a cone surface Mach number of 2.90 with two cone tip diameters. Boundary layer surveys were made over a range of Reynolds numbers from 500,000 to 1,800,000. The present investigation paralleled a previous study which was concerned with the effect of leading edge thickness on the boundary layer formed on a flat plate. The results indicate that the effect of tip blunting on the conical boundary layer is much less evident than the corresponding effect of the leading edge blunting on the plate boundary layer for equal values of t^*_{th}. A

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relationship is presented which predicts the deviation of experimental momentum thickness from the idealized boundary layer theory as a function of cone tip diameter. This relation is in reasonable agreement with the experimental results. Experimental local and average shear stress coefficients are presented as a function of Reynolds number and are compared with laminar boundary layer theory. (Contractor's summary)

MIN. 09:008

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

FINAL MODIFICATION OF A CONICAL SKIN FRICTION BALANCE SYSTEM AND MEASUREMENTS AT $M_1 = 2.6$, by C. B. Blumer and W. S. Bradfield. Feb. 1955, 1v. incl. illus. diagrs. refs. (Research rept. no. 111) [AFOSR-TN-55-80] (AF 18(600)384) AD 65520 Unclassified

Final development of an instrument capable of the accurate measurement of local skin friction coefficients in the axially symmetric, conical, turbulent boundary layer is reported. This single component balance system is housed within a 15° cone. Measurements of skin friction coefficients were made at a cone surface Mach number of $M_1 = 2.6$ over a Reynolds number range from 1×10^6 to 8×10^6. The data of primary interest are the measurements in the fully turbulent boundary layer, although transitional data are also presented. The turbulent data are compared with the results of other investigations. The agreement between these data and other experiments in the conical boundary layer is acceptable, but the present turbulent data do not agree with experiments in the 2-dimensional turbulent boundary layer which have been transformed to cone flow for comparison. (Contractor's abstract)

MIN. 09:009

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

AN EXPERIMENTAL STUDY OF THE EFFECT OF SMALL ANGLES OF ATTACK ON THE LAMINAR BOUNDARY LAYER OF A CONE, by D. G. DeCoursin. Aug. 1955 [62]p. incl. illus. diagrs. table, refs. (Research rept. no. 121) ([AF]OSR TN-55-405) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)384 and Ordnance Corps under DA 01-021 ORD-4589) AD 78480 Unclassified

An experimental investigation was conducted concerning the effect of angle of attack on the laminar boundary layer on a cone. The experimental technique involved the measurement of total pressure distribution through the boundary layer on the windward and leeward sides of the model. Velocity profiles, skin friction, and other pertinent data were calculated from these measurements. The tests were made with a 15° cone at $M_\infty = 2.73$ and over an angle of attack range of 0° to 4°. The local skin friction coefficient in the laminar boundary layer on the windward side increases with angle of attack, and the measured increases were in good agreement with the plane of symmetry theory developed by Moore. No laminar data were obtained on the leeward side of the model because of the change in boundary-layer character with angle of attack, which caused a boundary layer with a more nearly turbulent character to occur on the leeward side. Laminar skin friction measured at zero angle of attack was 10% below the theory of Chapman and Rubesin (applied to cone flow). (Contractor's abstract)

MIN. 09:010

Minnesota U. [Rosemount Aeronautical Labs.] Minneapolis.

MICROSCHLIEREN. A TECHNIQUE FOR THE STUDY OF DETAILS IN COMPRESSIBLE FLOW, by W. S. Bradfield and J. J. Sheppard, Jr. [1956] [11]p. incl. illus. diagr. (AF 18(600)384) Unclassified

Published in Proc. Fifth Biennial Technical Conference, Minnesota U., Minneapolis (Research rept. no. 137) Oct. 1956, p. 62-68.

Published in Aero/Space Engineering, v. 18: 37-40, May 1959.

A "microschlieren" technique has been developed for the study of details in a compressible flow. It provides an overall magnification of one hundred power of an object field of up to 1/4 in. diameter. Provision is made for utilization of shadowgraph, Toepler schlieren, and Zernike phase contrast principles. The practical depth of field of the instrument is approximately 1 mm. Photographic exposures of about 5 μsec and up are practical. Some results of flow studies are discussed and additional applications are indicated. (Contractor's abstract)

MIN. 10:001

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

THE DESIGN AND PERFORMANCE OF A FREE-JET SUPERSONIC WIND TUNNEL FOR EXPLOSION EXPERIMENTS, by T.-S. Liu, M. J. Teigen, and E. G. Voltin. June 1954, 31p. incl. illus. diagrs. (Research rept. no. 107) ([AF]OSR-TN-54-290) (AF 18(600)599) AD 56860 Declassified

An enclosed supersonic free-jet wind tunnel of test section size 6 x 6 in. for explosion experiments has been designed and built which produces satisfactory flow through its entire free jet length. Excellent plenum chamber pressure control is provided by a double-wedge center body type variable diffuser. Four sets of supersonic nozzle blocks were designed for this configuration at Mach numbers 1.5, 2.0, 2.5, and 3.0. (Contractor's abstract)

MIN. 10:002

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

DIRECTIONAL EFFECT OF MOVING CHARGES, by T.-S. Liu and E. G. Voltin. June 1956, 33p. incl. illus. diagrs. tables. (Research rept. no. 129) (AFOSR-TR-56-29) (AF 18(600)599) Declassified

Experiments were conducted in a supersonic wind tunnel with a free jet test section at Mach numbers 1.5, 2.0, 2.5, and 3.0 to investigate the directional effect of moving charges. One-ounce bare spherical charges were used in the tests. A strengthening of the blast effect of 98% at Mach number 1.5, 6% at Mach number 2.0, 44% at Mach number 2.5, and 53% at Mach number 3.0 was noted from pressure pulse measurements. The strengthening was qualitatively confirmed by spark photography of the blast wave shape. No conclusive correlation of the strengthening effect to the angle or to the velocity of the moving charge was established in this series of experiments. However, this technique of determining the directional effect of moving did prove to be feasible, and the pressure recordings and optical observations obtained were satisfactory.

MIN. 11:001

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

THE RUNNING TIME FOR SUPERSONIC BLOWDOWN WIND TUNNELS, by T.-S. Liu. [1953] 20p. incl. illus. table, refs. [AF 18(600)851] Unclassified

Published in Proc. Third Midwestern Conference on Fluid Mechanics, Minnesota U. Inst. of Tech., Minneapolis (Mar. 23-25, 1953), Minneapolis, Univ. Press, June 1953, p. 547-566.

Factors affecting the duration of run for supersonic blowdown wind tunnels (intermittent type) are discussed. Simple equations for the calculations of running time are derived for different tunnel configurations; atmospheric intake; high pressure intake; heated stagnation condition; unheated stagnation condition; discharging to the atmosphere; and discharging to a vacuum reservoir. Three possible conditions to cease the wind tunnel operation are treated separately. A unified "Running Time Parameter" is developed which permits the plotting of generalized curves of this parameter as a function of Mach numbers with one or two variables. Calculated values of running time from equations developed are compared with the reported experimental values of existing wind tunnels. The results from this study not only facilitate the determination of wind tunnel running time of known arrangement, but also serve the designers to adjust the requirements of some components of a blowdown wind tunnel with others prescribed during the design stage of such wind tunnels. (Contractor's abstract)

MIN. 11:002

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

ANALYTICAL STUDY OF SIMILARITY PARAMETERS FOR AERODYNAMIC MODEL-TESTING AT HIGH TEMPERATURES. PHASE I (SIMILARITY LAWS FOR STRUCTURAL-AERODYNAMIC MODELS), by L. A. Scipio, II and L. C. Teng. Aug. 22, 1954 [44]p. incl. diagr. refs. (Research rept. no. 104) [AFOSR-TN-54-187] (AF 18(600)851) AD 44792 Unclassified

A study was made to determine similarity parameters for wind-tunnel testing of thermal stresses and strains produced in free flight resulting from aerodynamic heating. Two general types of structures were considered: (1) solid or thick skin, and (2) shell or thin skin. The results indicate that similarity between prototype and its model is possible in each of the above cases. For solid or thick skin structures, it was assumed that all dimensions could be scaled by the same scale factor:

$$N_L \left(N_L = \frac{(X_1)_{\text{model}}}{(X_1)_{\text{prototype}}} \right)$$

For shell structures, it was assumed that all linear dimensions of the prototype except the skin thickness are scaled by N_L. In both cases, thermal stress similarity can be achieved by using the same materials for both model and prototype. The attendant rules for construction of a structural-aerodynamic model having the requisite similarity to each of the above types of structures establish conditions for an experimental study of the structural behavior and integrity of various types of aircraft and missiles. (Contractor's abstract)

MIN. 11:003

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

TEMPERATURE SIMILARITY LAWS FOR THIN SHELLS WITH INTERNAL STRUCTURES AND FOR SANDWICH STRUCTURES, by L. A. Scipio, II, L. C. Teng, and I. K. Ebcioglu. Oct. 1954, 42p. incl. diagrs. tables. (Research rept. no. 106) ([AFOSR-TN-54 284) (AF 18(600)851) AD 62663 Unclassified

Can the results of small-scale supersonic wind-tunnel tests be used to study the structural behavior and integrity of aircraft and missiles in free flight in the presence of aerodynamic heating? The purpose of the investigation described is to answer this question for web and sandwich structures. Experimental tests can be made on small-scale models of these structural types to study the behavior of their prototypes under temperature load. This is possible only by the use of different materials for the models than those of the prototype. It can be concluded from these results that similarity in the stress field is impossible to achieve.

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This means that for practical application, the temperature distribution that a prototype will experience under a given set of conditions is obtainable from wind-tunnel tests, but the resulting stress distribution must be calculated. The fact that the model is constructed of a different material than the prototype to assure similarity in the temperature fields, rules out the possibility of assuring stress similarity. It is clear that these materials, while possessing characteristics required for temperature similarity, will not at the same time have required elastic properties. (Contractor's abstract)

MIN. 11:004

Minnesota U. Rosemount Aeronautical Labs., Minneapolis.

THE DESIGN OF A REGENERATIVE-TYPE HEATER FOR AN INTERMITTENT SUPERSONIC WIND TUNNEL, by T.-S. Liu, E. J. C. Sun, and R. K. Knutson. Mar. 1955, 29p. illus. diagrs. tables, refs. (Engineering memorandum no. 48) (AF 18(600)851) Unclassified

A regenerator-type heater was designed and fabricated in the circuit of the 12 in. x 12 in. supersonic blowdown wind tunnel at the Rosemount Aeronautical Lab. The highest temperature expected is 900°F, which corresponds to the stagnation temperature at Mach number 3.5 in the stratosphere. This heater would cover test conditions for Mach numbers from 2.0 to 3.5, altitude of 20,000 to 60,000 ft, and a wide range of Reynolds numbers. All these conditions dictate a possible maximum air mass flow rate of more than 300 lb/sec. The heater system consists of a heat regenerator, a furnace, blowers, and circulating ducts. The heat storage units in the regenerator are aluminum oxide spheres. General Electric Calrod heating elements are used in the furnace. Design considerations, parameters, procedures, and calculated performances are presented in this paper.

MIN. 12:001

Minnesota U. School of Chemistry, Minneapolis.

NUCLEAR AND ELECTRONIC SPIN MAGNETIC RESONANCE, by J. E. Wertz. May 1955, 193p. incl. diagrs. tables, refs. (Technical note no. 1) ([AF]-OSR-TN-55-203) (AF 18(600)479) AD 67517 Unclassified

Also published in Chem. Rev., v. 55: 829-955, Oct. 1955.

A review is presented of the principles, experimental procedures, and applications of the spin resonance of nuclei and of nearly free electrons. Molecular beam methods, pure quadrupole resonance, and ferromagnetic and antiferromagnetic resonance are not included. A bibliography of 640 references is appended.

MIN. 12:002

Minnesota U. School of Chemistry, Minneapolis.

ELECTRON SPIN RESONANCE OF SEMIQUINONES, by J. E. Wertz and J. L. Vivo. Dec. 1955 [2]p. incl. diagrs. (AFOSR-TN-55-277) (AF 18(600)479) AD 14149 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2441-2442, Dec. 1955.

Semiquinone free radical intermediates in the reduction of quinones or the oxidation of hydroquinones were demonstrated first by magnetic susceptibility and by potentiometric measurements. The electron spin resonance absorption of semiquinone ions in the oxidation of hydroquinone and methyl-substituted hydroquinones was shown to be a more sensitive means of detecting them.

MIN. 12:003

Minnesota U. School of Chemistry, Minneapolis.

A TWO-STAGE INTEGRATOR FOR MAGNETIC RESONANCE LINES, by J. E. Wertz. [Aug. 25, 1955] [14]p. incl. diagrs. table, refs. (AFOSR-TN-55-278) (AF 18(600)479) Unclassified

A two-stage integrator is designed to give the integral of a nuclear or electron spin resonance signal. This permits the recording of weak absorption lines when a phase detector is used, its output being nearly the first derivative. A second integrator gives on a register a figure proportional to the area under the absorption curve. (Contractor's abstract)

MIN. 12:004

Minnesota U. School of Chemistry, Minneapolis.

ELECTRON SPIN RESONANCE OF 1, 4-NAPHTHOSEMIQUINONE ION, by J. E. Wertz and J. L. Vivo. Nov. 14, 1955 [1]p. incl. diagr. [AFOSR-TN-55-428] (AF 18(600)479) AD 141513 Unclassified

Also published in Jour. Chem. Phys., v. 24: 479, Feb. 1956.

Since the naphthosemiquinones coplanarity of the quinoid ring and the adjacent ring is assumed, an extra electron spin resonance multiplicity above that observed in the benzoquinones is to be expected. This holds true for 1, 4-naphthosemiquinone dissolved in basic alcohol solution, 3 groups of lines being observed. The 2, 3 dimethylseminaphthoquinone ion yielded 7 groups of lines, with 21 individual lines in the 5 inner groups. The 2-methyl-1, 4-naphthosemiquinone ion yielded 5 groups of lines having 24 discernable components.

MIN. 12:005

Minnesota U. School of Chemistry, Minneapolis.

RE-EXAMINATION OF TWO FREE RADICALS, by J. E. Wertz, C. F. Koelsch, and J. L. Vivo. Sept. 13, 1955 [1]p. [AFOSR-TN-55-429] (AF 18(600)479) Unclassified

Also published in Jour. Chem. Phys., v. 23: 2194, Nov. 1955.

In 1947 Kozyrev and Salikkov (Doklady Akademia Nauk SSSR, v. 58: 1023, 1947) reported values of 1.95 and 1.99 as g-values for the radicals pentaphenylcyclopentadienyl (PPCPD) and tri-tert-butylphenoxyl (TTBP). These values are outside the normal range of 2.0023 to 2.0151. Values of 2.0025 and 2.0043 have been obtained experimentally for PPCPD and TTBP, respectively. It is noted that no known organic free radical has a spectroscopic splitting factor differing by as much as 1% from the free electron value.

MIN. 12:006

Minnesota U. School of Chemistry, Minneapolis.

MULTIPLE THIO-RADICALS IN SULFURIC ACID SOLUTION, by J. E. Wertz and J. L. Vivo. Sept. 13, 1955 [1]p. incl. diagrs. [AFOSR-TN-55-430] (AF-18(600)479) AD 141511 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2193-2194, Nov. 1955.

The electron spin resonance absorption of thiophenol in sulfuric acid consists of lines A and B. It is observed that the A line disappeared slowly, while the B line was still present after 30+ days. Line B appeared to be the same as the one obtained from thianthrene. Diphenyl disulfide, 1-thionaphthol, and 2-thionaphthol gave 2 lines similar to those of thiophenol. Line B for thiophenol, diphenyl disulfide, and thiathrene had 5 hyperfine components suggesting that the unpaired electron is associated with a 4-proton system, much as found in the semiquinone radical of hydroquinone. It was suggested tentatively that a radical of the type $(C_6H_6S)H^+$ causes the A line.

MIN. 12:007

Minnesota U. School of Chemistry, Minneapolis.

HYDRATION EFFECTS IN CHLORINE-35 NUCLEAR SPIN RESONANCE, by J. E. Wertz. Oct. 18, 1955 [1]p. [AFOSR-TN-55-431] (AF 18(600)479) Unclassified

Published in Jour. Chem. Phys., v. 24: 484, Feb. 1956.

Observations on Cl^{35} nuclear spin resonance are cited which reveal striking evidence for the infrequent exchange of hydrate water with solvent in aqueous solutions of certain paramagnetic ions.

MIN. 12:008

Minnesota U. [School of Chemistry] Minneapolis.

ELECTRON SPIN RESONANCE OF DEFECT CENTERS IN MAGNESIUM OXIDE (Abstract), by J. E. Wertz and J. L. Vivo. Nov. 16, 1955 [1]p. [AFOSR-TN-55-432] [AF 18(600)479] Unclassified

Presented at meeting of the Amer. Phys. Soc., Southern Calif. U., Los Angeles, Dec. 28-30, 1955.

Published in Phys. Rev., v. 100: 1792, Dec. 15, 1955.

Attempts to find electron spin resonance (ESR) absorption by imperfection centers in MgO were complicated by the multiplet spectra of impurities. After a detailed study, we found one line which disappears on heating in vacuum. The splitting factor g is 2.003 along a principal axis, and the corresponding line width is 4.2 gauss, twelve-fold narrower than for KCl. This line and an absorption band at 2600 A which disappears on heating in vacuum, are presumably the result of excess oxygen. Heating in air at 600°C increases the intensity of the ESR line. Tentatively it is assumed that the ESR centers are O^- ions, although experiments on oxygen uptake at higher temperatures would indicate that at 600° the process would be very slow. Exposure to x-rays after annealing gives an ESR line of similar g-value and width, which decays slowly.

MIN. 12:009

Minnesota U. School of Chemistry, Minneapolis.

MULTIPLE THERMAL RELAXATION TIMES AND NUCLEAR SPIN ENERGY TRANSFER IN LIQUIDS, by J. E. Wertz, P. L. Jain, and R. L. Batdorf. Feb. 27, 1956 [1]p. incl. diagrs. (AFOSR-TN-56-92) [AF 18(600)479] AD 82007 Unclassified

Also published in Phys. Rev., v. 102: 920-921, May 1, 1956.

It is pointed out that just as distinguishable protons in a molecule may show discrete nuclear induction lines, they may also have their own characteristic time for return to the ground state from an excited spin state. This would lead to different optimum values of the rf field. In this study, such differences were observed for protons in CH_3, CH_2, CH, and OH.

MIN. 12:010

Minnesota U. School of Chemistry, Minneapolis.

BONDING INFERENCES FROM NUCLEAR SPIN

MIN. 13:001 - MIS. 01:002

RESONANCE, by J. E. Wertz. [Aug. 13, 1956] [5]p. incl. refs. [AF 18(600)479] Unclassified

Published in Jour. Phys. Chem., v. 61: 51-55, Jan. 195"

Nuclei of non-zero spin take up discrete orientations in a magnetic field, and transitions between the spin energy levels occur as a resonant process with radiation in the radiofrequency region. The frequency of resonant absorption to a first approximation depends solely upon the nuclear species. More accurately, it may be modified by a number of effects. Besides resonant frequency, the absorption line amplitude and width may yield important information about the interactions of a nucleus with its atomic environment. Local magnetic fields due to other nuclei in a rigid solid may broaden or split a line. Paramagnetic ions may cause both a broadening and a shift. Shielding of the nucleus by outer electrons displaces a line and may give rise to a multiple-line spectrum if identical but chemically non-equivalent nuclei exist in the same molecule. The transmission of nuclear polarization effects through an electron-pair bond may lead to observable multiplicity. Rapid chemical exchange of non-equivalent nuclei leads to a single line intermediate between the positions of the separated lines. Solvent interactions—especially hydrogen bonding—may cause major shifts. Hydration of an ion may alter its resonance absorption line characteristics to a marked degree. When a nucleus possesses a quadrupole moment, the absorption line amplitude and width are very sensitive to electric field gradients arising from anisotropic interactions such as ion-pair or complex formation. Even a sodium ion shows a marked sensitivity to its environment. Examples of such interactions are given for both inorganic and organic systems. (Contractor's abstract)

MIN. 13:001

[Minnesota U. School of Chemistry, Minneapolis.]

THE PREPARATION AND REACTIONS OF DIHALOTETRAALKYLDITIN COMPOUNDS, by O. H. Johnson, H. E. Fritz and others. [May 26, 1955] 10p. incl. table. [AFOSR-TN-55-152] [AF 18(600)984] Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 5857-5858, Nov. 20, 1955.

Dialkyldichlorotin compounds in ether-ethanol solutions of various organic bases react to form the corresponding tetraalkyldichlorodiitin compounds. The preparation and some properties of tetraethyl-, tetra n-propyl-, tetra n-butyl-, tetra n-amyl- and tetraphenyldichlorodiitin, and tetra-n-butyldibromodiitin are described. Results of syntheses of tetra-n-butyldichlorodiitin, using different organic bases, indicate that the reaction is general for stronger organic bases. (Contractor's abstract)

MIS. 01:001

Missouri U. Dept. of Mathematics, Columbia.

ESTIMATION OF PROBABILITIES MONOTONE IN SEVERAL PARAMETERS, by H. D. Brunk, G. M. Ewing, and W. R. Utz. July 1954 [18]p. incl. diagrs. (Technical note no. 1) ([AF]OSR-TN-54-159) (AF 18(600)1108) AD 36970 Unclassified

The problem is considered of the estimation of probabilities which depend upon several parameters and which are monotone in each separately. The problem is formulated by considering a set I of a finite number N of points $\mathbf{x} = (x_1, x_2, \ldots, x_n)$ in n-space each of which is associated with a probability $p(\mathbf{x}) = p(x_1, x_2, \ldots, x_n)$ that is known to be monotone in each variable separately. The probability p is assumed to be non-increasing in each variable. Corresponding to each $\mathbf{x}$, a finite number of trials are made of an event with probability $p(\mathbf{x})$; $a(\mathbf{x})$ of them are successes, and $b(\mathbf{x})$ are failures. The a priori probability that a specified $a(\mathbf{x})$ of the trials will result in success and that a specified $b(\mathbf{x})$ of them will result in failure is given by $\prod(p) = \prod_{\mathbf{x} \in I} p(\mathbf{x})^{a(\mathbf{x})} [1-p(\mathbf{x})]^{b(\mathbf{x})}$. The class of functions $p(\mathbf{x})$ defined on I, which are monotone nonincreasing in each variable separately, and bounded by 0 and 1 is denoted by P. The general problem is that of determining a function $\bar{p}(\mathbf{x}) \in P$ which affords a maximum value to the product $\prod = \prod(p)$ defined above, so that $\prod(\bar{p}) = \max_{p \in P} \prod(p)$. (ASTIA abstract)

MIS. 01:002

Missouri U. Dept. of Mathematics, Columbia.

A HELLY THEOREM FOR MONOTONE FUNCTIONS, by H. D. Brunk, G. M. Ewing, and W. R. Utz. July 1954, 13p. (Technical note no. 2) ([AF]OSR-TN-54-167) (AF 18(600)1108) AD 37022 Unclassified

The principle result is the proof of a Helly theorem for sequences of monotone functions of n-variables. The theorem is stated as follows: let $\{F_q(x_1, x_2, \ldots, x_n)\}$ be a sequence of monotone functions all of the same type on the set S, $a_i \leq x_i \leq b_i$, and let A be a positive number such that $|F_q(x_1, x_2, \ldots, x_n)| < A$ for $q = 0, 1, 2, \ldots$. Then there exists a sequence of integers $q_0 < q_1 < q_2 \cdots$ and a monotone function $F(x_1, x_2, \ldots, x_n)$ bounded by A such that $\lim_{i \to \infty} F_{q_i}(x_1, x_2, \ldots, x_n) = F(x_1, x_2, \ldots, x_n)$ on S. The proof of the theorem utilizes the selection principle of D. V. Widder

(The Laplace Transform, p. 26, Princeton U. Press Princeton, N. J., 1941) and the following result: if $F(x_1, x_2, \ldots, x_n)$ is a real-valued monotone function on the set S, $a_i \leq x_i \leq b_i$, $i = 1, 2, \ldots, n$, then there is a set R consisting of the points of a countable collection of (n-1)-spaces, $x_i = a_i^j$, $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots$, such that F is continuous at all points of S-R.

MIS. 01:003

Missouri U. Dept. of Mathematics, Columbia.

THE EXTENSIONS OF HOMEOMORPHISMS AND THE LIMITS OF ORBITS, by H. D. Brunk, G. M. Ewing, and W. R. Utz. Aug. 1954, 18p. (Technical note no. 3) ([AF]OSR TN-54-200) (AF 18(600)1108)
AD 48173 Unclassified

A paper by Schweigert (Bull. Amer. Math. Soc., v. 46: 963-969, 1940) is extended which concerned the nature of the limit set of a convergent sequence of point or component orbits under a pointwise periodic homeomorphism of compact metric space onto itself. Similar results are obtained for pointwise periodic, recurrent, and almost periodic transformations when compactness of the space is replaced by equicontinuity of the transformation. Schweigert's results do not hold if the word compact is weakened to complete. Schweigert's treatment of the extension of homeomorphisms from sets dense in a given space to the entire space is continued.

MIS. 01:004

Missouri U. Dept. of Mathematics, Columbia.

MINIMIZING INTEGRALS IN CERTAIN CLASSES OF MONOTONE FUNCTIONS WITH APPLICATIONS, by H. D. Brunk, G. M. Ewing, and W. R. Utz. Sept. 1954, 1954, 1v. incl. refs. (Technical note no. 4) ([AF]-OSR TN-54 245) (AF 18(600)1108) AD 48172
Unclassified

Considerations are presented concerning the existence of minima for integrals over classes of n variable monotone functions, the uniqueness of minimizing functions, methods of evaluating the minimizing functions, and applications to statistical problems. (Contractor's abstract)

MIS. 01:005

Missouri U. Dept of Mathematics Columbia.

A THIRD ORDER DIFFERENTIAL EQUATION, by W. R. Utz. July 1955, 6p. (Technical note no. 5) (AF OSR TN 55-215) (AF 18(600)1108) AD 95834
Unclassified

Also published in Monatsh. Math., v. 60: 329-332, 1956.

A proof is presented of the following theorem. Assume that $f(x)$ is a real differentiable function such that $\lim_{x \to \infty} f(x) = c$, $0 < c < \infty$, and such that $f'(x)$ is bounded as $x \to \infty$. Assume that $p(x)$ is a real polynomial such that for a real number $a > 0$, $p(a) = 0$ and $p'(a) = 0$. If $y = y(x)$ is a solution of $f(x)y''' - yy'' + p(y') = 0$ which is valid for all large values of x and for which $\lim_{x \to \infty} y'(x) = a$, then $y = ax + b$, where b is a constant. This theorem generalizes a theorem of Hardy (Proc. Cambridge Phil. Soc., v. 35: 652-653, 1939) in which $f(x) = 1$, $p(y') = 2(y'^2 - 1)$, and $a = 1$. (Contractor's abstract)

MIS. 01:006

Missouri U. [Dept. of Mathematics] Columbia.

BOUNDEDNESS AND PERIODICITY OF SOLUTIONS OF THE GENERALIZED LIENARD EQUATION, by W. R. Utz. June 1956, 29p. refs. (Technical note no. 6) (AFOSR TN-56-282) (AF 18(600)1108)
AD 89492 Unclassified

Also published in Ann. di Matem. (Bologna), Series 4, v. 42: 313-324, 1956.

An analysis is made of the behavior of solutions of the equation $x'' + f(x, x')x' + g(x) = e(t)$, where $x' = dx/dt$, and conditions are sought for the existence of periodic solutions. Sufficient conditions are given for the boundedness of solutions of certain important special cases of the above equation, and theorems are given concerning the behavior of solutions for large values of t in cases where boundedness is not inferred. Sufficient conditions are given for the existence of an infinity of periodic solutions when $e(t) = 0$. (ASTIA abstract)

MIS. 01:007

Missouri U. Dept. of Mathematics, Columbia.

MAXIMUM LIKELIHOOD ESTIMATION OF RESTRICTED PARAMETERS, by H. D. Brunk. Sept. 1956, 26p. refs. (Technical rept. no. 7) (AFOSR-TN 56 391) (AF 18(600)1108) AD 96049
Unclassified

Also published in Ann. Math. Stat., v. 28: 607-616, Dec. 1955.

The maximum likelihood estimation for independent random sampling from a finite number of populations belonging to exponential families is discussed when the parameter point is known to lie in a proper subset of its "natural" range. "Exponential family" is defined for the distribution functions $F(x; \ )$. A minimum problem with side conditions is formulated for solution. With an a priori upper or lower bound which is assignable to each estimator of a single parameter, computing the maximum likelihood estimator

MIS. 01:008 MIS 01:009

is reviewed as a problem in non-linear programming. A geometric approach technique and a means of obtaining the solution when the parameter point is restricted to a "convex" subset of its "natural" range are discussed. With populations of the same exponential family and order restrictions on the parameters, the maximum likelihood estimates are independent of the exponential family containing the populations. The property of the maximum likelihood estimate, related to sufficiency, is discussed.

MIS. 01:008

Missouri U. Dept. of Mathematics, Columbia.

A NOTE ON AUTONOMOUS SECOND ORDER NON-LINEAR DIFFERENTIAL EQUATIONS, by W. R. Utz. Sept. 1956, 12p. (Technical rept. no. 8) (AFOSR-TN-56-420) (AF 18(600)1108) AD 96230
Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 1047-1048, 1956.

Theorems on the boundedness of solutions of second order nonlinear differential equations are used as a departure for a more detailed examination of the behavior of solutions of such equations for large values of the independent variable. Theorems are cited which give sufficient conditions for the existence of constants A, B > 0, such that if $x = x(t)$ is a solution of the given equation valid for all large t, then $|x(t)| < B$ for all $t > A$, where A and B may depend upon the particular solutions $x = x(t)$. The coefficients in the equation are assumed to be differentiable throughout the analysis, and the function $x(t) \equiv 0$ is a solution of each equation considered. Use is made of the fact that, because of the uniqueness of solutions, no solution not identically zero is tangent to the t-axis. (Contractor's abstract, modified)

MIS. 01:009

Missouri U. Dept. of Mathematics, Columbia.

SOME HELLY THEOREMS FOR MONOTONE FUNCTIONS, by H. D. Brunk, G. M. Ewing, and W. R. Utz. [1956] [8]p. [AF 18(600)1108] Unclassified

Published in Proc. Amer. Math. Soc., v. 7: 776-783, Oct. 1956.

Let S denote a closed n-dimensional interval of the Euclidean n-space. A function $F(x_1, x_2, \ldots, x_n)$ defined on S is called "monotone" by the authors if it is monotone nondecreasing in each x_i $(i = 1, 2, \ldots, n)$ and if the first and second differences of F are non-negative. The following theorem (of a type which was first treated by E. Helly, Akad. Wiss. Wien. S.-B. IIa, v. 121: 265-297, 1912) is proved by the authors: Let $\{F_q(x_1, x_2, \ldots, x_n)\}$ be a sequence of monotone functions on S with

$$|F_q(x_1, x_2, \ldots, x_n)| \leq A \quad (q = 0, 1, 2, \ldots).$$

There exists a sequence of integers $q_0 < q_1 < q_2 < \ldots$ and a monotone function $F(x_1, x_2, \ldots, x_n)$ bounded by $\pm A$ such that

$$\lim_{i \to \infty} F_{q_i}(x_1, x_2, \ldots, x_n) = F(x_1, x_2, \ldots, x_n)$$ on S. For the proof of this result the following theorem is used: If $F(x_1, x_2, \ldots, x_n)$ is a monotone function on S, then there exists a set R of points of countably many $(n-1)$-spaces $x_i = a_i^j (i = 1, 2, \ldots, n; j = 1, 2, \ldots)$ such that F is continuous at all points of S-R. As consequences of both these results, also theorems on extended real valued functions F(i. e. $-\infty \leq F(x_1, x_2, \ldots, x_n) \leq +\infty$) are stated. Finally, by means of a simple example in two variables; it is shown that the first mentioned theorem does not hold if the functions F_q are only monotone in each of their variables. (Math. Rev. abstract)

NBS. 01:001

National Bureau of Standards, Washington, D. C.

EXPERIMENTAL EVIDENCE FOR THE EXISTENCE OF ABNORMAL OH ROTATIONAL "TEMPERATURES" IN LOW-PRESSURE FLAMES, by H. P. Broida and H. J. Kostkowski. [1955] [1]p. [AFOSR-TN-55-59] [CSO-18-600-25] Unclassified

Published in Jour. Chem. Phys., v. 23: 754, Apr. 1955.

Preliminary spectroscopic measurements are reported on OH absorption in low pressure (1.5 to 6 mm Hg) acetylene-oxygen flames, having relative intensities of the $^2\Sigma \longrightarrow {}^2\pi$ transition of OH characterized by rotational "temperatures" many times larger than the calculated adiabatic temperatures. An OH line rather than a continuum source was used to avoid influence of the resolving power of the monochromator on the measured absorption; the line, narrower than those in the flame, was obtained by discharge through water vapor at a pressure of 0.5 mm Hg with an ac electronic amplifier modulated by a metal chopper placed between the discharge and flame to amplify only the discharge radiation. The OH line absorption, thus measured essentially at the peak of the lines, was found to be very small. At 1.9 mm Hg in an acetylene-oxygen (in the ratio of 2 to 5) flame which was 7.5 cm thick, the greatest absorption of the strong $Q_f 5$ (0 – 0) line was only 15%. The absorption of the first line of the R_2 and second line of the P_f branches was less than 3% and 5%, respectively. The observed small absorption was confirmed by a two-path method. At the same position of the same flame on which the direct absorption measurements were made, the emission "temperatures" (as determined from the P_f and R_2 branches) were 6600°K for the single path and 6900°K for the double path. This difference is well within the experimental error. The ration of the double- to the single-path intensities also showed negligible absorption. This consistent set of experimental results shows that measured nonthermal rotational distributions of OH emission intensities in low-pressure acetylene flames are not caused by self-absorption.

NBS. 02:001

National Bureau of Standards, Washington, D. C.

THE FLUORESCENCE AND AVERAGE LIFETIME OF EXCITED OH ($^2\Sigma$, $^2\pi$) IN FLAMES, by H. P. Broida and T. Carrington. Aug. 19, 1955 1 p. incl. diagr. (AFOSR-TN-55-276) (CSO-630-55-25) AD 85606 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2202, Nov. 1955.

This study is concerned with the fluorescence of OH (measured as approximately 1 part in 10^7 of the light incident on the flame) in an acetylene-oxygen flame burning at atmospheric pressure. It is found that radiationless transitions are important in taking away excess electronic energy from the OH molecules in the flame. Measurements indicate that each collision removes some electronic energy, leading to quenching. As a result, the average lifetime of excited OH radicals in the flame is of the order of 6×10^{-10} sec.

NBS. 02:002

National Bureau of Standards, Washington, D. C.

SPECTRAL ABSORPTION METHOD FOR DETERMINING POPULATION "TEMPERATURES" IN HOT GASES, by H. J. Kostkowski and H. P. Broida. Sept. 26, 1955 [9]p. incl. illus. diagrs. tables, refs. [AFOSR-TN-55-458] [CSO-630-55-25] AD 106164 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 46: 246-254, Apr. 1956.

A spectroscopic method, useful for strongly absorbed lines, has been investigated for measuring temperatures of hot gases. The minimum transmission of discrete spectral lines in gases at equilibrium has a simple dependence upon the absolute temperature, and this relation is used to measure temperature from a straight line plot. An experimental study has been made of the absorption due to the rotational lines of OH ($^2\Sigma \longleftarrow {}^2\pi$) between 3067 and 3090 Å in an oxygen-acetylene flame. It is shown that temperatures measured by this method are less affected than the conventional one by lack of sufficient resolving power, flame thickness, and various light sources (either continuous or line). (Contractor's abstract)

NBS. 02:003

National Bureau of Standards, Washington, D. C.

TEMPERATURE OF FLAMES, by H. P. Broida and A. M. Bass. Technical rept. Dec. 1954-Dec. 1955. Jan. 16, 1956, iv, incl. illus. diagrs. tables, refs. (NBS rept. no. 4418) (AFOSR-TR-56-5) (CSO-630-55-25) AD 80550 Unclassified

The High Temperature Spectroscopy Laboratory of the National Bureau of Standards dates its research from 1949. The emission and absorption of radiant energy by a hot gas system are studied for information on the characteristics of the fundamental physical and chemical quantities involved. The work of the past year is given. In the ultraviolet region of the spectrum, the radiation emitted from flames at low pressure is surveyed. The result is the development of a new and convenient method for determining flame temperatures and the discovery of a previously unobserved region of burning in hydrocarbon flames. In the infrared, work is done on the measurement of the widths of resolved lines in the spectrum of CO. The distortion effects and a correction method for the spectrometer slit on recorded spectrum lines are considered. The details of the investigations are given in the report.

NBS. 03:001 - NBS. 05:001

NBS. 03:001

Nattonal Bureau of Siandards, Washingion, D. C.

TITRATIONS OF BASES WITH DIPHENYL PHOSPHATE IN SOME AQUEOUS AND NONAQUEOUS SOLVENTS, by M. M. Davis and H. B. Heizer. Jan. 20, 1955, 12p. incl. diagrs. iables, refs. (Research Paper no. 2593) [AFOSR-TN-54-175] [CSO-670-54-10 and CSO-580-56-36] AD 140135 Unclassifted

Also published in Jour. Res. Nai'l. Bur. Standards, v. 54: 309-320, June 1955.

Successful tiirations of various bases wtth diphenyl phosphate in benzene, methanol, waier, and mtxiures of these solvenis have been performed, in some cases potentiometrically (using ihe glass, saturated calomel elecirode-system), and in other cases ustng indicator dyes. Several of ihe dyes (bromophthalein magenia E, 5-phenyl-9-diethyl Nile blue, and the anhydro-base of tamarack green and Victoria blue B) have noi been used elsehwere as actd-base indicaiors. Diphenyl phosphaie is shown io be a strong acid which is eastly obiained and maintained as anhydrous crysials. It is noi strong enough, however, io serve as a replacemeni for perchloric acid tn tiriations tn acetic actd. Aiention ts called io ihe differing behavior of benzoic acid and diphenyl phosphaie when ihe solveni is changed from waier to methanol. Using a "nonleveling" solveni in place of water makes ti possible io obiain separaie, sharp endpoinis tn itirating a mixiure of iwo such actds. Other pertinent tnformation about diphenyl phosphaie ts summartzed. (Coniractor's abstract)

NBS. 04:001

National Bureau of Siandards, Washington, D. C.

THE IONIC DISSOCIATION OF 2, 4-, 2, 6-, AND 3, 4-DICHLOROBENZOIC ACIDS IN WATER, by M. M. Davis and H. B. Hetzer. Aug. 3, 1956, 10p. incl. tables, refs. (AFOSR-TN-56-353) (CSO-670-55-21) AD 95439 Unclasstfied

Also published in Jour. Phys. Chem., v. 61: 123-125, Jan. 1957.

The respective experimental pK values obtatned for 2, 4-, 2, 6-, and 3, 4-dichlorobenzoic acids at approximately 25°C were 2.76, 1.82, and 3.64. The experimental procedures and results are summarized. Agreement between the actual and calculated iontzatton constants for 2, 4-dibromobenzoic acid was apparently close. Spectral data for tonized and nontonized 2, 4-dichlorobenzoic acid did not agree with results reported by Doub and Vandenbelt (Jour. Amer. Chem. Soc., v. 77: 4535, 1955).

NBS. 04:002

National Bureau of Siandards, Washington, D. C.

THE IONIC DISSOCIATION OF 2, 6-DIMETHOXYBENZOIC ACID IN WATER, by M. M. Davis and H. B. Hetzer. Aug. 3, 1956, 4p. (AFOSR-TN-56-395) (CSO-670-55-21) AD 96053 Unclasstfted

Also published in Jour. Phys. Chem., v. 61: 125, Jan. 1957.

The "appareni" thermodynamtc dtssoctation constant (expressed as pK') of 2, 6-dimethoxybenzotc acid has been measured at approximately 25°C. The experimental and calculated pK' values are compared and discussed briefly. (Coniractor's abstract)

NBS. 04:003

National Bureau of Siandards, Washington, D. C.

ACIDITY AND BASICITY IN ORGANIC SOLVENTS, by M. M. Davis. Final rept. Jan. 1954-June 1956. Aug. 23, 1956, 9p. incl. diagr. iable. (NBS repi. no. 4823) (AFOSR-TR-56-33) (CSO-670-55-21) AD 96216 Unclassified

Absiracis are given for the followtng compleied siudtes: (1) tiirations of bases wtth diphenyl phosphaie in some aqueous and nonaqueous solvenis; (2) the tonic dtssociation of 2, 4-, 2, 6-, and 3, 4-dichlorobenzotc acids in waier; (3) the ionic dissociation of 2, 6-dimethoxybenzoic acid tn waier; and (4) ihe relative sirengths of 40 aromaitc carboxyitc acids in benzene ai 25°C. Summaries are given for ihe following parily compleied siudtes: (a) specirophoiometric siudtes of the reactions of miscellaneous organic actds wtth the bastc indicaior dye, iolyl dtpropyl Ntle blue, in benzene ai 25°C; and (b) ihe effect of temperaiure on the association of diphenylguanidine wtth aromatic actds in benzene.

NBS. 05:001

National Bureau of Siandards, Washington, D. C.

STERIC EFFECTS IN AZO AND INDIGO DYES, by W. R. Brode. Feb. 2, 1956, 16p. tncl. diagrs. iables, refs. (AFOSR-TN-56-28) (CSO-670-55-28) AD 150777 Unclassified

Presenied at a Symposium of the London Chemical Soc., London (England), Feb. 2, 1956.

Published in "Recent Advances in the Chemistry of Colourtng Matters," Special Publicatton No. 4, p. 1-16, 1956.

A revtew is gtven of the contributions during the last 30 yr tn the area of color and chemical consttutton. Steric effects are discussed relative to: (1) optically active dyes; (2) azo-dyes (mono- and disazo); (3) indigo and thtotndigo dyes; (4) associatton effects; and (5) x-ray and γ-radiation.

NBS. 06:001

National Bureau of Standards, Washington, D. C.

A NOTE ON THE PREPARATION OF SOLID OZONE AND ATOMIC OXYGEN (Abstract), by H. P. Broida and J. R. Pellam. [Nov. 3, 1954] [1]p. [CSO-680-56-21] Unclassified

Published in Jour. Chem. Phys., v. 23: 409, Feb. 1955.

Solid O_3 containing atomic O was prepared by passing O at a pressure of 0.1 to 3 mm Hg through a discharge region maintained by a microwave (2450 mc/sec) voltage. A violet coloration was observed on the cold walls within 15 to 30 sec after starting the flow of O through the discharge. The material became thick and began to peel and crack from the surface. The violet solid had the pungent odor of O_3 and decomposed rubber. When a small amount of H_2O was added prior to starting the O flow, a colorless amorphous solid was obtained which was attributed to O_3.

NBS. 06:002

National Bureau of Standards, Washington, D. C.

INTERPRETATION OF SPECTRA OF ATOMS AND MOLECULES IN SOLID NITROGEN CONDENSED AT 4.2°K, by C. M. Herzfeld and H. P. Broida. Oct. 13, 1955 [6]p. incl. illus. diagrs. table, refs. ([AF]OSR-TN-55-371) (Sponsored jointly by Air Force Office of Scientific Research and Office of Naval Research under CSO-680-56-21) AD 71618 Unclassified

Also published in Phys. Rev., v. 101: 606-611, Jan. 15, 1956, (Title varies).

The emission spectra observed from solids condensed at 4.2°K from an electric discharge through nitrogen are explained by assuming that large numbers of nitrogen atoms are deposited in the process. Approximate calculations of the interactions of the atoms with the surrounding solid show that the observed shifts, splittings, and changes of half-life of some atomic lines have the proper direction and magnitude. Analysis of new band system provides evidence for the formation of nitrogen molecules from atoms in the solid and provides information about a new electronic state of N_2 which may be the $^5\Sigma_g^+$ state. On this basis, a lower limit to the heat of dissociation of nitrogen of 9.632 ev can be given.

NBS. 06:003

National Bureau of Standards, Washington, D. C.

THEORY OF SPECTRA OF ATOMS AND MOLECULES IN SOLID NITROGEN CONDENSED AT 4.2°K (Abstract), by C. M. Herzfeld. Nov. 7, 1955, 1p. (AFOSR-TN-55-412) (CSO-680-56-21) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 58, Jan. 30, 1956.

The observed emission spectra[1] of solids condensed at 4.2°K from electric discharges through nitrogen are explained by assuming that large numbers of atoms in various excited states are deposited in the process. Approximate calculations show that one set of emission lines corresponds to the forbidden $^2D \longrightarrow {}^4S$ transition in N atoms, which is perturbed by crystal field effects. Band emission spectra are obtained which arise when atoms combine to form molecules in highly excited states. The most intense band band system is analyzed, and arises from the $^5\Sigma \longrightarrow A^3\Sigma$ transition. The analysis provides values of D_0 (= 1060 cm^{-1}), and r_0 (approximately 1.5A), for $^5\Sigma$, and a lower limit of 9.632 ev for the heat of dissociation of the ground state of N_2. Several effects of the crystal field on the molecular levels are observed. (Contractor's abstract)

NBS. 06:004

National Bureau of Standards, Washington, D. C.

THEORY OF SPECTRA OF ELECTRIC DISCHARGE PRODUCTS COLLECTED AT LOW TEMPERATURES, by C. M. Herzfeld. [1955] 7p. (CSO-680-56-21) Unclassified

The effects of perturbations of atoms and molecules in solids and the effect of the solid on the spectra of atoms is discussed in relation to the crystal field theory. Electric fields set up by neighboring molecules and ions are explicitly written out with special attention given to field symmetry. The average effects of these fields on a particular ion are then calculated with quantum mechanical perturbation theory. Relative splittings of ionic energy levels are thus deducible and relative transition probabilities estimated; agreement between theoretical calculations and experimental findings is usually good. Interactions between a specific ion and its neighbors must be considered if absolute magnitudes of splittings and transition probabilities are to be calculated; no reliable general technique is available to do this difficult operation in most cases.

NBS. 07:001

National Bureau of Standards, Washington, D. C.

THE (0, 1) AND (1, 2) BANDS OF THE $^2\Delta - {}^2\Pi$ SYSTEM OF CH, by N. H. Kiess. Mar. 18, 1955 71p. incl. illus. diagrs. tables, refs. (NBS rept. no. 3975) (In cooperation with Maryland U., College Park) [AFOSR-TN-55-181] [CSO-680-56-30] AD 67081 Unclassified

A description is presented of the experimental procedures for photographing the (0, 1) and 1, 2) bands of the $^2\Delta - {}^2\Pi$ system of the band spectra of the CH molecule, and the analysis of the structure of these bands. The theory of the spectra of diatomic molecules is given

NBS. 07:002 - NBS. 07:005

briefly in order to introduce those results and methods which are necessary for the analysis of the band structure. The previous work on the CH spectra is summarized. Although the (0, 1) band of the $^2\Delta - ^2\pi$ system was first noticed in 1916, its faintness prevented any high-resolution work; hence, the identity of its emitter could not be conclusively established. It is found, however, that a lean acetylene-oxygen flame burning on a slot burner emits this band with sufficient intensity for high-resolution work. The analysis shows that this band is the (0, 1) band of the $^2\Delta - ^2\pi$ system, and revelas the (1, 2) band of this system. It also leads to the determination of molecular constants for rotation, vibration, Λ-doubling, and spin-splitting. Although many of these constants have been determined from the analysis of other CH bands, the data from the (0, 1) and (1, 2) bands serve both to check the accuracy of the values given for these constants and to determine some new constant.

NBS. 07:002

National Bureau of Standards, Washington, D. C.

EXPERIMENTAL PROOF FOR THE EXISTENCE OF NONTHERMAL ROTATIONAL DISTRIBUTIONS OF OH ($^2\Sigma^+$) IN FLAMES, by H. P. Broida and H. J. Kostkowski. Nov. 15, 1955 [5]p. incl. diagrs. tables, refs. [AFOSR-TN-55-459] [CSO 680-56-30] AD 122249 Unclassified

Also published in Jour. Chem. Phys., v. 25: 676-680, Oct. 1956.

Experiments have been carried out to determine whether nonthermal rotational distributions in the $^2\Sigma^+$ electronic state of OH observed in certain flames are caused by self-absorption. A study of emission (single and double path) and absorption of OH between 3064 Å and 3350 Å in atmospheric and low-pressure flames has shown that self-absorption is negligible in at least 2 cases in which nonthermal distributions are found. This leads to the conclusion that anomalous "temperatures" of OH measured previously in hydrocarbon flames at low pressure and in highly diluted flames at atmospheric pressure are real. (Contractor's abstract)

NBS. 07:003

National Bureau of Standards, Washington, D. C.

SPECTRA EMITTED FROM SOLID NITROGEN CONDENSED AT 4.2° K FROM A GAS DISCHARGE, by A. M. Bass and H. P. Broida. Dec. 7, 1955 [8]p. incl. illus. diagrs. tables, refs. [AFOSR-TN-55-460, CSO-680-56-30. AD 106165 Unclassified

Also published in Phys. Rev., v. 101: 1740-1747, Mar. 15, 1956.

Products of an electrical discharge in flowing nitrogen are frozen at liquid helium temperatures. The solid material emits a glow. Emission spectra have been obtained in the region of 2200 Å to 7000 Å. The most intense features of these spectra, 5 sharp lines near 5230 Å and 3 diffuse lines between 5530 Å and 5670 Å, are attributed to radiation from nitrogen atoms as affected by the solid lattice. There is a less intense series of bands, degraded to the red, extending from 3500 Å to 6400 Å. This system most probably arises from a transition of the N_2 molecule, probably to the $A^3\Sigma_u^+$ state. In the same region, there is a group of very weak diffuse bands which may be emission from NO_2. In addition, several weak bands are attributed to the β- and γ-systems of NO and to NH. When the flow of nitrogen and the electrical discharge are removed, an afterglow from the solid is observed. The spectrum of the afterglow shows only the group near 5230 Å and a weak line at 5944 Å. The half-life of this afterglow radiation is about 15 sec. Intensities of all other features decay to zero in less than 1 sec. (Contractor's abstract)

NBS. 07:004

National Bureau of Standards, Washington, D. C.

SLIT FUNCTION EFFECTS IN THE DIRECT MEASUREMENT OF ABSORPTION LINE HALF-WIDTHS AND INTENSITIES, by H. J. Kostkowski and A. M. Bass. Feb. 15, 1956 [5]p. incl. diagrs. table. [AFOSR-TN-56-25] (CSO-680-56-30) AD 122982 Unclassified

Also published in Jour. Opl. Soc. Amer., v. 46: 1060-1064, Dec. 1956.

The distortion of spectral lines by the finite band pass of spectrometers is an effect which must be considered in measuring line shape parameters. The differences between actual line half-widths and line intensities and those which would be obtained directly from measurements by spectrometers with Gauss and Cauchy shaped slit functions have been calculated for Lorentz and Doppler lines of varying widths and intensities. A method of utilizing these results to correct actual measurements is developed. (Contractor's abstract)

NBS. 07:005

National Bureau of Standards, Washington, D. C.

SPECTROSCOPIC SURVEY OF ENERGY DISTRIBUTIONS OF OH, C_2, AND CH RADICALS IN LOW-PRESSURE ACETYLENE-OXYGEN FLAMES, by H. P. Broida and D. F. Heath. [Mar. 2, 1956] [7]p. incl. illus. diagrs. tables, refs. AFOSR-TN-56-46. (CSO-680-56-30) AD 80558 Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 4, 1956.

Also published in Jour. Chem. Phys., v.26: 223-229, Feb. 1957.

Rotational and vibrational "temperatures" from electronic transttions of OH, C_2, and CH radicals have been measured in detail as functions of position in low-pressure acetylene-oxygen flames. Pressures were varied from 0.8 to 6.0 mm Hg. Trends of "iemperaiure" are presented ai functions of mixture, pressure, posttion, mass-flow rate, and burner size. Abnormalities in "temperaiure" are dtscussed. Evtdence is presenied for the extstence of a newly dtscovered region ai the base of the flame. This regton is aboui 0.1 the visible flame ihickness and is characterized by strong emtssion of C_2 and CH relative to OH and by relatively high "temperatures" of C_2 and CH. Just above this region, the OH rotational "temperaiure" is very high, about 9000° K, and is independent of pressure. (Contractor's abstract)

NBS. 07:006

National Bureau of Standards, Washington, D. C.

ON THE RELAXATION OF VIBRATIONAL NONEQUILIBRIUM DISTRIBUTIONS. III. THE EFFECT OF RADIATIVE TRANSITIONS ON THE RELAXATION BEHAVIOR, by R. J. Rubin and K. E. Shuler. Mar. 6, 1956, 18p. (AFOSR-TN-56-106) (CSO-680-56-30) AD 82020 Unclassified

Also published in Jour. Chem. Phys., v. 26:137-142, Jan. 1957.

In previous papers of this series (Parts I and II), a theoretical study was made of the collistonal relaxation of a system of harmonic oscillators (with $h\nu/kT \ll 1$) from tnitial vibraiional nonequilibrium distributions, and of ihe influence of the collisional transition probabilities on the relaxation behavior. This paper is concerned with ihe extension of this study to include the effects of concurrent radiative transitions on ihe relaxation behavior. Concurrent radiative transitions do not change the relaxation behavior of the system of harmonic oscillators from that found previously for purely collistonal transitions. The only change is in the time-scale of the relaxation, in that the expressions obtained in Part I must be multiplied by a factor of the form $\exp[-t/\tau]$, where τ is the lifetime of the oscillators in their excited vibrational and electronic energy levels. (Contractor's abstract)

NBS. 07:007

National Bureau of Standards, Washington, D. C.

STABILIZATION OF FREE RADICALS AT LOW TEMPERATURES, by H. P. Broida. June 15, 1956, 18p. illus. diagrs. refs. (AFOSR-TN-56-139) (CSO-680-56-30) AD 86016 Unclassified

Also published in Ann. N. Y. Acad. Sciences, v. 67: 530-545, May 24, 1957.

Several methods are discussed for the production of free radicals for low-temperature stabilization. These methods are grouped tnto two categories: (1) methods in which the radicals are frozen into a solid after preparation at htgh temperaiure, and (2) methods in which the radtcals are produced directly in the solid at low temperature. In the ftrsi group, radtcals are formed tn a gas by eleciric discharges, high iemperature, or chemtcal reactions, and ihen solidified on a cold wall before they can react. In the second group, radicals are formed in the cold solid by irradiation of the proper material with γ-rays, x-rays, or ultraviolet light, or by bombardment with accelerated particles such as electrons, neutrons, or protons. The tncreased use of paramagnetic resonance absorptton measurements, the adaption of nuclear resonance, the study of thermal and electrical properties, and the use of x-ray diffraction techniques are all approaches which should give valuable information about free radicals. The ability to place free radicals in a solid permits the characteristics of the solid to be studied by means of the sensitivity of detecting free radicals whose properties are affected by the f rce fields of the solid.

NBS. 07:008

National Bureau of Standards, Washington, D. C.

SPECTROSCOPIC OBSERVATIONS ON PENTABORANE-AIR FLAMES AND EXPLOSIONS, by W. G. Berl, E. L. Gayhart and others [July 19, 1956] 1p. incl. illus. ([AF]OSR-TN-56-183) (Sponsored jotntly by Bureau of Ordnance under Nord-7386 and Air Force Offtce of Scientific Research under CSO-380-56-30) AD 87056 Unclassifted

Also published in Jour. Chem. Phys., v. 25: 797, Oct. 1956.

Spectroscopic studies were made by adding 0 to the N-diluted B_5H_9 in a flow system to prepare B_5H_9-O mixtures which were ignited by an electric spark producing a rapidly expanding flame kernel. The duration of such explosions is of the order of a msec. The main spectral features observed (B_5H_9-N ratio = 1:69.5) were the α bands of BO between 3370 Å and 6200 Å owing to the transitton from the $A^2\Pi_1$ staie to the $X^2\Sigma^+$ ground state. A weak system of diffuse bands observed in the same region was identical with the so-called "boric acid fluctuation band." No emission was observed at wavelengths shorter than 3350 or longer than 6400 Å. Neither BH, BN, nor OH bands were observed in either the diffusion flame or in the explosions. The BO-α and B_2O_3 bands observed in the low-temperature (~500°K) diffusion flame apparently indicated a chemiluminescent origin of the radiation in the flame.

NBS. 07:009

National Bureau of Standards, Washington, D. C.

SHARP LINE ABSORPTION IN SILICA NEAR 3400 cm^{-1}, by A. M. Bass and H. P. Broida. July 10, 1956 [2]p. incl. diagr. table. (AFOSR-TN-56-328.

NBS. 07:010 - NBS. 07:013

(CSO-680-56-30) AD 95204 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 47: 163-164, Feb. 1957.

Sharp absorption lines have been observed at temperatures near 4°K in samples of fused silica and crystal quartz. The strongest lines are near 3365 and 3472 cm^{-1} and have widths at half height of less than 2.5 cm^{-1}. With increasing temperature, the absorption lines are shifted to higher frequencies; in addition, the lines are broadened and the peak absorption is decreased. (Contractor's abstract)

NBS. 07:010

National Bureau of Standards, Washington, D. C.

STEREOSCOPIC STUDIES OF SOLIDS CONDENSED AT 4.2°K FROM ELECTRIC DISCHARGE THROUGH NITROGEN, OXYGEN, HYDROGEN, WATER, AND AMMONIA, by H. P. Broida. [Aug. 15, 1956] [6]p. incl. illus. diagr. [AFOSR-TN-56-362] (CSO-680-56-30) AD 95448 Unclassified

Also published in Proc. Conference on Chemical Aeronomy, Harvard U., June 1956, from The Threshold of Space, 1957, p. 194-199.

Absorption spectra between 2200 and 35,000 Å have been obtained of solids condensed at 4.2°K after passing N, O, H, H_2O, and NH_3 separately through an electrodeless discharge (Bass and Broida). Comparison spectra of the same solidified gases which were not subjected to the discharge have been obtained. A number of bands occur in the discharge products which do not occur in materials which have not passed through the discharge. These bands are diffuse and fairly broad (generally greater than 100 cm^{-1}). They disappear at higher temperatures and do not reappear when the solids are cooled again.

NBS. 07:011

National Bureau of Standards, Washington, D. C.

SPECTRUM OF THE C_3 MOLECULE BETWEEN 3600 Å AND 4200 Å, by N. H. Kiess and H. P. Broida. Aug. 27, 1956 [11]p. incl. illus. diagr. tables. [AFOSR-TN-56-363] (CSO-680-56-30) AD 95449 Unclassified

Also published in Canad. Jour. Phys., v. 34: 1471-1479, 1956.

C_3 bands were observed in the emission spectrum of an C_2H_2-O_2 flame with an excess of C_2H_2. In addition to the usually observed bands of the 4050 Å group, weak bands at wavelengths less than 4000 Å and greater than 4100 Å were observed. Measured wavelengths are given of 40 band-heads superimposed on a strong continuum, extending from 3600 to 4200 Å. A rotational analysis of the 2 strongest bands with heads at 4050 Å and 4072 Å is given also. The relative simplicity of these 2 bands indicates that the complexity of the other C_3 bands is caused by lines of over-lapping bands. Rotational constants and band origins are also given for both bands. (Contractor's abstract, modified)

NBS. 07:012

National Bureau of Standards, Washington, D. C.

ABSOLUTE INTENSITIES OF THE 721 AND 742 CM^{-1} BANDS OF CO_2, by H. J. Kostkowski and L. D. Kaplan. [Aug. 15, 1956] [2]p. incl. diagr. refs. (AFOSR-TN-56-393) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under CSO-680-56-30) AD 96051 Unclassified

Also publisned in Jour. Chem. Phys., v. 26: 1252-1253, May 1957.

The absolute intensities of the $01^10 \longrightarrow 10^00$ and $02^20 \longrightarrow 11^10$ bands of CO_2 at 721 and 742 cm^{-1}, respectively, have been determined with a curve-of-growth method utilizing the Elsasser periodic line pattern and a slit function calculation. The resulting intensities were $S_{01^10 \longrightarrow 10^00}329°K = 7.5\ cm^{-2}\ atm^{-1}$ and $S_{02^20 \longrightarrow 11^10}329°K = 0.22\ cm^{-2}\ atm^{-1}$. In addition the intensity of the $03^10 \longrightarrow 12^00$ band at 740 cm^{-1} was estimated to be $S_{03^10 \longrightarrow 12^00}329°K = 0.032\ cm^{-2}\ atm^{-1}$. (Contractor's abstract)

NBS. 07:013

National Bureau of Standards, Washington, D. C.

ABSORPTION SPECTRA OF SOLIDS CONDENSED FROM AN ELECTRICAL DISCHARGE THROUGH OXYGEN (Abstract), by A. M. Bass and H. P. Broida. [1956] [1]p. (CSO-680-56-30) Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 23.

The products of a high frequency electrical discharge in flowing oxygen are frozen out on a fused silica plate maintained near the temperature of liquid helium. The absorption spectra of the collected material are studied as a function of layer thickness and of temperature. Spectra are obtained over the range 2200 to 8500 A with prism spectrographs, and from 1 to 3.5 microns with a grating spectrometer, using a cooled lead sulfide detector. The absorption spectrum of the condensate from the discharge through oxygen shows some 25 diffuse bands in the range 3500 to 7000 A. A few of these bands correspond to bands observed in solid molecular oxygen. In the ultraviolet there is a strong continuous

absorption starting at about 3500 A and increasing very rapidly toward shorter wavelengths. In the infrared two bands, about 20 cm^{-1} wide, are observed peaking at 3030 and 3499 cm^{-1}. The band at 3030 cm^{-1} may be due to ozone, which in the gas phase has an absorption band at 3050 cm^{-1}. In addition there are observed six narrow lines (about 2 cm^{-1} wide) coming from the fused silica collecting plate. The two strongest lines, at 3364 and 3470 cm^{-1}, show marked broadening and shift by about 10 cm^{-1} to shorter wavelengths upon warming the plate from liquid helium temperature to room temperature. (Contractor's abstract)

NBS. 07:014

National Bureau of Standards, Washington, D. C.

LINE-WIDTHS AND SHAPES IN CO AT PRESSURES ABOVE ONE ATMOSPHERE (Abstract), by H. J. Kostkowski and A. M. Bass. [1956] [1]p. (CSO-680-56-30) Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 50.

The widths of self-broadened lines in the first overtone band of CO at pressures from 2½ to 20 atm were measured directly with a small grating menochromator whose spectral slit-width was approximately 0.25 cm^{-1}. Line intensities were also determined but at pressures below one atmosphere. Both the line widths and intensities are believed to be in error by less than 5%. These independently determined parameters were then used with assumed line shapes to calculate the absorption, as a function of pressure, at various troughs throughout the band. Comparisons were made with actual measurements to try to obtain some information about the line shape and widths for pressures up to 60 atm. The method for determining the width and intensity of the lines as well as the results obtained on widths and shapes are presented. (Contractor's abstract)

NBS. 07:015

National Bureau of Standards, Washington, D. C.

DIRECT MEASUREMENT OF LINE WIDTHS AND INTENSITIES IN CARBON MONOXIDE AT 2.35 MICRONS (Abstract), by A. M. Bass and H. J. Kostkowski. [1956] [1]p. [CSO-680-56-30] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 14, Jan. 30, 1956.

The widths and intensities of absorption lines have been measured in the first overtone vibration-rotation band of CO at 2.35 microns. Sufficiently high CO pressures were used so that direct measurements could be made with a grating spectrometer having a spectral slit width of about 0.3 cm^{-1}. Data were obtained at room temperature for a range of pressures from 1/4 to 67 atm and for path lengths from 5 to 750 mm. The direct measurements at 5 and 10 atm were corrected by about 10% for the distortion effects of the finite spectrometer slit width. The results obtained are discussed in terms of the line shape and the pressure dependence of line widths in CO and are compared with results obtained from the curve-of-growth method in this work and by others. (Contractor's abstract)

NBS. 07:016

National Bureau of Standards, Washington, D. C.

SPECTROSCOPIC STUDY OF "TEMPERATURES" DETERMINED FROM OH, C_2, AND CH RADICALS IN LOW-PRESSURE ACETYLENE-OXYGEN FLAMES (Abstract), by D. F. Heath and H. P. Broida. [1956] [1]p. [CSO-680-56-30] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 13, Jan. 30, 1956.

Rotational and vibrational "temperatures" from electronic transitions of OH, C_2, and CH radicals have been measured in detail as functions of position in low-pressure acetylene-oxygen flames. Pressures were varied from 1.6 to 6.0 mm Hg. Trends of temperature are presented as functions of mixture, pressure, position, mass flow rate, and burner size. Abnormalities in temperature are discussed. Evidence is presented for the existence of a new "burning" region at the base of the flame. This region is about 1/10 the visible flame thickness and is characterized by strong emission of C_2 and CH relative to OH and by relatively high temperatures of C_2 and CH. Just above this region the OH rotational temperature is very high, about 9000°K. (Contractor's abstract)

NBS. 08:001

National Bureau of Standards, Washington, D. C.

INFRARED MEASUREMENTS FROM 50 TO 125 MICRONS, by E. K. Plyler and N. Acquista. Nov. 30, 1955 [5]p. incl. illus. (NBS research paper no. 2660) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research under [CSO-680-56-31], and Atomic Energy Commission) AD 106656 Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 56: 149-153, Mar. 1956.

NBS. 08:002 - NBS. 08:005

A prism spectrometer has been changed to a long wavelength grating spectrometry by removing the prism and by replacing the Littrow mirror with a grating. Gratings of 320 and 180 lines/in. were used for the region 50 to 125 microns. A thermocouple with a crystal quartz window served as the detector. Stray radiation was greatly reduced by the use of reflection filters. Three types of reflection filters were found to be efficient. They were gratings with 2000 lines/in., roughened silver mirrors, and reststrahlen plates of NaCl, KBr, and CsBr. The absorption lines of water vapor were used to calibrate the spectrometer. The spectra of several substituted ethylenes and ethanes have been measured, and absorption bands have been found between 50 and 100 microns.

NBS. 08:002

National Bureau of Standards, Washington, D. C.

INFRARED AND RAMAN SPECTRA OF TRANS-DIFLUORODICHLOROETHYLENE, by D. E. Mann and E. K. Plyler. Mar. 1956 [27] p. incl. diagrs. tables, refs. (NBS rept. no. 4575) (AFOSR-TN-56-244) (CSO-680-56-31) AD 88364 Unclassified

Also published in Jour. Chem. Phys., v. 26: 773-779, Apr. 1957.

The IR and Raman spectra of trans-difluorodichloroethylene, t-$C_2F_2Cl_2$, have been measured and an assignment of fundamentals made. They are (in cm^{-1}): 1707, 1186, 632, 425, and 288 in a_g; 333 and 140 in a_u; 529 in b_g; and 1190, 892, 426, and 175 in b_u. A table of thermodynamic functions is given for the molecule in the ideal gaseous state. (Contractor's abstract)

NBS. 08:003

National Bureau of Standards, Washington, D. C.

MICROWAVE SPECTRUM AND STRUCTURE OF SULFURYL FLUORIDE, by D. R. Lide, Jr., D. E. Mann, and R. M. Fristrom. Apr. 1956 [25] p. incl. diagrs. tables, refs. (NBS rept. no. 4650) (AFOSR-TN-56-269) (CSO-680-56-31) AD 88989 Unclassified

Also published in Jour. Chem. Phys., v. 26: 734-739, Apr. 1957.

The microwave spectrum of sulfuryl fluoride (SO_2F_2) has been investigated. The spectra of the S^{32} and S^{34} species in natural abundance have been analyzed, and the structure has been determined with the aid of the S^{34} isotope shift. The correction for zero-point vibration was shown to be small. The structural parameters are: r_{SO} = 1.405 ± 0.003A, r_{SF} = 1.530 ± 0.003A, ∠OSO = 123°58' ± 12', and ∠FSF = 96°7' ± 10'. The molecular dipole moment is 1.110 ± 0.015 Debye units. A number of satellite lines were observed and assigned to excited vibrational states. Some anomalies in the measured rotational constants for the excited states have been interpreted in terms of a Cortolts-type interaction between the fundamentals $\nu_4(A_1)$ and $\nu_5(A_2)$. From an analysis of this interaction the frequency of the hitherto unobserved $\nu_4(A_1)$ fundamental was found to be 388 ± 15 cm^{-1}. (Contractor's abstract)

NBS. 08:004

National Bureau of Standards, Washington, D. C.

NORMAL COORDINATE ANALYSIS OF HALOGENATED ETHYLENES. I. GENERAL METHODS, by D. E. Mann, T. Shimanouchi and others. Apr. 1956, 28p. incl. diagr. refs. (NBS rept. no. 4654) (AFOSR-TN-56-272) (CSO-680-56-31) AD 89482 Unclassified

Also published in Jour. Chem. Phys., v. 27: 43-51, July 1957.

Methods and detailed algebraic expressions are given for the normal-coordinate analysis of ethylenic molecules. They are applied to the calculation of potential constants, normal modes, and vibrational frequencies for a series of perhalogenated ethylenes. A force field of the Urey-Bradley type is used for the planar vibrations, and a simple valence-type potential function is applied to the nonplanar motions. The force constants established for the molecules with V_h symmetry are to be used, with only linear interpolation and no further adjustment, to calculate the fundamental frequencies and modes of all the remaining, less symmetrical ethylenes. For the V_h molecules, the vibrational secular equations are set up in the customary GF matrix fashion. The other ethylenes require a somewhat different form which is more readily adapted to calculation by an electronic digital computer. In order that the force constants determined for the V_h molecules be as good as possible, a method is given for their adjustment by a least-squaring process. (Contractor's abstract)

NBS. 08:005

National Bureau of Standards, Washington, D. C.

NORMAL COORDINATE ANALYSIS OF HALOGENATED ETHYLENES. II. PERHALOGENATED ETHYLENES, by D. E. Mann, L. Fano and others. Apr. 1956, iv. incl. diagrs. tables, refs. (NBS rept. no. 4655) (AFOSR-TN-56-273) (CSO-680-56-31) AD 89483 Unclassified

Also published in Jour. Chem. Phys., v. 27: 51-59, July 1957.

The methods described in item no. NBS. 08:004 have been applied to the normal coordinate analysis of the fundamental vibrations of 27 perhalogenated ethylenes which contain F, Cl, or Br. Force constants for the planar modes of the key molecules (C_2F_4, C_2Cl_4, and C_2Br_4) have been obtained by an adjustment procedure

based on the method of least squares. The agreement between the calculated and observed fundamentals is quite good. The constants established for the key molecules were then used, either directly or with a simple interpolation scheme, to calculate the fundamentals of the remaining 24 ethylenes. Comparisons with experimental results have been made where possible and indicate good agreement for the out-of-plane, as well as in-plane vibrations. The planar normal modes of C_2F_4, C_2Cl_4, and the 5 fluorochloroethylenes are depicted. (Contractor's abstract)

NBS. 08:006

National Bureau of Standards, Washington, D. C.

VIBRATIONAL SPECTRUM AND FORCE CONSTANTS OF DIBORON TETRACHLORIDE, by D. E. Mann and L. Fano. Aug. 1956, 25p. incl. diagrs, tables, refs. (NBS rept. no. 4811) (AFOSR-TN-56-450) (CSO-680-56-31) AD 96795 Unclassified

Also published in Jour. Chem. Phys., v. 26: 1665-1670, June 1957.

The infrared spectrum of gaseous diboron tetrachloride (B_2Cl_4) and the Raman spectrum of the liquid are analyzed. The molecular symmetry is shown to be V_d, in accord with the electron diffraction result for the vapor. A complete vibrational assignment is given. The fundamentals are (in cm^{-1}): 1131, 401, 225 in a_1; 730, 291 in b_2; 917, 617, 180 in e. A normal coordinate analysis, based on a Urey-Bradley potential function and a least-squares method of force constant adjustment, is used to establish the assignment. With the aid of the third-law entropy, the barrier restricting internal rotation about the B-B single bond is fixed at 1700 ± 600 cal/mole. (Contractor's abstract)

NBS. 09:001

National Bureau of Standards, Washington, D. C.

AN EXTENSION OF GAUSS' TRANSFORMATION FOR IMPROVING THE CONDITION OF SYSTEMS OF LINEAR EQUATIONS, by G. E. Forsythe and T. S. Motzkin. [1952] 9 p. incl. refs. [CSO-670-54-12] Unclassified

Published in Math. Tables and Other Aids to Computation, v. 6: 9-17, Jan. 1952.

Gauss (Werke, Bd. 9, Tuebner, Leipzig, 1903, pp. 250-253, 278-281; for an annotated translation by G. E. Forsythe, see same journal, v. 5: 255-258, 1952; see also R. Dedekind, Gesammelte mathematische Werke, Bd. 2, Vieweg, Braunschweig, 1931, pp. 293-306) suggested the following transformation to improve the convergence of the relaxation method for the solution of a system of linear equations (1) $\sum a_{ij}x_j = b_i$ (i = 1, 2, ..., n) of which the matrix (a_{ij}) is symmetric and positive definite. Replace x_i by $y_1 - y_{n+1}$ (i = 1, 2, ..., n) and adjoin to the system an (n + 1)th equation by adding the first n. The new system is redundant but this does not matter since the x_i's are determined by the differences of the y_i's. Interest in this transformation was roused by its description by Zurmühl (Matrizen ..., Springer, Berlin-Göttingen-Heidelberg, 1950, p. 280; Math. Rev., v. 12: 73). The authors study a generalization of the above transformation; they consider $x_i = y_i + s_i y_{n+1}$ where the s_i's are parameters. They also consider the case when (a_{ij}) is singular. Let λ_i be the characteristic root of (a_{ij}). Let $\lambda = \max|\lambda_i|$ and let $\mu = \min|\lambda_i|$ where we disregard vanishing λ_i. It is suggested that the size of the ratio λ/μ, called the P-condition number, is decisive in the speed of convergence of iterative solutions of (1). (cf. von Neumann and Goldstine, Bull. Amer. Math. Soc., v. 53: 1021-1099, 1947; Turing, Quart. Jour. Mech. Appl. Math., v. 1: 287-308, 1948; J. Todd, Quart. Jour. Mech. Appl. Math., v. 2: 469-472, 1949; Proc. Cambridge Philos. Soc., v. 46: 116-118, 1950). It is shown that the characteristic roots of the transformed matrix separate those of the original and that although values of the s_i can be chosen to reduce the P-condition number it is not true that the original Gauss transformation will always effect this. The case of a well-known 4 x 4 ill-conditioned matrix is discussed in numerical detail. (Math. Rev. abstract)

NBS. 09:002

National Bureau of Standards, Washington, D. C.

BOOLEAN GEOMETRY. 1., by L. M. Blumenthal. Feb. 11, 1952, 28p. (NBS rept. no. 1482) [CSO-670-54-12] U72062 Unclassified

Also published in Rend. Circ. Matem. Palermo, Series II, v. 1: 1-18, 1952.

This paper studies the geometry of the distance space obtained by associating with each two elements a, b of a Boolean algebra the element $d(a, b) = ab' + a'b$ of the algebra as distance. Since $d(a, b) = 0$ if and only if $a = b$, $d(a, b) = d(b, a)$, and $d(a, b) + d(b, c) = d(a, c)$ for each three elements a, b, c of the algebra, the distance function has the formal properties of a metric. This permits, as well as motivates, the introduction of geometric notions into Boolean algebra, and suggests that the application of metric methods might yield new results as well as novel interpretations of old ones. Theorems of order (linearity) are established, and properties of segments are obtained. (Extracted from rept.)

NBS. 09:003

National Bureau of Standards, Washington, D. C.

ON PÓLYA FREQUENCY OF FUNCTIONS. III. THE POSITIVITY OF TRANSLATION DETERMINANTS WITH AN APPLICATION TO THE INTERPOLATION PROBLEM BY SPLINE CURVES, by I. J. Schoenberg

NBS. 09. 004 - NBS. 09:007

and A. Whitney. Feb. 18, 1952, 24p. (NBS rep. no. 1[illegible]) [CSO-670-54-12] U72067 Unclassified

Also published in Trans. Amer. Math. Soc., v. 74: 246-259, Oct. 1953.

A non-negative function $\Lambda(x)$ in $L(-\infty, \infty)$ is called a Pólya frequency function if for any two sets of increasing numbers

$$x_1 < x_2 < \ldots < x_n,\ y_1 < y_2 < \ldots < y_n,\ n = 1, 2, \ldots,$$

we have the inequality $D \equiv \det \|\Lambda(x_i - y_j)\|_{1,n} \geq 0$. It was shown in Part I that the bilateral Laplace transform of $\Lambda(x)$ is the reciprocal of an entire function $\psi(s)$ of the form

$$\psi(s) = Ce^{-\gamma s^2 + \delta s} \prod_{\nu=1}^{\infty} (1 + \delta_\nu s)e^{-\delta_\nu s},$$

where $C > 0$, $\gamma \geq 0$, δ_ν are real, $0 < \gamma + \sum \delta_\nu^2 < \infty$. Case 1 is that in which $\psi(s) = \prod (1 + \delta_\nu s)$, $\sum |\delta_\nu| < \infty$, case 2 that in which $\gamma > 0$ or $\gamma = 0$ and $\sum |\delta_\nu| = \infty$. It is shown in the present paper that D is always positive in case 2. In case 1 let k be the number of $\delta_\nu > 0$, h the number of $\delta_\nu < 0$. Then

$D > 0$ if and only if $x_{\nu-k} < y_\nu < x_{\nu+h}$ for $\nu = 1, \ldots, n$ with the convention that $x_r = -\infty$ if $-\infty \leq r < 1$ and $x_r = +\infty$ if $n < r \leq +\infty$. The proof involves the consideration of a large number of subcases. If $x_+ = \max(0, x)$, $\Lambda(x) = e^{-x}(x_+)^k$ is a Pólya frequency function belonging to case 1 and the main theorem shows that $\det \|[x_i - y_j)^k]\| > 0$ if and only if $x_{\nu-k-1} < y_\nu < x_\nu$, $\nu = 1, \ldots, n$. A spline function of degree k is an expression of the form $F(x) = P_k(x) + \sum_{\nu=1}^{n} A_\nu [(x - \xi_\nu)_+]^k$ where $P_k(x)$ is an arbitrary polynomial of degree $\leq k$ and the ξ_ν are the n given knots. The interpolation problem consists in deciding if a spline curve can be laid through $n + k + 1$ given points (x_ν, Y_ν), the degree k and the knots ξ_ν being given. Necessary and sufficient conditions are given with the aid of the spectal result mentioned above. (Math. Rev. abstract)

NBS. 09:004

National Bureau of Standards, Washington, D. C.

A REMARK ON M. M. DAY'S CHARACTERIZATION OF INNER-PRODUCT SPACES AND A CONJECTURE OF L. M. BLUMENTHAL, by I. J. Schoenberg. Mar. 6, 1952, 7p. (NBS rept. no. 1515) [CSO 670-54-12] U72068 Unclassified

Also published in Proc. Amer. Math. Soc., v. 3: 961-964, Dec. 1952.

The following two theorems are discussed and proved: (1) let S be a real semi-normed space which is ptole maic. Then $\|\ \|$ is a norm which springs from an inner product, i.e. S is a real inner product space; (2) the real normed space S is an inner product space if it has the property that $\|f+g\|^2 + \|f-g\|^2 = 4$, $(\|f\| = 1, \|g\| = 1)$.

NBS. 09:005

National Bureau of Standards, Washington, D. C.

ON APPROXIMATE SOLUTIONS OF SYSTEMS OF LINEAR INEQUALITIES, by A. J. Hoffman. June 4, 1952, 10p. (NBS rept. no. 1739) [CSO-670-54-12] Unclassified

Published in Jour. Res. Nat'l. Bur. Standards, v. 49: 263-265, 1952.

Let $Ax \leq b$ be a consistent system of linear inequalities. The principal result is a quantitative formulation of the fact that if x "almost" satisfies the inequalities, then x is "close" to a solution. It is further shown how it is possible in certain cases to estimate the size of the vector joining x to the nearest solution from the magnitude of the positive coordinates of Ax-b. (Math. Rev. abstract)

NBS. 09:006

National Bureau of Standards, Washington, D. C.

THE SUMS OF DIHEDRAL AND TRIHEDRAL ANGLES IN A TETRAHEDRON, by J. W. Gaddum. [1952] [2]p. [CSO-670-54-12] Unclassified

Published in Amer. Math. Monthly, v. 59: 370-371, June-July 1952.

It is shown that the sum of the dihedral angles of a tetrahedron is comprised between 2π and 3π, and consequently the sum of the trihedral angles of a tetrahedron lies between 0 and 2π. Moreover, these bounds are the best that can be given. (Math. Rev. abstract)

NBS. 09:007

National Bureau of Standards, Washington, D. C.

ON LINEAL ENTIRE FUNCTIONS OF n COMPLEX VARIABLES, by T. S. Motzkin and I. J. Schoenberg. [1951] [10]p. [CSO-670-54-12] Unclassified

Published in Proc. Amer. Math. Soc., v. 3: 517-526, Aug. 1952.

A polynomial $P(z) = P(z_1, \ldots, z_n)$ with complex coefficients is called lineal if it is a product of linear functions. An entire function f(z) is called lineal if it is the limit of a sequence of lineal polynomials uniformly convergent on every compact set. The author proves that f(z) is lineal if and only if it vanishes on planes only. If f(z) is lineal, it can be written as a Weierstrass product

$$l(z) = \exp G(z) \prod_{1}^{n} (z, c_j) \prod_{1}^{\infty} P_k(z, d_k)$$

where G(z) is an entire function, c_j and d_k complex vectors, and

$$P_k(u) = (1-u)\exp\left(u + \tfrac{1}{2}u^2 + \ldots + \frac{1}{k-1}u^{k-1}\right).$$

The function f(z) is called really linear if the approximating polynomials split into products of linear functions with real coefficients. This happens if and only if

$$f(z) = \exp\left(\sum_1^m c_{rs}z_r z_s + (z,d)\right)\prod_1^n (z,c_j)\prod_1^\infty (1+(z,d_k))e^{-(z,d_k)},$$

where c_j, d and d_k are real vectors, $\sum \|d_k\|^2$ convergent and $\sum_1^m c_{rs}z_r z_s \geq 0$ for every real z. Finally f(z) is called positively linear if the approximating polynomials split into linear factors with positive coefficients. In this case the vectors c_j, d, and d_k have positive coordinates, $\sum \|d_k\|$ converges and the quadratic form vanishes. Detailed proofs of these statements are given. (Math. Rev. abstract)

NBS. 09:008

National Bureau of Standards, Washington, D. C.

THE RELAXATION METHOD FOR LINEAR INEQUALITIES, by T. S. Motzkin and I. J. Schoenberg. Aug. 13, 1952, 21p. (NBS rept. no. 1881) [CSO-670-54-12] Unclassified

Presented at meeting of the Amer. Math. Soc., Sept. 1952.

Also published in Canad. Jour. Math., v. 6: 393-404, 1954.

This paper presents an elegant proof of the fundamental theorem established in the article reviewed above and obtains new results for the case $\lambda = 2$ (the reflection method). Denoting by A the solution set of a consistent system of m linear inequalities in n indeterminates, it is shown that the reflection method always terminates when dim A = n, while if dim A = r < n then either the sequence $\{p_\nu\}$ terminates, or else there is a number ν_0 such that for $\nu \geq \nu_0$ the points p_ν are on a spherical surface S_{n-r-1} having the r-dimensional subspace containing A as axis (i.e., L_r is the locus of points equidistant from the points of S_{n-r-1}). The concluding section of the paper is concerned with establishing analogous theorems for the reflection process when the (infinite) set of half-spaces considered all contain a given bounded, closed, and convex subset A (which it is desired to enter) and their boundaries are supporting hyperplanes of A. (Math. Rev. abstract)

NBS. 09:009

National Bureau of Standards, Washington, D. C.

ON REPRESENTATIONS OF FINITE GROUPS, by T. S. Motzkin and O. Taussky. Sept. 27, 1952 [2]p. [CSO-670-54-12] Unclassified

Published in Neterl. Akad. Wetensch. Proc. Ser. A. Indag. Math., v. 55: 511-512, 1952.

If every pair of matrices A, B of a faithful representation (by matrices over the complex field) of a finite group Γ has the property (L) that their roots α_t and β_t can be ordered so that the roots of $\lambda A + \mu B$ are $\lambda\alpha_t + \mu\beta_t$ for all complex λ and μ, then Γ is abelian; also, if the roots of $\prod C_k$, each C_k = A or B, are the corresponding products of the α_t and β_t, Γ is abelian. If the matrix elements may be in a field of finite characteristic, examples show that p(A, B) may have roots $p(\alpha_t, \beta_t)$ for every polynomial and yet Γ be non-abelian. (Math. Rev. abstract)

NBS. 09:010

National Bureau of Standards, Washington, D. C.

SWAC CODING GUIDE, by R. B. Hargan. Nov. 4, 1952, 1v. incl. illus. diagrs. (NBS rept. no. 1047) [CSO-670-54-12] Unclassified

This is a manual to be used for SWAC coding. Definitions of terms used are given. Basic rules for coding procedure are outlined, and some aids to coding are cited. The input-output system is described and the procedure involved outlined. The routine of the memory check is described. The means of changing or "modifying" commands already in the memory is explained. The three ways of tallying to govern the number of times a particular cycle is followed are cited. Finally, procedures for coding complex operations as subroutines are given.

NBS. 09:011

National Bureau of Standards, Washington, D. C.

EIGENVECTORS OF MATRIC POLYNOMIALS, by M. Marcus. Nov. 24, 1952, 13p. (NBS rept. no. 2077) [CSO-670-54-12] Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 51: 33-36, July 1953.

The object of this paper is to compare the eigenvectors of an arbitrary n x n matrix A over the complex field with those of the matrix polynomial f(A). While it is well known that each eigenvector of A is an eigenvector of f(A), it is not, in general, true that A and f(A) have identical eigenvectors. In this regard a necessary and sufficient condition that A and f(A) have identical eigenvectors is given. The condition is that both (1) and (2) hold: (1) $f'(\lambda) \neq 0$ for all eigenvalues λ of the matrix A corresponding to nonlinear elementary divisors; (2) the values of $f(\lambda)$ are distinct for all eigenvalues of λ of the matrix A corresponding to linear elementary divisors. When either (1) or (2) fails to hold, then f(A) has eigenvectors that are not eigenvectors of A. This situation is also discussed. (Contractor's abstract)

NBS. 09:012

National Bureau of Standards, Washington, D. C.

A THEOREM ON CONVEX CONES WITH APPLICATIONS

NBS. 09:013 - NBS. 09:016

TO LINEAR INEQUALITIES, by J. W. Gaddum. [Dec. 1952] [4]p. (NBS. rept. no. 1473) [CSO-670-54-12] U72061 Unclassified

Published in Proc. Amer. Math. Soc., v. 3: 957-960, Dec. 1952.

This note is concerned with the convex cone associated with the two systems of linear inequalities,

(1) $\sum_{j=1}^{n} a_{ij}x_j \geq 0$, $i = 1, 2, \ldots, m$, and

(2) $\sum_{j=1}^{n} a_{ij}x_j \geq 0$, $i = 1, 2, \ldots, m$, where the symbol $\geq$

demands that the inequality ($>$) hold for at least one value of i. For brevity these systems are written (1) $Ax \geq 0$ and (2) $Ax \geq 0$. Interpreting $(a_{i1}, \ldots, a_{in})$ as a vector a_i in E_n, with initial point at the origin, we denote by A convex cone generated by these m vectors and by A^* the polar cone, the vectors of which give the solutions of (1). The purpose of this paper is to show that in general $A \cdot A^* \neq 0$ and to characterize the cases in which A and A^* do intersect in the null vector. Some applications are then made to obtain theorems on the existence of, and methods of obtaining, solutions of (1) and (2).

NBS. 09:013

National Bureau of Standards, Los Angeles, Calif.

TWO EXISTENCE THEOREMS FOR SYSTEMS OF LINEAR INEQUALITIES, by L. M. Blumenthal. Dec. 12, 1951 [10]p. (NBS rept. no. 1356) [CSO-670-54-12] Unclassified

Also published in Pacific Jour. Math., v. 2: 523-530, Dec. 1952.

The author develops the theory of linear inequalities by means of metric methods which was initiated in a previous paper [Duke Math. Jour. v. 15, 955-966 (1948) Preliminaries – E_n: n-dimensional Euclidean vector space. $p_1, p_2, \ldots p_n, p_{n+1}$: vectors of E_n such that $p_1, p_2, \ldots, p_{n-1}$ are linearly independent. L: linear manifold spanned by $p_1, \ldots, p_{n-1}$. x_{il} ($l = 1, \ldots, n$): components of p_l ($l = 1, \ldots, n+1$) with respect to a normal orthogonal basis. p_n and p_{n+1} lie on the same or on opposite sides of L according as the product of the signed volumes

$V(p_1, \ldots, p_{n-1}, p_n) \cdot V(p_1, \ldots, p_{n-1}, p_{n+1}) = |x_{kl}| \cdot |x_{hl}|$ (k, l = 1, 2, ..., n, h = 1, 2, ..., n - 1, n + 1) $|\text{sum } x_{kl}\, x_{hl}| = |(p_k, p_h)|$ is positive or negative. If the p_l's are unit vectors, $(p_k, p_h) = \cos p_k p_h$. Theorems – System ($g_*$) of linear inequalities in n indeterminates with rank $r + 1$: $(p_l, x) \geq 0$, $l = 1, \ldots, m$, one at least of the left members having to be positive. A p_l, A^T transpose of A, B AA^T. The system (g_*) has a solution if and only if and only if a shifting of rows and corresponding columns exists such that (i) the upper left principal minor M of B of order $r + 1$ does not vanish, (ii) each minor of B formed from M by replacing its last row with that part of the jth row of B contained in the first r + 1 columns (j = r + 2, r + 3, ..., m) is positive or zero. The second theorem is concerned with the existence of a nontrivial solution of the same system of inequalities, the positivity requirement being dropped. (Math. Rev. abstract)

NBS. 09:014

National Bureau of Standards, Washington, D. C.

THE DOUBLE DESCRIPTION METHOD, by T. S. Motzkin, H. Raiffa and others. [1953] [23]p. incl. diagrs. tables, refs. (Sponsored jointly by [Air Force] Office of Scientific Research under [CSO-670-54-12] and Office of Naval Research] Unclassified

Published in Contributions to the Theory of Games, v. 2: 51-73, 1953.

A computational method is presented for the determination of the value and of all solutions of a two-person zero-sum game with a finite number of pure strategies, and for the solution of general finite systems of linear inequalities and corresponding maximization problems. Part I deals with intuitive concepts of the games; Part II, with the computational procedure; and Part III, with general inequalities and second variant of the computational procedure.

NBS. 09:015

National Bureau of Standards, Washington, D. C.

ON A COMBINATORIAL THEOREM, by A. J. Hoffman. [1953] [3]p. (NBS rept. no. 2377) [CSO-670-54-12] Unclassified

Let S be a set with v elements and v distinguished subsets $S_1, \ldots, S_v$. Let there be 2 integers λ and k, $(o < \lambda < k < v)$, such that S_i contains k elements of S ($i = 1, \ldots, v$), and S_i and S_j have λ elements of S in common ($i \neq j$; $i, = 1, \ldots v$). The purpose of this note is to offer new proofs to the following: (1) $\lambda = k(K-1)(v-1)$ and (2) each element of S is contained in k sets S_1; any 2 distinct elements of S are contained simultaneously in λ sets S_1.

NBS. 09:016

National Bureau of Standards, Washington, D. C.

MINIMAX THEOREMS, by K. Fan. Jan. 1953 [6]p. [CSO-670-54-12] Unclassified

Published in Proc. Nat'l. Acad. Sciences, v. 39: 42-47, Jan. 1953.

This note contains three generalizations of von Neumann's minimax theorem. These theorems, however, involve no structures of linear space. The first theorem can be used to provide simple proofs for

minimax theorems for infinite games. The second theorem generalizes Kneser's minimax theorem by eliminating the structure of linear spaces. The third theorem is free of topological structures. This is made possible by generalizing von Neumann's almost periodic functions on a group.

NBS. 09:017

National Bureau of Standards, Washington, D. C.

ON THE APPROXIMATION OF LINEAR ELLIPTIC DIFFERENTIAL EQUATIONS BY DIFFERENCE EQUATIONS WITH POSITIVE COEFFICIENTS, by T. S. Motzkin and W. Wasow. [Jan. 1953] [7]p. [CSO-670-54-12] Unclassified

Published in Jour. Math. and Physics, v. 31: 253-259, Jan. 1953.

The problem considered is that of approximating a given linear elliptic second-order partial differential equation $L[u] = 0$ in n-space by a linear difference equation $L_h[u] = 0$ (referring to a square mesh of width h) in such a way that (i) the operator $L_h[u]$ should be a formal analogue of $L[u]$, (ii) the equation $L_h[u] = 0$ should express the value of n at a lattice point P as a weighted average, with positive weights, of the values of n at certain lattice points $Q_1, \ldots, Q_s$. If the system of neighboring points $S = \{Q_1, \ldots, Q_s\}$ is given and contains at least all lattice points whose distance from P does not exceed $(nh)^{1/4}$, condition (i) can always be satisfied. The authors prove that for no S can condition (ii) be satisfied for all elliptic equations, but that for any given equation condition (ii) can be satisfied by choosing S appropriately. Condition (ii) is of importance for proving the solvability of Dirichlet's problem for the difference equation and the convergence of the solution of this problem to the appropriate solution of the differential equation, and also in view of the connection between linear elliptic equations and random walks. Condition (ii) also implies a maximum principle for solution of $L_h[u] = 0$, which the authors establish in the last section of this paper. (Math. Rev. abstract)

NBS. 09:018

National Bureau of Standards, Washington, D. C.

A NOTE ON THE PAIRS OF NORMAL MATRICES WITH PROPERTY L, by N. Wiegmann. [1953] [2]p. [CSO-670-54-12] Unclassified

Published in Proc. Amer. Math. Soc., v. 4: 35-36, Feb. 1953.

If A and B are square matrices such that $\alpha A + \beta B$ has roots $\alpha\lambda_i + \beta\mu_i$ for a suitable ordering of the roots λ_i of A and μ_i of B, then if they are normal, they must commute. (Math. Rev. abstract)

NBS. 09:019

National Bureau of Standards, Washington, D. C.

ON THE DERIVATIVE OF A POLYNOMIAL AND CHEBYSHEV APPROXIMATION, by T. S. Motzkin and J. L. Walsh. Aug. 25, 1951, 20p. (NBS repl. no. 1444) [CSO-670-54-12] Unclassified

Also published in Proc. Amer. Math. Soc., v. 4: 76-87, Feb. 1953.

Let E be a closed and bounded point set in the complex z-plane, $\mu(z)$ a positive function continuous on E. Let f(z) be continuous on E. The Chebyshev polynomial of best approximation $t_m(z)$ is the polynomial of degree not exceeding m such that $\max\{\mu(z)|f(z) - t_m(z)|\}$, for $z \in E$, is least. In particular, if $f(z) = z^{m+1}$, then $T_{m+1}(z) = z^{m+1} - t_m(z)$ is called the Chebyshev polynomial of degree m + 1 for E with the weight function $\mu(z)$. This paper discusses the properties of these polynomials (explicit expressions, location of zeros) for the case that E is a finite set and contains just one point too many to preclude the case of interpolation when all deviations can be made to vanish. The following theorem is established: Let E be the finite set of distinct points $z_1, \ldots, z_n$ $(n > 1)$, $\omega(z) = (z - z_1)\ldots(z - z_n)$. Let also the positive numbers $\lambda_1, \ldots, \lambda_n$ be given such that $\sum \lambda_i = 1$. Then the Chebyshev polynomial $T_{n-1}(z)$ for E with the weight function $\mu(z_i) = (\lambda_i|\omega'(z_i)|)^{-1}$, is the polynomial

$$T_{n-1}(z) = \omega(z) \sum_1^n \frac{\lambda_i}{z - z_i}.$$

Since $T_{n-1}(z_i) = \lambda_i \omega'(z_i)$, it is observed that the arguments of the quantities $T_{n-1}(z_i)$ are independent of the choice of the λ_i and that the origin belongs to the convex hull of the $T_{n-1}(z_i)$. These results are applied to a discussion of the Chebyshev polynomial of best approximation $t_{n-2}(z)$ to an arbitrary function f(z) and weight function $\omega(z)$ in the case that the set E has exactly n distinct points. (Math. Rev. abstract)

NBS. 09.020

National Bureau of Standards, Washington, D. C.

A GENERALIZATION OF THE KRONECKER CAPELLI THEOREM ON A SYSTEM OF LINEAR EQUATIONS, by S. N. Tchernikow. C. D. Bensier, Jr. and T. S. Motzkin, ed. Feb. 5, 1953, 19p. (NBS repl. no. 2346) (Trans. from Matematicheskii Sbornik, v. 15 (57): 437-447, 1944) (In cooperation with California U., Los Angeles) (Sponsored jointly by National Bureau of Standards, Washington, D. C. and [Air Force] Office of Scientific Research under [CSO-670-54-12] Unclassified

The value of the present paper rests on two main features: it treats, apparently for the first time, linear inequalities with complex coefficients, and it gives, in its real specialization (which the author leaves unmentioned) an explicit criterion for solvability that enables one, in principle, to decide on solvability (compatibility, consistency) from the coefficients by an algebraic-combinatorial method. The type of system treated is the one most important in the theories of errors and observations and of the approximate solution of linear equations.

NBS. 09:021 - NBS. 09:025

NBS. 09:021

National Bureau of Standards, Washington, D. C.

THE NUMBER OF FARTHEST POINTS, by T. S. Motzkin, E. G. Straus, and F. A. Valentine. [1953] [11]p. [CSO-670-54-12] Unclassified

Published in Pacific Jour. Math., v. 3: 221-232, Mar. 1953.

In this mathematical study, a range of general theorems is developed concerning closed convex curves, each point of which has a single point on the curve farthest from it. Also, sets of the Euclidean plane are studied, each point of which has at least 2 points on the set farthest from it. It is revealed that a compact set having the above property lies in the union of a finite number of line-segments.

NBS. 09:022

National Bureau of Standards, Washington, D. C.

THE VARIATION OF THE SPECTRUM OF A NORMAL MATRIX, by A. J. Hoffman and H. W. Wielandt. [Mar. 1953] 6p. (NBS repl. no. 1518) [CSO-670-54-12] Unclassified

Also published in Duke Math. Jour., v. 20: 37-40, Mar. 1953.

The following two theorems are presented and proven: (1) if A and B are normal matrices with eigenvalues $\alpha_1, \ldots, \alpha_n$ and $\beta_1, \ldots, \beta_n$ respectively, then there exists a suitable numbering of the eigenvalues such that $\Sigma_1 |\alpha_1 - \beta_1|^2 \leq ||A - B||^2$, and (2) if A is a normal matrix with spectrum α and k is a positive number, then β is the spectrum of a normal matrix B with $||A-B|| \leq k$ if and only if $d(\alpha, \beta) \leq k$.

NBS. 09:023

National Bureau of Standards, Washington, D. C.

ON SMOOTHING OPERATIONS AND THEIR GENERATING FUNCTIONS, by I. J. Schoenberg. [1953] [32]p. [CSO-670-54-12] Unclassified

Published in Bull. Amer. Math. Soc., v. 59: 199-230, 1953.

This is an exposition of various problems most of which were solved by the author and his collaborators, grouped under the general title of smoothing operations. The problems deal mainly with the characterization and properties of certain transformations belonging to one of the following types. (*) The finite linear transformation $y_l = \sum_1^n a_{lk} x_k$, $l = 1, \ldots, m$. (**) The sequence convolution $y_n = \sum_{-\infty}^{+\infty} a_{n-\nu} x_\nu$. (***) The integral convolution $g(x) = \int_{-\infty}^{+\infty} A(x-t) f(t) dt$. A problem considered for the three types is the characterization of variation-diminishing transformations. For (*) this was solved (partially) by the author (Math. Z., v. 32: 321-328, 1930) and by Motzkin (Basel dissertation, 1933, Jerusalem, 1936). A different solution was also given by Schoenberg and Whitney (Compositio Math., v. 9: 141-160, 1951), who also considered cyclic v.d.t. For (**) the problem was solved by the author (Courant Anniversary Volume, Interscience, New York, 1948, pp. 351-370); the (necessary and sufficient) condition being that $\{a_n\}$ is a totally positive normalized sequence. For (***) the problem was solved by the author (Acta Sci. Math. Szeged, v. 12, Pars B, 97-106, 1950). A necessary and sufficient condition in this case is that except for a sign $A(x)$ be a Pólya frequency function. Various other problems are discussed: notably, when can a transformation (**) be referred to as a smoothing operation (Schoenberg, Quart. Appl. Math., v. 4: 45-99; 112-141, 1946; and Courant Anniversary Volume, same ref. as above); convex curves in higher dimensional spaces, and the problem of characterizing totally positive sequences by means of the associated generating function $\sum_{-\infty}^{\infty} a_n z^n$ which was successfully solved by the author (Courant Anniversary Volume, same ref.), Aissen, Schoenberg and Whitney (Jour. Analyse Math., v. 2: 93-103, 1952); and Edrei (Ibid. v. 2: 104-109, 1952; Canad. Jour. Math., v. 5: 86-94, 1953). (Math. Rev. abstract)

NBS. 09:024

National Bureau of Standards, Washington, D. C.

COMPUTATIONAL EXPERIENCE IN SOLVING LINEAR PROGRAMS, by A. [J.] Hoffman, M. Mannos and others. May 15, 1953, 27p. incl. tables, refs. (NBS repl. no. 2501) [CSO-670-54-12] Unclassified

Also published in Jour. Soc. Indus. Appl. Math., v. 1: 17-34, Sept. 1953.

Three methods are considered for use in solution of problems in linear programming: (1) the simplex method of G. Danizig; (2) the fictitious play method of G. Brown; and (3) the relaxation method of T. S. Motzkin. Certain results obtained by their use in conjunction with the SEAC (computer) at the National Bureau of Standards are tabulated and compared.

NBS. 09:025

National Bureau of Standards, Washington, D. C.

A CHARACTERIZATION OF NORMAL MATRICES, by A. J. Hoffmann and O. Taussky. July 7, 1953, 10p. (NBS rept. no. 2662) [CSO-670-54-12] Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 52: 17-19, Jan. 1954.

A matrix A is called normal if $AA^* = A^*A$, where A^*

is the transposed and conjugate matrix of A. It is known that for a pair of commuting matrtces, A, B, there exists an ordering of the characteristic roots $\alpha_1, \ldots, \alpha_n$ of A and $\beta_1, \ldots, \beta_n$ of B, such that every polynomial p(A, B) has characteristic roots the numbers $p(\alpha_1, \beta_1)$. This property ts, in general, weaker than commutativity, but does imply it if $B = A^*$. It is shown that this property already tmplies commutativity of A and A^* if it ts assumed to holy for only one polynomial, provided the latter is suttably chosen. Polynomials of first and second degree are examined for their suitability. (Contractor's abstract)

NBS. 09:026

National Bureau of Standards, Washington, D. C.

LEAST p-th POWER POLYNOMIALS ON A REAL FINITE POINT SET, by T. S. Motzkin and J. L. Walsh. July 7, 1953, 29p. (NBS rept. no. 2661) (Sponsored jointly by Office of Naval Research and [Air Force] Offtce of Scientific Research under [CSO-670-54-12]) AD 28411 Unclasstfied

Also published in Trans. Amer. Math. Soc., v. 78: 67-81, 1955.

The authors consider polynomials

$$T_{n+1}(z) = z^{n+1} + \sum_{1}^{n+1} b_r z^{n+1-r}$$

which minimize a devtation from zero of the form

$$\delta(|T_{n+1}(z_1), \ldots, T_{n+1}(z_m)|)$$

and the z_k form a ftnite real point set E; tn most of the cases the T_{n+1} are not unique. For a general class of δ, between two zeros of a T_{n+1} lies a potnt of E; numerous other properties are proved. In the case $\delta = \sum u_k |T_{n+1}(z_k)|$, $u_k > 0$, the totality of T_{n+1} form a convex set generated by basic polynomials having their zeros at points of E; the set of T_{m-1} can be found explicttly, even tf E is not real. If $\delta = \sum u_k |T_{n+1}(z_k)|^p$, $p > 1$, a separation property holds for the zeros of T_n, T_{n-1}. Other results connect best aproximations with tnterpolation, covering also cases of approximation by famtlies of functions more general than polynomtals. (Math. Rev. abstract)

NBS. 09:027

Nattonal Bureau of Standards, Washington, D. C.

THE DOUBLE DESCRIPTION METHOD ON THE SEAC, by S. Pollack. Dec. 9, 1953, 6p. Incl. tables. (NBS rept. no. 2961) [CSO-670-54-t2] Unclassifted

The method of double descrtption for ftnding all vertices of a convex set descrtbed by a system of linear tnequalitties has been coded by SEAC tn the (frequently occurrtng) special case that all vartables are non-negative. A general description of the code ts given. The code makes judicious use of 3 magnetic tape units in order to handle the accumulated quantities of information. The object of the code is to find all the vertices of the convex set satisfying

(1) $x \geq 0 \qquad x = (x_1, \ldots, x_n)$
(2) $Ax \geq b$

The computation takes place not in n-dimensional affine space, but in the convex region of n-dtmensional projective space consisting of all potnts $(y_o, y_1, \ldots, y_n)$ where $y_1 \geq 0$, $i = 0, 1, \ldots, n$;

(3) $x_i = \frac{y_i}{y_o}$ $(i = 1, \ldots, n)$.

A number of computational experimerts with the method are presented.

NBS. 09:028

National Bureau of Standards, Washington, D. C.

ON THE SOLUTION OF THE CATERER PROBLEM, by J. W. Gaddum, A. J. Hoffman, and D. Sokolowsky. Dec. 16, 1953, 12p. incl. diagr. tables. (NBS rept. no. 2971) [CSO-670-54-12] Unclassified

Published in Naval Research Logistics Quart., v. 1: 223-229, Sept. 1954.

Walter Jacobs has shown how a problem arising in connection with the overhaul of engines by the Air Force could be treated by linear programming. This paper presents an explicit algorithm for computing the solutions of the problem. The problem is introduced as follows: Let $t_1, \ldots, t_m$ be gtven constants, $r_1, \ldots, r_n$ given non-negative constants, let X be a variable, $z = (z_1, \ldots, z_n)$ be a variable vector lying in the rectangular parallelopiped (1) $0 \leq z_i \leq r_i$, $(i = 1, \ldots, n)$. Let $A_1, \ldots, A_m$ be gtven vectors in n-space, the coordinates of each consisting of 1's and 0's such that: (2) The 1's in each A_i are consecutive; and (3) if the coordtnates tn A_i which are 1 are a, a + 1, ..., b, and the coordinates tn A_j which are 1 are c, c + 1, ..., d, and if $a < c$, then $b \leq d$. We assume tacitly that each A_i contains at least one t. The problem ts: for any number $\lambda \geq 0$, to find values for X and z, subject to (1) and (4) $(A_i, z) \geq t_i - X$ $(i = 1, \ldots, m)$ which minimtze the ltnear form $\lambda X + \sum_{i+1}^{n} z_i$. The solutions to the problem are:

	X	z_1	z_2	z_3
$\lambda \geq 2$	-t	3	5	5
$2 \geq \lambda \geq t$	1	1	5	3
$t \geq \lambda \geq 0$	10	0	0	0

NBS. 09:029

National Bureau of Standards, Washington, D. C.

A REMARK ON THE SMOOTHING PROBLEM, by H. A. Antosiewicz and A. [J.] Hoffman. Dec. 28, 1953, 6p.

NBS. 09:030 - NBS. 09:034

(NBS rept. no. 2995) [CSO-670-54-12] Unclassified

Published in Management Science, v. 1: 92-95, Oct. 1954.

A formula was found for the solution of the problem of smooth patterns of production in the special case where the requirements r_i are increasing. This formula will hold if $0 < r_1 < \ldots < r_{n-1}$, $r_{n-1} > r_n > 0$. Actually, the formula holds more generally if the r_i increase up to a certain value i_0, then decrease to $r_n = 0$. For simplicity, however, attention in this report is confined to the case $i_0 = n - 1$. (Contractor's abstract, modified)

NBS. 09:030

National Bureau of Standards, Washington, D. C.

SMOOTH PATTERNS OF PRODUCTION, by A. J. Hoffman and W. Jacobs. Jan. 20, 1954, 12p. incl. diagr. (NBS rept. no. 3068) [AFOSR-TN-54-98] (NBS proj. no. 1102-10-5116) [CSO-670-54-12] Unclassified

Also published in Management Science, v. 1: 80-91, 1954.

This report considers a simple model, allowing for inventory costs, for scheduling rates of production to meet a projected series of requirements. (Contractor's abstract)

NBS. 09:031

National Bureau of Standards, Washington, D. C.

DISCRETE ANALOGS OF INEQUALITIES OF WIRTINGER, by K. Fan, O. Taussky, and J. Todd. July 29, 1954, 26p. incl. refs. (NBS rept. no. 3488) [AFOSR-TN-54-261] [CSO-670-54-12] Unclassified

Also published in Monatsh. Math., v. 59: 73-90, May 1955.

The first section discusses inequalities in the continuous case. The second and third sections proceed in a discussion of the discrete analogs of those integral inequalities involving functions and their first derivatives and of those involving the function and its second derivatives. In these cases best possible theorems were obtained. In the 4th and 5th sections, the analogs of theorems of Bellman and Norcott are handled by different methods. The best possible theorems are given.

NBS. 09:032

National Bureau of Standards, Washington, D. C.

AN ISOPERIMETRIC INEQUALITY FOR CLOSED CURVES CONVEX IN EVEN-DIMENSIONAL EUCLIDEAN SPACES, by I. J. Schoenberg. [1954] [22]p. refs. [CSO-670-54-12] Unclassified

Published in Acta Math., v. 91: [143]-164, 1954.

Convex properties of polygons and curves are discussed. For the main theorem consider C be a closed curve convex in E_{2n} and let L denote its length. Let $K = K(C)$ be the convex hull of C and let $V = V(K)$ denote the 2n-dimensional volume of K. Then the following inequality holds $L^{2n} \geq (2\pi n)^n n!(2n)!V(K)$ with the equality sign if and only if the curve C agrees up to a rigid motion and a similitude, followed perhaps by a reflexion, with the curve C_0^2 (convex curve). Two related theorems are discussed and various features of all the theorems are analyzed and proved.

NBS. 09:033

National Bureau of Standards, Washington, D. C.

LOWER BOUNDS FOR THE RANK AND LOCATION OF THE EIGENVALUES OF A MATRIX, by K. Fan and A. J. Hoffman. Feb. 6, 1953, 15p. incl. refs. (NBS rept. no. 2246) [CSO-670-54-12] Unclassified

Published in Nat'l. Bur. Standards Applied Math. Series 39, Part 6, 1954, p. 117-130.

Discussion is presented of the problems involved in finding lower bounds for the rank and location of the eigenvalues of arbitrary square matrices and normal matrices. Various facets of the relationships of some of the problems are mentioned. A number of theorems are offered and applied to the various aforementioned problems.

NBS. 09:034

National Bureau of Standards, Washington, D. C.

ON A THEOREM OF OSTROWSKI AND TAUSSKY, by R. Bellman and A. J. Hoffman. [1954] [5]p. [CSO-670-54-12] Unclassified

Published in Arch. der Math., v. 5: 123-127, 1954.

This note is essentially a commentary on the following theorem of Ostrowski and Taussky: if H_1 and H_2 are Hermitian matrices of order n, and H_1 is positive definite, then $|\det(H_1 + iH_2)| \geq \det H_1$. Alternative proofs are given of a generalization and of a special case of this theorem. These proofs employ methods which may be applied to a variety of problems. Also a short demonstration is presented of a well-known inequality of Hardy, Littlewood, and Pólya, the proof of which had already been somewhat simplified by Ostrowski. (Contractor's abstract, modified)

NBS. 09:035

National Bureau of Standards, Washington, D. C.

THE RELAXATION METHOD FOR LINEAR INEQUALITIES, by S. Agmon. [1954] [11]p. [CSO-670-54-12] Unclassified

Published in Canad. Jour. Math., v. 6: 382-392, 1954.

If $\sum_{j=1}^{n} a_{ij}x_j + b_i \geq 0$ (i = 1, 2, ..., m) is a consistent system of linear inequalities, the non-empty solution set A is the product of the m closed half-spaces H_i (i = 1, 2, ..., m) defined in the n-space E_n of the indeterminates x_j by the individual inequalities of the system. Denote by π_i the hyperplane bounding H_i (i = 1, 2, ..., m) and let p be an arbitrary point of E_n. If p non-ϵ A, consider the point $p_1 = p + \lambda(q - p)$, where q is the orthogonal projection of p on a farthest π_i, and λ is a positive constant at most 2. If p_1 non-ϵ A, a similar process yields p_2, and a continuation of the procedure (with λ fixed) either terminates in a point of A or an infinite sequence of points $p_1, \ldots, p_n, \ldots$ is obtained, all outside A. The process is known as the relaxation method for linear inequalities. The principal result of this paper is the fundamental one of justifying the method by proving that if $0 < \lambda < 2$, an infinite sequence yielded by the process converges to a point of A. (Math. Rev. abstract)

NBS. 09:036

National Bureau of Standards, Washington, D. C.

A THEOREM ON ALTERNATIVES FOR PAIRS OF MATRICES, by H. A. Antosiewicz. [1955] [2]p. (NBS rept. no. 2978) [CSO-670-54-12] Unclassified

Published in Pacific Jour. Math., v. 5: 641-642, 1955.

It is shown that the following two versions of the transposition theorem, in which A, B are matrices, A', B' their transposes, x, y, u column vectors and ≥ 0 means ≥ 0 but not $= 0$, are easily deducible from each other. (1) Either A'u >0, B'u ≥ 0 for some u or Ax + By = 0 for some x ≥ 0, y ≥ 0. (2) Either A'u ≥ 0, B'u ≥ 0 for some u or Ax + By = 0 for some x > 0, y ≥ 0. (Math. Rev. abstract)

NBS. 09:037

National Bureau of Standards, Washington, D. C.

A DETERMINANTAL INEQUALITY, by K. Fan and J. Todd. Apr. 27, 1954, 10p. incl. refs. [Project no. R354-10-8] [CSO-670-54-12] Unclassified

Published in Jour. London Math. Soc., v. 30: 58-67, Jan. 1955.

An equality was first established by J. E. Chassan, OEG, using statistical considerations. It is relevant to the determination of the position of an object, based on line-of-sight observations. Direct algebraic proofs of the insight observations and wide generalization of it are given. (Contractor's abstract)

NBS. 09:038

National Bureau of Standards, Washington, D. C.

PROCEEDINGS OF THE SECOND SYMPOSIUM IN LINEAR PROGRAMMING, WASHINGTON, D. C. (Jan. 27-29, 1955), 2 vols., by H. A. Antosiewicz, ed. [1955] 685p. incl. diagrs. refs. [CSO-670-54-12] Unclassified

A linear Programming Symposium, sponsored by the Air Force Office of Scientific Research, was held jointly by the National Bureau of Standards and the Directorate of Management Analysis, DCS/Comptroller, USAF, in Washington, D. C., 27-29 January 1955. The thirty-three papers presented appear in these two volumes of the Proceedings (six by abstract), under the general headings of Applications and Economic Theory (in Volume I), and Computation, the Theory of Linear Inequalities, and Developments in Linear Programming (in Volume II). The papers range from the basic theory concerning the solution of linear inequalities to a representative number of different applications.

NBS. 09:039

National Bureau of Standards, Washington, D. C.

AN EXTREMUM PROPERTY OF SUMS OF EIGENVALUES, by H. [W.] Wielandt. [1955] [5]p. [CSO-670-54-12] Unclassified

Published in Proc. Amer. Math. Soc., v. 6: 106-110, Feb. 1955.

Let A be a Hermitian operator in n-dimensional unitary space R_n, having eigenvalues $\alpha_1 \geq \alpha_2 \geq \ldots \geq \alpha_n$. Let S be a subset of the set $\{1, 2, \ldots, n\}$, and Let $R = (R_\sigma)_{\sigma \epsilon S}$ be a family of subspaces of R_n such that $\dim R_\sigma = \sigma$, $R_\sigma \subset R_\tau$ $(\sigma \leq \tau)$. Let $A_R = \min \{\sum_{\sigma \epsilon S}(Ax_\sigma, x_\sigma): x_\sigma \epsilon R_\sigma, (x_\sigma, x_\tau) = \delta_{\sigma\tau}\}$. Then the author shows that $\sum_{\sigma \epsilon S} \alpha_\sigma = \max_R A_R$. A dual result is also given. The author then deduces the following theorem. Let A, B and C be Hermitian operators such that A + B = C. Let (α_ν), (β_ν), (γ_ν) be their respective sequences of eigenvalues, each arranged in decreasing order. Let S be a subset of $\{1, 2, \ldots, n\}$ containing k elements. Then

$$\sum_{\sigma \epsilon S} \gamma_\sigma \leq \sum_{\sigma \epsilon S} \alpha_\sigma + \sum_{k=1}^{k} \beta_k.$$

This is shown to be equivalent to a statement by V. Lidskiĭ (Dokl. Akad. Nauk SSSR (N.S.), v. 75: 769-772, 1950): if α, β, γ are the points (α_ν), (β_ν), (γ_ν) and the above assumptions hold, then γ lies in the

NBS. 09:040 - NBS. 09:042

convex cover of the n! points $\alpha + P\beta$, where P runs over all n x n permutation matrices. (Math. Rev. abstract)

NBS. 09:040

National Bureau of Standards, Washington, D. C.

SOME METRIC INEQUALITIES IN THE SPACE OF MATRICES, by K. Fan and A. J. Hoffman. [CSO-670-54-12] Unclassified

Published in Proc. Amer. Math. Soc., v. 6: 111-116, Feb. 1955.

Let $||A||$ be any unitarily invariant norm in the vector space of n x n matrices over the complex field, i.e., such that $||A|| = ||UA|| = ||AU||$ for every unitary matrix U. The authors prove the following inequalities. If $A = UH$, where U is unitary and H is non-negative definite, and W is also unitary, then $||A-U|| \leq ||A-W|| \leq ||A + U||$. This is analogous to the statement that if $z (\neq 0)$ is a complex number, the nearest and farthest points of the unit circle are $\operatorname{sgn} z = z/|z|$ and $-\operatorname{sgn} z$. If H is Hermitian, then $||A - \frac{1}{2}(A + A^*)|| \leq ||A - H||$. (The point of the real axis nearest to z is $\Re z$. If H and K are Hermitian, and U and V are their respective Cayley transforms, i.e., $U = (H - iI)(H + iI)^{-1}$, $V = (K - iI)(K + iI)^{-1}$, then $||U - V|| \leq 2||H - K||$. Furthermore if (α_ν) and (β_ν) are the singular values of $\frac{1}{2}(U - V)$ and $H - K$ respectively, each sequence being arranged in decreasing order, then $\alpha_\nu \leq \beta_\nu (1 \leq \nu \leq n)$. (Math. Rev. abstract)

NBS. 09:041

National Bureau of Standards, Washington, D. C.

PAIRS OF MATRICES WITH PROPERTY L, [PART] II, by T. S. Motzkin and O. Taussky. [1955] [5]p. [CSO-670-54-12] Unclassified

Published in Trans. Amer. Math. Soc., v. 80: 387-401, Nov. 1955.

This paper, equally interesting as to results and method, continues the study of pairs of matrices, A, B (over an algebraically closed field F of characteristic $p \geq 0$) with the property L (that is, if α_i, β_i are the roots of A, B taken in a certain order, then $\lambda\alpha_i + \mu\beta_i$ (i = 1, ..., n) are those of $\lambda A + \mu B$ for all $\lambda, \mu \in F$), which the authors began in Part I (same Trans., v. 73: 108-114, 1952). The roots of $\lambda A + \mu B$ are the roots in ν of the polynomial

$$f(\lambda, \mu, \nu) = |\nu I - \lambda A - \mu B| = \prod_{i=1}^{n} f_i \nu^i$$

whose ν-discriminant Δ (like the coefficient f_i) is a form in λ, μ; its roots in the ratio λ/μ are the so-called discriminant roots of the pencil $\lambda A + \mu B$. In the case of property L one has $f(\lambda, \mu, \nu) = \prod_{i=1}^{n}(\nu - \lambda\alpha_i - \mu\beta_i)$ and therefore $\Delta = \prod_{i<k}(\lambda\alpha_i + \mu\beta_i - \lambda\alpha_k - \mu\beta_k)^2$. Thus all discriminant roots are of even order (except when $\Delta \equiv 0$) and their number is $\leq \frac{1}{2}n(n-1)$ in the case L. Conversely, a pair A, B is said to have the property D if all its discriminant roots are of even order or if $\Delta \equiv 0$. Thus from L follows D. The first part of the paper establishes a sufficient condition for D to imply L. In the case of characteristic $p \neq 2$ that is so if no $\lambda A + \mu B$ has a root of multiplicity ≥ 3 or two different double roots. The proof is based on a discussion of the so-called characteristic curve C of the pencil $\lambda A + \mu B$ which, in the projective λ, μ, ν-plane over F, is represented by the equation $f(\lambda, \mu, \nu) = 0$. In the case L it splits into straight lines. By counter-examples it is shown that the conditions are necessary if $p \neq 2$ and $p \neq 2, 3, 5$, respectively. If $p = 2$ all pairs have property D, but not necessarily L. If $p \neq 2$ and $n = 2$, then D (with $\Delta \not\equiv 0$) implies L and thus, apart from scalar multiples, there is only one matrix with double characteristic root in an L-pencil. In the subsequent part of the paper the method of the characteristic curve C is further employed to prove the following results. If in the pencil $\lambda A + \mu B$ all matrices are diagonable and $n \leq p$ (if $p \neq 0$), then A, B have the property L and they can be diagonalized simultaneously and therefore commute. (If $n > p$ the property L must be assumed for this result to hold.) If a single matrix in the pencil is not diagonable, then the theorem fails to be true. The paper concludes with three theorems in a way inverting the preceding result. Assuming the complex pair A, B commutative, it is shown that it is the limit of a sequence of simultaneously diagonable commuting matrix pairs (thus extending the known fact that every complex matrix is the limit of a sequence of diagonable matrices). Commutative A, B over F are in general diagonable; "in general" means that within the manifold of commutative pairs there is a lower-dimensional submanifold of non-diagonable pairs. (Math. Rev. abstract)

NBS. 09:042

National Bureau of Standards, Washington, D. C.

COMPLETE SEQUENCES AND APPROXIMATIONS IN NORMED LINEAR SPACES, by P. Davis and K. Fan. [1956] 64p. refs. (NBS rept. no. 4637) (AFOSR-TN-56-110) (In cooperation with American U., Washington, D. C. and Notre Dame U., South Bend, Ind.) (Sponsored jointly by Air Force Office of Scientific Research under CSO-670-54-12, Office of Naval Research and National Science Foundation) AD 82506 Unclassified

Also published in Duke Math. Jour., v. 24: 183-192, Mar. 1957.

An analysis is made of 4 types of completeness of $\{f_n\}$, a sequence of elements in a normed linear space X: (1) $|\Phi(f_n)| \leq a_n$, $n = 1, 2, 3, \ldots$ implies $\Phi = 0$; (2) $\lim_{n\to\infty} \Phi(f_n) = 0$ implies $\Phi = 0$; (3) $|\Phi_n(f_n)| \geq a_n$,

n = I, 2, 3, ... implies

$\|\Phi\| < b$; and (4) $\sum_{n=1}^{\infty} |\Phi(f_n)|^p < \infty$ implies $\Phi = 0$. The symbol Φ denotes any continuous linear functional on X. Completeness of the first type is called $\{a_n\}$- completeness and theorems are given for constructing $\{a_n\}$ - complete sequences from a given complete sequence. Several examples in concrete function spaces are given to show that the concept of $\{a_n\}$- completeness is a natural one in analysis. Completeness theorems of the Paley-Wiener type (Amer. Math. Soc. Colloq. Pub., v. t9: t00-108, 1934) are proved for the first 3 types of completeness. (ASTIA abstract)

NBS. 09:043

National Bureau of Standards, Washington, D. C.

UNIQUENESS THEORY FOR ASYMPTOTIC EXPANSIONS IN GENERAL REGIONS, by P. Davis. [t955] 16p. (NBS rept. no. 4638) (AFOSR-TN-56-t11) (CSO-670-54-12) AD 82507 Unclassified

Also published in Pacific Jour. Math., v. 7: 849-859, 1957.

Necessary and sufficient conditions on the sequence of constants $\{m_n\}$ are given in order that the relation

$$\|f_n\|^2 = \int_C |f_n(z)|^2 ds$$

$$\int_C \left| \frac{f(z) - a_0 - a_1(z-t) - \ldots - a_{n-1}(z-1)^{n-1}}{(z-1)^n} \right|^2 ds <$$

$Mk^n n!_n{}^2$ will determine f(z) uniquely from the asymptotic coefficients a_n. The uniqueness theorem states that given an arbitrary sequence of positive constants $\{m_n\}$, the class $A(m_n)$ is a uniqueness class for asymptotic expansions at z = t only if for all t > 0, the

$$\lim_{n \to \infty} \sup \int_C \log \left(\sum_{k=0}^{n} \frac{t^k}{m_k^2} |(z-1)^{n-k}|^2 \right) \frac{\partial}{\partial n} \log |m(z)| ds = \infty.$$

The uniqueness theory under consideration is that of distinguishing nontrivial subclasses of A within which the asymptotic expansion at z = t, $f(z) \sim \sum_{n=0}^{\infty} a_n (z-t)^n$ in the sense of Poincaré is unique. The problem relates to a simply connected region D with an analytic boundary C for which z = 0 is an interior point and z = 1 lies on the boundary. The tangent to C at z = t is assumed not to parallel the real axis. (ASTIA abstract)

NBS. 10:001

National Bureau of Standards, Los Angeles, Calif.

CONTRACTIBILITY AND CONVEXITY, by H. W. Kuhn. [1954] [3]p. (Sponsored jointly by Air Force Office of Scientific Research under [CSO-680-56-50], Logistics Project, Office of Naval Research and Princeton U., N. J.) Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 777-779, Oct. 1954.

The purpose of this mathematical study is to present a purely geometrical result that appeared as a by-product of research in the theory of games. Though a proof of the theorem has already been published by I. Liberman (On Certain Characteristic Properties of Convex Bodies, Matem. Sbornik, v. t3: 239-262, 1943), the present proof retains its interest, both for its conciseness and the fact that it reveals a connection between the geometry of convex sets and fixed-point theory. The following result is proved: In order that a locally contractible compact set X in n-dimensional Euclidean space be convex, it is necessary and sufficient that the set X be contractible and that every support contact of X be contractile. Liberman's theorem is stronger than the result just proved in that it does not presuppose local contractibility. This condition entered the proof by way of the fixed-point theorems and it does not seem possible to eliminate it directly without a stronger theorem than exists in the literature.

NBS. t I:00t

National Bureau of Standards, Washington, D. C.

DAMPING OF ELASTICALLY SUPPORTED ELEMENT IN A VACUUM TUBE, by S. Levy, E. V. Hobbs and others. June t952, 7p. illus. diagrs. (NBS rept. no. t707) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-t8-600-22] and Atomic Energy Commission) ATI 207894 Unclassified

This report describes a phase of the development work on the Ramberg vacuum tube accelerometer. It is shown that it is possible to damp the motion of an element in a vacuum by making the tube part of a two-degree-of-freedom system. The equations of motion of this system are presented. The optimum values of the parameters are determined on SEAC, the Bureau of Standards electronic automatic computer, for a particular set of design requirements. In carrying out this computation, SEAC is used not only to compute the responses of the system for given values of the parameters, but also to choose that set of parameters for which the performance is optimum. A description is given of a lube mount built in accordance with the computations and of the degree of damping achieved. (Contractor's abstract)

NBS. t1:002

[National Bureau of Standards, Washington, D. C.]

INVESTIGATIONS OF THE PROPERTIES OF CORRUGATED DIAPHRAGMS, by W. A. Wildhack, R. F.

NBS. 11:003 - NBS. 12:002

Dressler, and E. C. Lloyd. [1955] [38]p. incl. diagrs. tables, refs. (ASME Paper no. 55-A-181) ([AF]OSR-TN-55-409) [CSO-18-600-22] AD 119564 Unclassified

Presented at Diamond Jubilee annual meeting of the Amer. Soc. Mech. Engineers, Chicago, Ill., Nov. 13-18, 1955.

The pressure-deflection characteristics of corrugated diaphragms are correlated by methods of dimensional analysis. Experimental results for various sizes, materials, thicknesses, and shapes of diaphragms indicate that the performance for diaphragms of any given shape may be computed from a dimensionless formula derived from experimental data on other diaphragms of that shape. Linear shell equations are derived for combined bending and stretching effects with lateral loading terms for rotationally symmetrical shells in appropriate independent and dependent variations suitable for complicated meridial shapes, and with boundary conditions associated with practical diaphragm applications. The method used for solving this system of equations on an electronic digital computer is described,and numerical solutions are presented for a specific diaphragm subject to uniform pressure loading. Suggestions are presented for future research, both theoretical and experimental, on diaphragm properties and performance. (A supplement Behavior of all local stresses is attached.) (Contractor's abstract)

NBS. 11:003

National Bureau of Standards, Washington, D. C.

THE VIBRATION OF TRIANGULAR WINGS (Abstract), by R. F. Dressler. [Sept. 1956] [1]p. [CSO-18-600-22] Unclassified

Presented at Ninth International Congress of Applied Mech., Brussels (Belgium), Sept. 5-13, 1956.

The vibration of a delta wing is considered as an eigenvalue problem for the elastic plate equation $\Delta^4 W - \lambda W = 0$ for right triangles of constant thickness having various aspect ratios. One side is clamped, and the other side and hypotenuse are free. The problems are transformed to one isosceles triangular domain with two essential parameters, the aspect ratio and Poisson's ratio, the latter appearing explicitly in the boundary conditions for the free edges. The associated finite difference matrix is solved numerically for its lowest eigenvalue and eigenvector by electronic digital computer. To permit local elimination of mesh points exterior to the hypotenuse boundary, it is necessary to use asymmetric finite-difference operators in the boundary conditions for the free edges and the sharp corner. These then lead to asymmetric matrices. To determine dependence of modal shapes and frequencies upon Poisson's ratio, various problems have been computed using matrices of order 78. The computational method incorporates a technique with orthogonal hypergeometric polynomials of degree 19 to separate eigenvalues for faster convergence. Results for one value of Poisson's ratio are compared with known experimental values due to Gustafson, and indicate the magnitude of overall damping and loading in the experimental cases. (Contractor's abstract)

NBS. 12:001

National Bureau of Standards, Washington, D. C.

AN ACOUSTIC VISCOMETER FOR GASES, I, by M. Greenspan and F. N. Wimenitz. Jan. 2, 1953 [20]p. incl. illus. diagrs. tables, refs. (NBS rept. no. 2658) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-610-55-22], and Atomic Energy Commission) AD 17139 Unclassified

Frequency response measurements were made on several double Helmholtz resonators containing air. From the data so obtained, the viscosity of air was computed on the basis of the classical theory of Kirchhoff. The results are not in agreement with the known viscosity of air and it is concluded that this method does not at present furnish a satisfactory basis for the construction of an acoustic viscometer. However the material of this report would be of value for this purpose if the discrepancies should in the future be explained in terms of a revision of theory or of systematic error in technique. (Contractor's abstract)

NBS. 12:002

National Bureau of Standards, Washington, D. C.

ABSOLUTE MEASUREMENT OF VIBRATION AMPLITUDES, by W. Koidan. Sept. 1953, 11p. incl. diagrs. (NBS rept. no. 2799) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-610-55-22], and Atomic Energy Commission) AD 18512 Unclassified

By means of a modification of the pistonphone, a technique was developed to obtain the response of a capacitance type vibration pickup probe; the reciprocity calibration of a condenser microphone was used as a reference. The raised center portion of a circular piston, driven by a Ba titanate cylinder, projects into one end of a 19.9-cc cavity, the shelf of the piston being located outside of the enclosure. A calibrated condenser microphone is coupled to the other end of the cavity and responds to the sound pressure developed by the piston. The output of an annular capacitance type vibration pickup, which detects the motion of the piston shelf, is compared with the generated microphone voltage. With the microphone removed from the cavity, the output of the probe, located adjacent to the top surface of the piston is compared with that of the annular pickup. The probe response is computed from these measurements and the microphone response. Mechanical coupling

between the driver and the main supporting structure is minimized by the use of vibration mounts and the maintenance of a small, acoustically sealed clearance between the piston and the cavity enclosure. Calibrations of the probe have been obtained from 100 to 10,000 c with an estimated probable error not exceeding 0.5 db. Peak vibration amplitudes as small as 10^{-9} cm can be measured with a comparable degree of accuracy by a similar probe built for high sensitivity. (Contractor's abstract)

NBS. 12:003

National Bureau of Standards, Washington, D. C.

ELASTIC WAVES IN ANISOTROPIC MEDIA, by J. L. Synge. Apr. 2, 1956 [25]p. incl. diagr. (NBS rept. no. 4601) (AFOSR-TN-56-143) [CSO-610-55-22] AD 86301 Unclassified

Also published in Jour. Math. and Phys., v. 35: 323-334, Jan. 1957.

Against the background of 21-constant elastic theory, isotropy presents a highly degenerate case, and the study of waves in isotropic media throws little light on the algebraic structure of the theory of waves in anisotropic media. Some known results are given in tensor notation, for the sake of convenience and compactness, and new general results are developed for waves in a layer of anisotropic material. In the limit in which the layer becomes a half-space, we have a generalization of Rayleigh waves, and it is found that, in general (for a given frequency), the surface waves either do not exist at all, or are propagated in certain discrete directions with certain speeds. Calculations for a medium possessing transverse isotropy are given; it is shown that the slowness surface (or, equivalently, the wave surface) possesses a spheroidal sheet. (Contractor's abstract)

NBS. 13:001

National Bureau of Standards, Washington, D. C.

A STUDY OF THE PERFORMANCE OF PHOTOMULTIPLIERS OPERATED AT HIGH VOLTAGE, by B. Petree and F. Viera, Jr. Nov. 17, 1952 [21]p. incl. diagrs. refs. (NBS rept. no. 2065) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-53-7], and Atomic Energy Commission) AD 972 Unclassified

A study has been made of the performance of type 931-A photomultipliers when the voltage is applied to the electrodes in pulses of a few microseconds duration. It was found that selected tubes can be operated without breakdown at pulsed voltages as high as about 2500 volts, which is twice the rated dc value. Greater amplification and output current are obtained as a result of the increased voltage. The amplification is increased by a factor of 40, while the output current and useful speed of response are increased by a factor of ten. (Contractor's abstract)

NBS. 13:002

National Bureau of Standards, Washington, D. C.

VAPOR PRESSURE OF NITROGEN, by G. T. Armstrong. May 18, 1954 [4]p. incl. diagr. tables, refs. (NBS rept. no. 2543) [AFOSR-TR-55-15] [CSO-670-53-7] AD 67824(a) Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 53: 263-266, Oct. 1954.

The vapor pressure of N has been measured in the liquid range below the normal boiling point (bp), and can be represented by log P (mm) = 6.49594 -255.821/(T-6.660). The normal bp calculated from this equation is 77.364°K. N vapor densities along the saturation lines are represented by log ρT = 3.39858 - 282.953/(T - 3.83), where ρ = vapor density in g/cc. The fugacity function in f/p for the saturated vapor is tabulated. (Contractor's abstract)

NBS. 13:003

National Bureau of Standards, Washington, D. C.

SURFACE TENSION OF OXYGEN, NITROGEN, AND THEIR MIXTURES, by M. L. Reilly and G. T. Furukawa. Feb. 24, 1955, 39p. incl. diagrs. tables, refs. (NBS rept. no. 3958) [AFOSR-TN-55-20] (CSO-670-53-7) AD 67828 Unclassified

The surface tension of liquid oxygen, nitrogen, and 3 of their mixtures was determined by the method of capillary rise in the temperature range from about 70° to 90°K. The results with oxygen and nitrogen are in fair agreement with those published previously. The surface tension of the mixtures has been compared with an equation based on the ideal solution law and was found to agree with a maximum deviation of about 2.5%. A slight modification of the equation using activity in place of mole fraction decreased the maximum deviation to about 2%. (Contractor's abstract)

NBS. 13:004

National Bureau of Standards, Washington, D. C.

LIQUID-VAPOR PHASE EQUILIBRIUM IN SOLUTIONS OF OXYGEN AND NITROGEN AT PRESSURE BELOW ONE ATMOSPHERE, by G. T. Armstrong, J. M. Goldstein, and D. E. Roberts. Jan. 31, 1955, iv. incl. illus. diagrs. tables, refs. (NBS rept. no. 3921) [AFOSR-TR-55-22] [CSO-670-53-7] AD 67824 Unclassified

A cryostat and equilibrium vessel together with auxiliary apparatus for establishing equilibrium between

NBS. 14:001 - NBS. 15:001

liquid and vapor phases of solutions for low-boiling maierial by a circulation method is described. The equilibrium vessel incorporates a novel liquid sampling device. Vapor and ltquid compositions and totat vapor pressures of solutions of O_2 and N_2 were measured atong isotherms at 77.5°, 70°, and 65°K. The activity coefficients of N_2 and O_2 may be represented by equations of the form

$$\frac{RT}{V_{N_2}} \log_e \gamma_{N_2} = A_{12}\varphi^2 O_2, \text{ and } \frac{RT}{V_{O_2}} \log_e \gamma_{O_2} = A_{12}\varphi^2 N_2,$$

in which A_{12} in cal/cc mol has the values 1.22 at 77.5°, 1.38 at 70°, and 1.47 at 65°K. The deviations of the solutions from ideality are much less than is to be expected of regular sotutions, tn which the interaction energy between unlike motecules follows a geomeiric mean taw. The data are not entirety consistent with the assumption thai molar volumes are additive tn the solutions. In an appendix a study of the vapor pressure of N_2 is described. (Contractor's absiract)

NBS. 14:001

National Bureau ot Standards [Washtngton, D. C.]

A PHASE-SAMPLING TELEMETER, by M. G. Pawley and J. O. Dick. Sepi. 29, 1952, 14p. diagrs. (NBS rept. no. 2020) (Sponsored joinity by Office of Naval Research, [Air Force Office of Scientific Research CSO-680-56-20], and Atomic Energy Commtssion) AD 971 Unclassified

The laboratory model of the Phase-Sampltng Telemeter has demonstrated the feastbility of transmitting a number of channels of tnietitgence by mechanicalty swttchtng samptes of sine waves. The phase of a channel with respect to a reference wave, which is also transmitted tnlermittently, is oroportionat to the input for that channet. Although the low-channel sampling rate of one per second does not provide adequate channel frequency response for generat application to guided missite telemeterlng, the extreme simplicity of the iransmiiting unit shoutd prove to be ot tnterest tn appltcations where higher sampting rates are not required, and where the ltmitted ltfe ot a mechantcal commutator ts not a sertous drawback.

NBS. t4:002

Nationat Bureau of Standards, Washington, D. C.

A SING-AROUND ULTRASONIC VELOCIMETER FOR LIQUIDS, by M. Greenspan and C. E. Tschtegg. Jan. 2, t953 [t8]p. tncl. tttus. dtagrs. (NBS rept. no. 2702) (Sponsored joinity by Offtce ot Navat Research, [Air Force Otttce ot Sctentiltc Research CSO-680-56-20], and Atomtc Energy Commisston) AD t7t40 Unctassttted

There has been designed, butlt, and tested a model of an tnsirument utilizing a repetitive pulse technique ("sing-around" system) which automatically measures and records with great precision the speed of sound in a tiquid system as it changes with temperature, pressure or composition. The accuracy is limited principalty by that of the device against which the instrument is calibrated. (Contractor's abstract)

NBS. 14:003

National Bureau of Standards, Washington, D. C.

APPARATUS FOR THE DIRECT DETERMINATION OF THE DYNAMIC BULK MODULUS, by J. E. McKinney, S. Edelman, and R. S. Marvin. [Jan. 30, 1956] [6]p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Office of Navat Research, Atr Force Office of Scientific Research under CSO-680-56-20, Atomic Energy Commission, and National Bureau of Standards) Unclassified

Presented at annual meeting of the Soc. of Rheology, New York, Nov. 2-4, 1955.

Published in Jour. Appl. Phys., v. 27:425-430, May 1956.

An apparatus has been developed for the direct measurement of the reat and imaginary parts of the dynamic bulk modulus of sotid and liquid materials over the frequency range of 50 to 10,000 cps. Ptezoetectric crystals serving as driver and detector, together with the sample and a confining liquid, are contained in a cavity small compared with the wavelength of sound at these frequencies. Static pressure is superposed to eliminate the effect of small air bubbles. The comptex compltances of the sample, confining ttquid, and the cavity, are additive in this region, where the compliance is pure dilatation. The dynamic compliances of several natural rubber-sultur mixtures were obtained tn a preltmtnary evaluation ot the behavtor ot the apparatus. (Contractor's abstract)

NBS. t5:001

National Bureau ot Standards, Washington, D. C.

STATIONARY PRINCIPLES FOR FORCED VIBRATIONS IN ELASTICITY AND ELECTROMAGNETISM, by J. L. Synge. Mar. 26, 1956, t9p. tnct. dtagr. (NBS rept. no. 4582) (AFOSR-TN-56-122) (tn cooperation with Amertcan U., Washtngton, D. C.) [CSO-680-56-38] AD 825t8 Unclassttted

Also published in Proc. 8th Symposium on Appl. Math. ot the Amer. Math. Soc., Apr. t956.

The concepi of a function-space with a suitable scalar product is used to exhibit several siationary prtnctples tn a simple geometrtcal form. The basic technique is to split the problem so that a point of a function-space, which corresponds to the solution of a physical problem, is the point of intersection of 2 orthogonal linear sub-

spaces. If the metric is positive-definite, Schwarz's inequality yields 2 minimum principles. If the metric is indefinite, one orthogonality condition exists which yields 2 stationary principles. The stationary principles are either known or closely related to known results. Illustrations are given for the vibrating membrane, vibrations of an elastic body, and electromagnetic vibrations. A procedure for improving approximations is considered.

NBS. 16:001

National Bureau of Standards, Washington, D. C.

ELASTIC SCATTERING OF PHOTONS FROM 5 TO 30 MEV (Abstract), by E. G. Fulter. 1955, 1p. (CSO-640-55-33) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 1955.

A brief discussion is given of previous measurements that have been made of the elastic scattering of photons having energies in the region of the "giant resonance." This is followed by a brief description of the experimental techniques that are being used at NBS to study the elastic scattering cross-section for various nuclei. It was this work that led to the first determination of the elastic scattering cross-section as a function of photon energy. The results that have been obtained to date are discussed. These results are presented in the form of a systematics of the photonuclear interaction as derived from the elastic scattering measurements.

NBS. 17:001

National Bureau of Standards, Washington, D. C.

THE ELASTIC SCATTERING OF PHOTONS, by E. G. Fuller and E. Hayward. Feb. 10, 1954 [7]p. incl. illus. table. (NBS rept. no. 3129) ([AF]OSR-TN-54-13) (CSO-670-53-22) AD 28184 Unclassified

Also published in Phys. Rev., v. 94: 732-733, May 1, 1954.

Measurements were made on the elastic scattering cross section as a function of photon energy. X-rays observed were produced by a 50-mev betatron and were scattered by Au, Pb, and U. An NaI(Tl) crystal 5 in. in diameter and 4 in. long, a DuMont 5-in.-diameter photomultiplier tube, a linear amplifier, and a series of discriminators with associated scaling units were used to detect the rays. With the crystal in the direct beam from the betatron at the zero degree position, the number of counts were observed which were produced for a charge collected on the ionization chamber. The resonance scattering for the 3 elements was near 15 mev. (ASTIA abstract)

NBS. 17:002

National Bureau of Standards, Washington, D. C.

NUCLEAR ELASTIC SCATTERING OF PHOTONS, by E. Hayward and E. G. Futter. [1954] [2]p. incl. diagr. table. [CSO-670-53-22] Unclassified

Published in Phys. Rev., v. 95: 1106-1107, Aug. 15, 1954.

The earlier work on the differential cross section at 120° for the nuclear elastic scattering of photons of 10-25 mev by Au, Pb, and U, is extended to 10 energies, 4-28 mev, for Cu, Mn, Sn, Au, Bi, and Pb. In addition to the maximum associated with the "giant resonance," a pronounced peak was found near the γ, n threshold for all elements except Au.

NBS. 18:001

National Bureau of Standards, Washington, D. C.

AN EVALUATION STUDY OF A FAST-NEUTRON SPECTROMETER BASED ON THE TOTAL ABSORPTION PRINCIPLE, by M. R. Ctetand. Oct. 27, 1952 [40]p. incl. diagrs. refs. (NBS rept. no. 2036) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-680-57-2], and Atomic Energy Commission) AD 1815 Unclassified

The Monte Carlo sampling procedure has been used to evaluate a proposed spectrometer for neutrons with energies above 1.0 mev. The instrument employs a cylindrical phosphor 5 centimeters in diameter and 5 centimeters long composed of a half-and-half mixture of phenylcyclohexane and methyl borate activated with 3-5 grams of p-terphenyl and 10-15 milligrams of diphenylhexatriene per kilogram of phosphor. The total light output pulse which results from recoil charged particles indicates the neutron energy and is observed with a photomultiplier tube. It was arranged to record only those events in which the neutron is first thermalized by elastic collisions and then captured by boron. The capture criterion with the small volume scintillator strongly favors neutrons that lose most of their energy at the first collision and leads to good energy resolution. The efficiency for the borated scintillator is shown to be 0.15% and the energy resolution about 10% for 14.0 mev neutrons. The mean time interval between the recoil proton pulse and the boron capture pulse is shown to be 2.0 microseconds with 18.8% B^{10} in the methyl borate. A brief summary of other neutron spectrometers and calculations for an infinite volume scintillator are also presented. (Contractor's abstract)

NBS. 18:002

National Bureau of Standards, Washington, D. C.

CHARACTERISTICS OF SR-4 AND G-H POST YIELD

NBS. 18:003 - NBS. 18:005

RESISTANCE STRAIN GAGES, by D. Namkoong, D. W. Hinze, and W. R. Campbell. June 1953, 5p. illus. diagrs. (NBS rept. no. 2537) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-680-57-2], and Atomic Energy Commission) AD 17289 Unclassified

Twenty SR-4 type PA-3 resistance strain gages and twenty G-H type A820S resistance strain gages were calibrated for post yield tensile strains up to 0.14. For strains up to 0.04 the strains indicated by ten single gages of each type did not differ from the applied strain by more than 1500 x 10^{-6}. For strains above 0.04 and up to 0.065 nine of the ten G-H gages indicated strains within 3.7% of the applied strain. All ten G-H gages failed at applied strains between 0.07 and 0.12. For strains above 0.04 and up to 0.12 nine of the ten SR-4 gages indicated strains within 4.7% of the applied strain. No gage failed at strains less than 0.12, and seven of the gages sustained strains up to 0.135, the maximum strain applied. Higher strains could not be applied because of limitations in the strain-measuring equipment. (Contractor's summary)

NBS. 18:003

National Bureau of Standards, Washington, D. C.

CHARACTERISTICS OF TWO TYPES OF TEMPERATURE-COMPENSATED RESISTANCE STRAIN GAGES, by D. W. Hinze, D. Namkoong, and W. R. Campbell. June 1953 [15]p. incl. illus. diagrs. table, refs. (NBS rept. no. 2552) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research CSO-680-57-2], and Atomic Energy Commission) AD 17288 Unclassified

Tensile calibrations and measurements of gage output vs. temperature were made on SR-4 gages of types EBD-1S and EBD-1D. Six gages of each type were calibrated for strains up to 0.0025 at temperatures ranging from 70° to 250°F. With the exception of two gages of type EBD-1S, calibration factors were within the tolerance set by the manufacturer. No significant variation of calibration factor with temperature was observed. The performance of the gages with respect to linearity, zero shift, and stability was generally improved by preloading. Eight EBD-1D gages and nine EBD-1S gages attached to unstressed bars were subjected to varying temperatures in the range 0° to 300°F. Gage output, measured as apparent strain, for the EBD-1D gages on 24S-T aluminum alloy did not vary more than ± 50 x 10^{-6} for temperatures between 50° and 280°F. Temperature sensitivity in this range from the EBD-1S gages on hot rolled spring steel produced maximum variations in apparent strain of ± 100 x 10^{-6}. (Contractor's summary)

NBS. 18:004

National Bureau of Standards, Washington, D. C.

PHOTOELECTRIC COUNTER FOR AN INTERFEROMETRIC CALIBRATION DEVICE, by H. R. Smith and D. R. Tate. June 1953, 5p. illus. diagr. (NBS rept. no. 2536) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research under [CSO-680-57-2], and Atomic Energy Commission) AD 17173 Unclassified

A description is given of a simple photoelectric device for counting linear interference fringes as they move across the field of a pair of interferometer plates. The counter requires no modification of the viewing system designed for visual use. The use of the counter has been found to speed up calibrations without a loss in accuracy and has permitted use of interferometry over greater ranges of extension than would be practical with visual counting.

NBS. 18:005

National Bureau of Standards, Washington, D. C.

DIRECT MEASUREMENT OF THE NUCLEAR ABSORPTION OF X-RAYS (Abstract), by H. W. Koch and R. S. Foote. Apr. 30, 1953 [1]p. [CSO-680-57-2] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 455, July 15, 1953.

The nuclear absorption of x-rays from a betatron operating at 30 mev has been measured directly for carbon and copper. The technique employed good geometry, the maximum tolerable number of absorber mean free paths (4 to 8.5), and an x-ray spectrometer with high detection efficiency and good energy resolution. Carbon absorbers 5 cm in diameter, up to 306 cm long and an absorber 25 cm in diameter and 30 cm long were used. The x-ray cone was 0.06 degrees. The source to spectrometer distance was 935 cm. The detector was a calibrated NaI total absorption spectrometer. The pulse-height spectrum produced by x-rays transmitted by a particular absorber was analyzed and showed marked depressions in intensity due to nuclear absorption. The percentage intensity change is proportional to the absorber length and to the ratio of nuclear to electronic absorption. The maximum length is limited by the geometry. The copper results give one nuclear absorption peak at approximately 18 mev as expected. The carbon data show pronounced nuclear absorption peaks below 20 mev. (Contractor's abstract)

NBS. 18:006

National Bureau of Standards, Washington, D. C.

TOTAL-ABSORPTION X-RAY SPECTROMETRY: APPLICATION TO BETATRON EXPERIMENTS, by H. W. Koch and R. S. Foote [1954] [3]p. incl. illus. diagrs. [CSO-680-57-2] Unclassified

Published in Nucleonics, v. 12: 51-53, Mar. 1954.

Physical and operating charactertstics as well as general applicattons are given of a NaI sctntillation spectrometer which can measure the energy of individual x-ray photons tn the range from ½ to 50 mev with an energy resolution better than 11% and a detection efficiency larger than 80%. The spectrometer ts called a total absorption spectrometer because tndtvidual x-ray photons that enter the device are almost totally absorbed tn a sctntillator. The absorption results tn a light pulse. The magnitude of a majority of the light pulses ts proportional to the x-ray photon energy. Research involving use of the spectrometer is briefly summartzed with regard to: (1) determination of the shape of the x-ray photon spectrum from a betatron; (2) the study of the "giant resonance" nuclear absorption; and (3) observation of x-ray absorption by tndtvidual nuclear levels. (Extracted from rept.)

NBS. 18:007

National Bureau of Standards, Washington, D. C.

SCINTILLATION SPECTROMETERS FOR MEASURING THE TOTAL ENERGY OF X-RAY PHOTONS, by R. S. Foote and H. W. Koch. [Oct. 7, 1953] [13]p. incl. diagrs. tables, refs. [CSO-680-57-2] Unclassified

Published in Rev. Sctent. Instruments, v. 25: 748-758, Aug. 1954.

X-ray spectrometers described that operate on the principle of totally absorbing the energy of an individual x-ray photon tn a sctntillator. Experiments with sctntillators of xylene containing terphenyl, and of sodtum iodide activated by thallium, show that detection efficiencies better than 80% and energy resolutions better than 10% are attainable in the x-ray energy range from ½ to 50 mev. Monte Carlo calculations and crude scaling laws that simplify extrapolations to othar stze scintillators are discussed. (Contractor's abstract)

NBS. 18:008

National Bureau of Standards, Washington, D. C.

DIRECT OBSERVATION OF THE NUCLEAR ABSORPTION AND ELASTIC SCATTERING OF X-RAYS, by H. W. Koch. [1955] [5]p. [CSO-680-57-2] Unclassified

Published in Proc. Conference on Nuclear and Meson Physics, Glasgow (Scotland) (July 1954), 1955, p. 155-159.

The application of large crystal scintillation spectrometers to the measurement of x-ray energies makes possible 2 companion experiments. In the first, the white light or continuum of x-rays from a 50-mev betatron ts transmitted by long absorbers. At constant energy, the x-ray photons are detected individually and their energies recorded. Dark absorption bands are found in the spectra resulting from giant resonance absorption. In the 2nd experiment, elastic scattering cross section is measured for x-rays scattered at an angle of 120°. In most cases the cross-section curves show 2 peaks.

NBS. 18:009

National Bureau of Standards, Washington, D. C.

RESPONSE OF A SODIUM IODIDE SPECTROMETER TO HIGH ENERGY ELECTRONS (Abstract), by H. W. Koch, J. M. Wyckoff, and B. Petree. 1955, 1p. [CSO-680-57-2] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28, 1955.

Published in Phys. Rev., v. 99: 663, July 15, 1955.

Mono-energetic electrons from a 50 mev betatron operated between 1 and 20 mev were used to study the performance of a 5" by 4" and a 5" by 9" NaI(Tl) total absorption spectrometer. The pulse height distributions produced by bombardment of the central axis of the large crystals show very peaked distributions with small tails. The energy resolution reached tts optimum valus at 10 mev where the total width at half maximum ts 4%, whereas the comparable resolution for 10 mev x-rays would be 9%. This added width to the x-ray pulse height distribution results largely from the escape of the annihilation photon from the crystal. Synthesis of the x-ray distributions from the electron distributions and the linearity of spectrometer response to electron energy will be discussed. (Contractor's abstract)

NBS. 18:010

National Bureau of Standards, Washington, D. C.

THE ANGULAR DISTRIBUTION OF 15-MEV GAMMA RAYS SCATTERED FROM C^{12} (Abstract), by J. E. Leiss and J. M. Wyckoff. [1956] [1]p. [CSO-680-57-2] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 197, Apr. 26, 1956.

NBS. 18:011 - NBS. 18:013

Fuller, Hayward, and Svantesson have observed a 15-mev gamma ray tn their elastic scattering experiments and have associated this line with resonant scattertng by the 15.09-mev level tn C^{12}. Ustng the NBS synchrotron operating at 82 mev and a NaI detector in a technique similar to that of Fuller and Hayward but wtth better resolution, the angular dtstribution has been measured of these 15-mev gamma rays scattered tn a 2.32 gm/cm^2 graphite target. This distribution is conststent with the $1 + \cos^2\theta$ dtstribution expected for dipole absorption but is inconsistent with $1 - 3\cos^2\theta + 4\cos^4\theta$ expected for quadrupole absorption. This result establishes this level in C^{12} as a J = 1 level. The absorption length for the gamma rays in graphite after correction for Compton degraded photons in the target ts 2.2 gm/cm^2 in reasonable agreement wtth Fuller et al. (Contractor's abstract)

NBS. 18:011

National Bureau of Standards, Washington, D. C.

CRYSTAL SPECTROMETER CALIBRATION OF A HIGH ENERGY X-RAY INTENSITY MONITOR (Abstract), by H. W. Koch, J. E. Leiss, and J. S. Pruitt. 1956, 1p. [CSO-680-57-2] Unclassifted

Presented at meettng of the Amer. Phys. Soc., Washington, D. C., Apr. 26, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 199, Apr. 26, 1956.

Preltminary tests have been made of a new technique for the absolute energy calibration of high energy x-ray monitors. With this method the total number of x-ray photons transmttted through a carbon absorber is determined with a 5-in. diameter, 9-in. long sodium iodide crystal in a good geometry arrangement. Such a spectrometer counts about 96% of the incident photons. If the primary photon spectrum and the carbon absorption coefficients are assumed known, the spectrometer counts can be related to the total energy in the primary x-ray beam. Measurements were made with carbon absorber lengths of 306, 401, and 497 gm/cm^2 for synchrotron energies of 56, 80, and 110 mev. The data were used to determine a value of 4480 erg/esu/cm for a flat ionization chamber monitor at 80 mev. The estimated uncertainty is ± 4%, mostly due to an inadequate knowledge of the carbon absorption coefficients, to which the calculations are very sensitive. Improved techniques should allow a reduction of this uncertainty. This method allows accurate monitor calibrations with smaller beam intensities than can be used with a calorimeter. (Contractor's abstract)

NBS. 18:012

National Bureau of Standards, Washington, D. C.

RESPONSE OF A SODIUM IODIDE SCINTILLATION SPECTROMETER TO 10- TO 20-MILLION ELECTRON VOLT ELECTRONS AND X-RAYS, by H. W. Koch and J. M. Wyckoff. [1956] [8]p. tncl. dtagrs. table, refs. (Research paper no. 2682) [CSO-680-57-2] Unclassifted

Published in Jour. Nat'l. Bur. Standards, v. 56: 319-326, June 1956.

The response of a large-crystal sodium todide spectrometer was studied for tndivtdual monoenergetic electrons extracted from a 50 million electron-volt betatron operated between 1 and 20 mev. The energy resolution with crystals 5 in. in diameter by 4 in. in length and 5 in. in diameter by 9 in. in length reaches its optimum value for electrons of 6 mev, where the total wtdth of the pulse-hetght distributions for 11 and 19 mev monoenergetic x-ray photons are made by using the experimental electron pulse-hetght dtstributtons. The computed results compare favorably wtth the measured pulse-height dtstrtbutions for 11.6 and 17.6 mev gamma rays. Synthests provides one of the few procedures for predtcting spectrometer response functtons tn this x-ray energy range. (Contractor's abstract)

NBS. 18:013

National Bureau of Standards, Washington, D. C.

DIFFERENTIAL CROSS SECTION MEASUREMENTS FOR THIN-TARGET BREMSSTRAHLUNG PRODUCED BY 2.7 TO 9.7 MEV ELECTRONS, by N. Starfelt and H. W. Koch. Jan. 25, 1956 [39]p. tncl. diagrs. tables, refs. (NBS rept. no. 4507) [CSO-680-57-2] Unclassified

Also published in Phys. Rev., v. 102: 1598-1612, June 15, 1956.

The electron beam removed from a 50-mev betatron and a total absorption scintillation spectrometer containing a sodium iodide crystal 5 in. in diameter and 9 in. long were used for the measurement of bremsstrahlung cross sections that are differential in photon energy and angle. Thin targets of beryllium, aluminum, and gold were bombarded by electrons with kinetic energies of 2.72, 4.54, and 9.66 mev. The bremsstrahlung spectra from thick tungsten targets were also studied. The results were compared with the differential cross-section predictions of Sauter, Schiff, and Gluckstern and Hull. The spectral shapes obtained with the beryllium and aluminum targets agreed with those expected from theory for the electron energies of 2.72 and 4.54 mev. The 9.66-mev experiment gave 20% more low-energy than intermediate-energy photons when compared with theory. For gold the experimental cross sections for the high photon energies are larger than theory with the differences increasing with decreasing electron primary energy. Evidence for electron-electron bremsstrahlung is obtained from the absolute magnitude of the differential cross section, which are $(Z + 1)/Z$ times larger than theory within the

experimental errors. The thick-target tungsten spectra produced by 9.66-mev electrons decreased more rapidly with increasing photon energy than did the thin-target cross sections derived by Schiff. (Contractor's abstract)

NBS. 18:014

National Bureau of Standards, Washington, D. C.

MEASUREMENT OF THE RESPONSE OF HIGH-ENERGY X-RAY DETECTORS (Abstract), by J. E. Leiss, J. M. Wyckoff, and H. W. Koch. 1956, 1p. [CSO-680-57-2] Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 284, June 21, 1956.

Quantitative interpretations of most data from high-energy x-ray detectors, particularly spectrometers require accurate pulse height distributions produced by mono-energetic x-rays. These response distributions have been difficult to obtain above 20 mev. A preliminary study will be described which has been used to measure the response of a 5" by 9" sodium iodide spectrometer to 33 mev x-rays. The method consists in the unfolding of an experimental curve of counts, $a(E_o, k_o)dk$, recorded in a fixed differential pulse height bin, dk, at k_o and produced by a synchrotron spectrum, whose peak energy, E_o, was varied from 30 to 60 mev. The spectrum was distorted by a 180-cm carbon absorber so that the total count of transmitted photons could provide a sufficiently accurate normalization of the counts in the activation curve. The desired response S(K, E)dk for a photon of energy E, can be evaluated from the activation integral $a(E_o, k_o)dk = \int_0^{E_o} P(E_o, E)e^{-\tau x} s(k_o, E)dEdk$ with tables of the inverse of the bremsstrahlung number spectrum matrix, $P(E_o, E)$. The method can provide response functions of detectors for any given experimental arrangement. (Contractor's abstract)

NBS. 18:015

National Bureau of Standards, Washington, D. C.

ELASTIC SCATTERING OF ELECTRONS AND POSITRONS BY POINT NUCLEI, by J. A. Doggett and L. V. Spencer. [1956] [5]p. incl. tables. [CSO-680-57-2] Unclassified

Published in Phys. Rev., v. 103: 1597-1601, Sept. 15, 1956.

The Mott cross section has been systematically tabulated, by means of an electronic computer, for intermediate relativistic energies. Results are presented at 15° angular intervals, for electrons and positrons, for Z = 6, 13, 29, 50, 82, 92 and for energies 10, 4, 2, 1, 0.7, 0.4, 0.2, 0.1, and 0.05 mev. Intercomparisons with earlier results are presented, as well as a subsidiary tabulation of a function important in the limit $\theta \longrightarrow 0$. (Contractor's abstract)

NBS. 18:016

National Bureau of Standards, Washington, D. C.

PARAMETERS OF THE 15 MEV LEVEL IN C^{12} (Abstract), by E. Hayward and E. G. Fuller. [1956] [1]p. [CSO-680-57-2] Unclassified

Published in Physica, v. 22: 1138, Nov. 1956.

Bremsstrahlung x-rays have been used to excite a level in C^{12}, presumably the first T = 1 state which decays by magnetic dipole radiation to the ground state. The scattered photons have been detected by a NaI(Tl) spectrometer and the pulse height distribution studied. Measurements have been made of (1) the absolute number of 15 mev photons scattered, which is a measure of the integral scattering cross-section, and (2) the attenuation produced when a carbon absorber is placed between the betatron and the scattering target. The latter is a measure of the peak absorption cross-section in the level. Both quantities have been measured using either graphite or polystyrene targets and absorbers approximately 2 g/cm^2 in thickness. For example, the self-absorption (and therefore the peak absorption cross-section) is so great that only half of the photons are transmitted through such an absorber whereas electronic processes would only reduce the intensity by 3%. If the nuclear absorption cross-section associated with this level is expressed as a Doppler-broadened Breit-Wigner formula, the observed transmission yields a value of 24.6 ± 2.5 barns for the peak absorption cross-section in the resonance. Since the maximum cross-section that a magnetic dipole transition proceeding from a J = 1 level can have is $4\pi\lambda^2/\pi$ or 32 barns at 15 mev, the measured peak cross-section gives $\Gamma_\gamma/\Gamma = 0.77 \pm 0.0$[illegible] for the branching ratio. The level width, obtained by combining the peak absorption cross-section with the integral scattering cross-section of 2.1 ± 0.2 mb/mev, is then 74 ± 11 ev. (Contractor's abstract)

NBS. 19:001

National Bureau of Standards, Washington, D. C.

BOLTZMANN EQUATION FROM THE STATISTICAL MECHANICAL POINT OF VIEW, by M. S. Green. Nov. 7, 1955 [20]p. incl. diagrs. refs. (NBS rept. no. 3327) [AFOSR-TN-55-272] (Sponsored jointly by Air Force Office of Scientific Research under CSO-630-55-34 and Office of Naval Research) Unclassified

Published in Jour. Chem. Phys., v. 25: 836-855, Nov. 1956.

NBS. 20:001 - NBS. 21:001

The Bolizmann equation for a spactally uniform situation is derived by the method of expansion of the molecular distribution functions tn powers of the concenlration. These expansions are shown to imply thai afier a time which depends on the initial phase space disiribution, and for configurations in which the molecules are noi ioo widely separaied, all the disiribution functions are functionals of the single-particle distribution. The single-particle distribution obeys an equation which ts a generalization of the Bolizmann equation which includes the effecis of triple and higher collisions. The irtple-collision term ts given explictily.

NBS. 20:001

National Bureau of Siandards, Washington, D. C.

NUCLEAR ELASTIC SCATTERING OF PHOTONS, by E. G. Fuller and E. Hayward. Jan. 15, 1956 [9]p. tncl. diagrs. tables, refs. (AFOSR-TN-56-260) (CSO-630-55-35) AD 88980 Unclassified

Also published in Phys. Rev., v. 101: 692-700, Jan. t5, 1956.

A NaI(Tl) scintillation spectromeier biased io deteci only photons tn the upper energy tip of a betairon-produced bremsstrahlung spectrum ts used to measure the differential nuclear elastic scattering cross section at 120° as a function of photon energy from 4 io 40 mev. The targets ranged in Z from Na io U. Total cross sections are calculaied by assuming a dipole angular distribution. The scaiiering cross sections tend io exhibii two maxima, one below the particle threshold thai corresponds to the scattering by separaie levets, and one thai follows the giant resonance for photon absorption. Both the maximum cross section and the energy of the giani resonance vary smoothly with A from Na to U and are roughly proportional to $(NZ/A)^2$ and $A^{-1/3}$, respectively. The dipole dispersion relation ts used to compare the scattering data with the neutron yield data tn the giani resonance region. (Coniractor's abstract)

NBS. 20:002

National Bureau of Standards, Washington, D. C.

OXYGEN-16(γ, pγ')N^{t5} AND O^{16}(γ,pγ')O^{15} (Abstract), by N. Svantesson. [1956] [1]p. (CSO-630-55-35) Unclassified

Presented ai meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. t: 27, Jan. 30, 1956.

The pulse height distribution produced by the photons emitted by a waier targei trradtated by bremsstrahlung spectra was studied as a function of the peak energy of the bremssirahlung specira from 16-30 mev. A 20 channel analyzer was used io cover the range of pulse stzes from 2-12 mev. A peak appears tn the pulse heighi dtsirtbution for bremsstrahlung energies greaier than 21 mev. A compartson with the pulse height disiribution produced by the 4.43 mev phoion from a RaD-Be source gives 6.3 mev as the energy of the phoion emiiied by the oxygen target. Both the energy and the threshold of this line are consisteni with tts resulting from the decay of the second excited staies of N^{15} and O^{15} following (γ, p) and (γ, n) processes in O^{16}. Ii is estimated that no other lines tn N^{15} and O^{15} are preseni in the pulse height disiributions with intensities as greai as 20% of thai of the 6.3 mev line. The activation curve of this line indicates thai the cross section for tis production peaks at aboui 24 mev with a cross section of a few miliibarns. (Contracior's abstract)

NBS. 20:003

National Bureau of Standards, Washington, D. C.

X-RAY EXCITATION OF 15-MEV LEVEL IN C^{12} (Abstract), by E. G. Fuller, E. Hayward, and N. Svaniesson. 1956, 1p. (CSO-630-55-35) Unclassified

Presenied ai meeting of the Amer. Phys. Soc., New York, Jan. 30- Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 10, Jan. 30, 1956.

A pronounced maximum in the spectrum of photons scaiiered by a carbon targei trradiaied by bremsstrahlung specira having 15 mev < E_{max} < 40 mev was observed. The threshold for the production of this line based on the Cu^{63}, Cu^{65}, B^{10}, and Be^9 (γ, n) thresholds is 13.0 ± 0.2 mev. The line presumably results from the elastic scatiering by the 15.09 mev, T = 1 level tn C^{12}. The excitation function of this line as a function of E_{max} is consisteni with a 15.09 mev isochromat calculated from Schiff bremsstrahlung spectra. When 2.1 g/cm^2 of graphiie was placed between the scattering targei and the betatron, the scattered counts were attenuated by a factor of 0.49 ± 0.04. When 7.8 g/cm^2 of grapiie was placed between the scatiering target and the detector, the scattering intensity was reduced by 0.8t ± 0.07. For this latter case the expected electronic transmission is 0.87. The level width is then less than the energy given the recoiling C nucleus (~10^4 ev). The mean scattering cross sections from 14.4 to 15.8 mev is C.7 ± 0.2 mb. (Contractor's abstract)

NBS. 21:001

National Bureau of Standards, Washington, D. C.

A MINIATURE BARIUM TITANATE ACCELEROMETER, by L. Fleming. Nov. 26, t95t, 22p. incl. diagrs. tables. (NBS rept. no. 1004) (Sponsored jointly by

Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9], and Atomic Energy Commission) ATI-140036 Unclassified

A miniature barium titanate accelerometer is described. Several models of the NBS barium titanate accelerometer have been constructed differing only in dimensions. The small 3/8 in. -diam Model 3 is found most generally useful at NBS where it is used for monitoring vibration sources and for measuring vibrations in comparatively small structures. Experimental results to date show that the sensitivity transverse to the axis is less than one-fifth the sensitivity along the axis. Temperature effects upon sensitivity of "piezoelectric" barium titanate are reported as less than 5% from -60°C to + 70°C. The lower limit is not yet known, but the safe upper limit is about 90°C. Data from controlled experiments on aging effects are at present lacking. General principles of vibration pickups are discussed. The barium titanate accelerometer in the form described has proved highly practical in a variety of vibration-measurement applications.

NBS. 21:002

National Bureau of Standards, Washington, D. C.

ELECTRICAL NOISE FROM INSTRUMENT CABLES SUBJECTED TO SHOCK AND VIBRATION, by T. A. Peris. Jan. 1952, 17p. diagrs. tables. (NBS rept. no. 1388) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9], and Atomic Energy Commission) ATI-144492 Unclassified

Also published in Jour. Appl. Phys., v. 23: 674, June 1952.

Existing information on the reduction of spurious signals from instrument cables is reviewed. A tentative theory is formulated to account for the known data. Subsequent experiments confirm this theory and allow the formulation of a detailed mechanism of noise generation in cables. The noise may be eliminated for practical purposes (reduced by a factor of 500 or more in some cases) by having continuous electrical conduction between both surfaces of the insulating dielectric and the adjacent conductors. A simple procedure is outlined to make short lengths of this cable for laboratory use and an industrially applicable method is suggested. There appears to be no limit on how small the diameter of such cables could be made. (Contractor's abstract)

NBS. 21:003

National Bureau of Standards, Washington, D. C.

ELECTRON INTERFEROMETER, by L. Marton. [1952] [2]p. incl. diagrs. (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9], and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 85: 1057-1058, Mar. 15, 1952.

The basic principles of an interferometer operating with electron beams are discussed. A wide beam is diffracted by thin crystal lamellae. The dimensional and other tolerances of the instrument are well within experimental possibilities. (C. A., 1952:53691)

NBS. 21:004

National Bureau of Standards, Washington, D. C.

METHODS OF RESPIRATORY GAS ANALYSIS, by H. J. Morowitz. June 1952, 13p. incl. table, refs. (NBS rept. no. 2167) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9], and Atomic Energy Commission) AD 3989 Unclassified

This report is a survey designed to examine the existing methods of respiratory gas analysis and to look into additional physical instruments and techniques which may be applicable to the problem. The following methods seem to contain the most promise or to merit further basic study to ascertain their potentialities. (1) Mass spectrometry, because of its versatility in handling a wide range of materials should prove a valuable tool in future respiratory analysis work. Its disadvantages lie in the expense of the equipment and the professional skill required to operate and maintain an instrument. (2) The potentialities of critical flow methods used in conjunction with chemical reactions should be investigated. If sufficiently short response times can be obtained, this technique offers a wide range of possibilities. (3) Absorption spectroscopy is very satisfactory when absorption occurs in a workable range of spectrum. The study of new sources and detectors may enhance the range of applicability of these techniques. (4) For the rapid determination of oxygen, an extension of paramagnetic methods should in theory provide a workable method. The measurement of ionization currents should also be investigated in regard to oxygen measurement. Both possibilities are in need of further experimental work. (5) Emission spectrometry offers rapid response along with the potentiality of measuring several gases. However, basic work must be done on discharge phenomena before this can be developed into a routine analytical tool. Obtaining a utilizable emission from oxygen has thus far proven a very difficult problem.

NBS. 21:005

National Bureau of Standards, Washington, D. C.

THERMALLY OPERATED GLASS VALVE TO PROVIDE VERY SMALL CONTROLLED GAS FLOW RATES, by R. Forman. June 27, 1952 [12]p. incl. illus. diagrs. (NBS rept. no. 1762) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9) ATI-168762 Unclassified

NBS. 21:006 - NBS. 21:010

Information is presented on the development of a glass metal valve which can provide small controlled vacuum leaks. It combines the advantages of a glass instrument with that of reproducibility over a definite range of leak rates. A number of possible variations in the design of the valve suggest themselves. Replacement of the nickel sleeve, for instance, with a metal having a much higher creep strength at elevated temperatures would have obvious advantages. Another interesting design change is the use of piezoelectric or magnetostrictive properties of materials rather than that of thermal expansion for opening and closing the valve.

NBS. 21:006

National Bureau of Standards, Washington, D. C.

THE DEVELOPMENT OF A SUBLIMING CARBON DIOXIDE ALTIMETER, by A. S. Iberall and S. B. Garfinkel. Mar. 30, 1953, 35p. illus. (NBS rept. no. 2387) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9), and Atomic Energy Commission) AD 9054 Unclassified

This report covers the results of an investigation of the feasibility of utilizing the vapor pressure-temperature relationship of subliming carbon dioxide snow in a continuous stream as a basis for a wide range altimeter. Laws are formulated governing the application of a subliming solid for obtaining pressure-altitude in the upper air as a function of the measured temperature of the vapor pressure in equilibrium with the ambient air. (Contractor's abstract)

NBS. 21:007

National Bureau of Standards, Washington, D. C.

A BROADBAND, LOW-LEVEL, ERROR-VOLTAGE DETECTOR, by M. L. Kuder. June 15, 1953, 9p. incl. diagrs. (NBS rept. no. 2603) [CSO-640-55-9] AD 17283 Unclassified

An error-voltage detector is described which used ordinary germanium diodes in a circuit of unusual zero-drift stability, and which is self-compensating for the temperature coefficients of the crystals. The crystals are operated at a high carrier potential as compared to their contact potentials. An RF chopper principle was used in place of the conventional (limited bandwidth) mechanical choppers. Tests showed that a control signal of 1 mv would produce a Δit of approximately 12 ohm in about 3000 ohm of resistance of each germanium diode. This condition results from an excitation at 30 mc and an experimentally determined optimum amplitude of about 200 mv. A 0.4% unbalance of the bridge is obtained which produces an output of about 0.0008 v. Transformed to the 50-ohm output, this provides about 0.0001 v to the amplifier. A very useful output control-signal with an over-all bandwidth of about 1 mc was obtained from the amplifier. Production of a useful output requires a gain of about 95 db. The zero drift did not exceed 1 mv/day. Possible applications of the detector are discussed.

NBS. 21:008

National Bureau of Standards, Washington, D. C.

EDDY-CURRENT MUTUAL-INDUCTANCE TRANSDUCERS WITH HIGH-CONDUCTIVITY REFERENCE PLATES, by H. M. Joseph and N. Newman. June 15, 1953, 72p. incl. diagrs. tables, refs. (NBS rept. no. 2558) (Sponsored jointly by [Air Force Office of Scientific Research under CSO-640-55-9], Office of Naval Research, and Atomic Energy Commission) AD 15128 Unclassified

The design considerations of mutual-inductance devices for use in non-contacting measurements of distance are studied with special emphasis on the eddy-current type utilizing perfectly conducting reference plates. The force on the plate due to the exciting current, some typical schematic circuits used to detect the results, and the effects of rapid motion of the gauge are given. Since actual reference plates are not perfectly conducting, some indications of the effects of finite conductivity and limited extent of reference plates are included. (Contractor's abstract)

NBS. 21:009

National Bureau of Standards, Washington, D. C.

BIBLIOGRAPHY AND INDEX ON DYNAMIC PRESSURE MEASUREMENT, by W. G. Brombacher and T. W. Lashof. Feb. 14, 1955, 124p. incl. refs. (NBS circular no. 558) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-640-55-9], and Atomic Energy Commission) AD 115880 Unclassified

This circular contains a bibliography of 850 items on dynamic pressure measurement and, in less detail on related subjects such as static pressure measurement and general information on the components of instruments. An index of the bibliography by both subject and author is included.

NBS. 21:010

National Bureau of Standards, Washington, D. C.

A SIMPLE, OBJECTIVE TEST FOR CABLE NOISE DUE TO SHOCK, VIBRATION OR TRANSIENT PRESSURES, by T. A. Perls. May 1955 [17]p. incl. illus. tables. (NBS rept. no. 4094) (Sponsored jointly by Office of Naval Research under NAonr 21-48, [Air Force] Office of Scientific Research under CSO-640-55-9, and Atomic Energy Commission) AD 67143 Unclassified

A survey was made of methods used or proposed for objecttve, reproducible, notse-tndex tests of the electrtcal rotse generated tn cables subjected to shock, vtbration, and transtent pressures. A reproducible test ts described by J. Hannon (BuShips Memorandum, Ser 8f7A3-M-1561A) tn which a suitable weight ts clamped at the center of a 5-ft length of test cable suspended belween supports 4 ft apart. The cable nolse ts recorded when the cable and weight are released from a position 90° from the verttcal. The test cable ts shunted to a tolal capacttance of 1000 ptcofarads, the tnput tnipedance of the first preamplifier is made equal to 10 megohms, and the over-all frequency response of the amplifying and recordfng system ts chosen flat wtthin ± 15% from 5 to 40 c. The notse tndex was taken as the number of ptcocoulombs (or millivolts) peak-to-peak recorded tn a series of swtngs of the cable. The noise ftgure for any particular sample ts repeatable wtthin ± 30%, but thts ftgure may vary by a factor of 3 or more for dtfferent samples of the same cable. Tests of 21 cables, conststing of JAN types, commercial cables with and wtthout clatmed low-notse properties, commerctal pre-production samples of low-notse cables, and the NBS low-noise cable described hy Perls (Jour. Appl. Phys., v. 23: 674-680, 1952), ytelded notse tndices ranging from 0. f to 1600. After simulated severe use, the range of noise tndices was from 0. 2 to f900, wtth the notse tn one of the cables tncreased by a factor of 50. A posstbly significant decrease was noted for several other cables. (ASTIA abstract)

NBS. 2f:011

National Bureau of Standards, Washington, D. C.

SURVEY OF STRESS-STRAIN RECORDERS FOR TESTfNG MATERIALS, by R. R. Bouche and D. R. Tate. May 1955, 20p. illus. tables, refs. (NBS rept. no. 4109) (Sponsored jointly by Office of Naval Research under NAonr 21-48, [Air Force] Office of Sctenttftc Research under CSO-640-55-9, and Atomtc Energy Commission) AD 67f44 Unclassified

A discussion is presented on the principles of operation (mechanical, electrical, and optical) and the performance characteristics of stress-strain recorders. The recorders include only those whtch plot simultaneously stress vs strain. In an accuracy study of stress-strain recorders, 3 widely used recorders and associated extensometers were subjected to performance tests. The results of the performance tests could not be considered an evaluation of the performance of all recorders of the type tested. The recorders tested conformed reasonably well with ASTM Spec E83-52T established for the evaluation of strain measuring devices. The errors in strain indication were essentially within the given tolerances. The recorders described were considered suitable for obtaining an automatic plot of the stress-strain diagram of specimens under certain testing conditions. The use of stress-strain recorders is ltmited under extreme conditions of high temperature, creep testing, measuring large plastic strains, and testing specimens of unusual shape or of some nonmetallic malertals.

NBS. 21:012

Nattonal Bureau of Standards, Washington, D. C.

IMAGE PROCESSING, by L. S. G. Kovasznay, H. M. Joseph, and N. Newman. June f955, 31p. illus. (NBS rept. no. 4108) (Sponsored jointly by Offtce of Naval Research under NAonr 21-48, [Air Force] Office of Sctentiftc Research under CSO-640-55-9, and Atomtc Energy Commisston) AD 68058 Unclassified

A scalar function of two tndependent vartables can be vtsualfzed as an image. Any mathematical operation can be regarded as a modtftcatton or processtng of the ortginal tmage. An tmportant class of modifytng operators can be realizeo by spectal scanning techniques wtthout using a raptd access memory storage devtce. Two operators so far explored may have practical fmportance. One ts contour enhancement which has "deblurrtng" effects akin to aperture correction and "crtspening" tn televiston practtce; the other is contour outltning which produces a ltne drawtng from a picture with continuous tones. The general concepts developed may also permtt extenston of the method to analogue computers for certatn classes of partial dtfferentlal equations. The flexibtlity and adaptabtlty of the system offer practical applicatton whenever some predetermined operation is requtred on picture material.

NBS. 2f:0f3

National Bureau of Standards, Washington, D. C.

A JERKMETER FOR BALLISTOCARDIOGRAPHY, by T. A. Perls and C. W. Kisstnger. June f955, 8p. illus. (NBS rept. no. 4122) (Sponsored jointly by Office of Naval Research under NAonr 21-48, [Air Force] Office of Scienttfic Research under CSO-640-55-9, and Atomic Energy Commission) AD 68046 Unclassified

"Jerk" is defined as the time derivattve of acceleration. Simple methods for designing jerkmeters are briefly discussed. The present design consists of a low-frequency (20 cps) piezoelectric accelerometer, the output of which is electrically differentiated. The response of the instrument is flat wtthtn ± 7% from zero-frequency to f8 cps, at 21°C, but changes in response up to 33% are introduced in the range between f0 and 18 cps at temperatures between 12°C and 32°C. A ballistocardiogram is shown, with simultaneous displacement, velocity, acceleration and jerk records. (Contractor's abstract)

NBS. 21:014 - NBS. 21:017

NBS. 21:014

National Bureau of Standards, Washington, D. C.

A RECORDING MICROWAVE HYGROMETER, by J. Sargent. June 1955 [53]p. incl. illus. diagrs. tables, refs. (NBS repl. no. 4257) (Sponsored jointly by Office of Naval Research under NAonr 21-48, [Air Force] Office of Scientific Research under CSO-640-55-9, and Atomic Energy Commission) AD 71410 Unclassified

A description is given of a microwave refractometer designed to measure and record the water-vapor pressure in air particularly at very low vapor pressures. At low water-vapor pressures the instrument has a sensitivity of 0.005 mb, with a four decade range extending to 95 mb. By means of microwave techniques the difference in refractive index between dry and humid air is determined and then converted to vapor pressure by an empirical formula. The instrument can be readily calibrated by the use of pure gases whose dielectric constants are precisely known. Because of the automatic null-balancing technique used, the calibration has exceptional stability. Test results involving the measurement of known vapor pressures in the ranges of 0 to 0.2 mb and 0 to 20 mb are described. Possible applications of this instrument for the measurement of refractive index variation, and its use for quality control, are briefly discussed.

NBS. 21:015

National Bureau of Standards, Washington, D. C.

DATA PROCESSING DEVICES AND SYSTEMS, by J. Stern, R. Greenstone, and J. H. Wright. Sept. 1955. 26p. incl. tables, refs. (NBS rept. no. 4310) (Sponsored jointly by Office of Naval Research under NAonr 21-48, Air Force Office of Scientific Research under CSO-640-55-9, and Atomic Energy Commission) AD 71904 Unclassified

The information in this compilation takes the form of descriptions of available devices and systems for the processing of data derived from physical measurements. Coverage is limited to a sampling considered adequate to orient the reader in data handling and enable him to seek more detailed information as his problem dictates. Information about commercially available devices is taken largely from manufacturers' literature. Included are devices for automatically transforming data from one form to another, for instance, conversion of analog to digital data, conversion of magnetic tape data to punched cards, conversion of data plotted on graphs to electrical, magnetic or mechanical signals. Factors involved in selecting compatible elements for use in a data processing chain are included.

NBS. 21:016

National Bureau of Standards, Washington, D. C.

A STUDY OF BASIC LIMITATIONS TO THE CONCEPT AND MEASUREMENT OF TEMPERATURE; INCOMPLETE EQUILIBRIUM, by C. M. Herzfeld. Jan. 1956, 14p. refs. (NBS rept. no. 4420) (Sponsored jointly by Office of Naval Research under NAonr 21-48, Air Force Office of Scientific Research under CSO-640-55-9, and Atomic Energy Commission) AD 85386 Unclassified

A survey was made of problems associated with temperature measurement during the approach to equilibrium. Methods are described for measuring temperature from (1) the population of atomic levels; (2) the spectral time reversal; (3) the Doppler line width; (4) the vibrational spectra; (5) the rotational spectra; (6) optical pyrometers; (7) thermocouples; and (8) the velocity of sound. Additional methods include the pneumatic, the pyrometric-cone, and the absolute radiation-intensity methods. The survey revealed that temperature, in the equilibrium sense can be measured with an accuracy which depends only on the intrinsic limits of the apparatus. In most practical situations, T (temperature) is not well defined, but one or several T* (quantities which resemble T) can often be found which can be measured and defined with sufficient accuracy. In situations which are too complex to allow definition of a T*, a purely empirical temperature-like parameter T** may exist which can be measured and can be related empirically to other features of the system.

NBS. 21:017

National Bureau of Standards, Washington, D. C.

CORRECTIONS IN HIGH ACCURACY FRESNEL REGION MICROWAVE INTERFEROMETRY, by E. S. Dayhoff. Feb. 1956 [101]p. incl. illus. tables, refs. (NBS rept. no. 4514) (Sponsored jointly by Office of Naval Research under NAonr 21-48, Air Force Office of Scientific Research under CSO-640-55-9, and Atomic Energy Commission) AD 87803 Unclassified

In optical interferometry the wavelength is ordinarily so small compared with the transverse dimensions of the apparatus that no account need be taken of possible corrections to the apparent phase velocity due to diffraction effects. In the analogous microwave interferometer, where propagation is only quasi-optical, this happy situation does not exist since the wavelength is not so small that diffraction effects of low order are negligible. The attainment of high absolute accuracy in phase velocity measurements by microwave interferometry then requires a thorough study of the low order corrections to measured phase velocity. This report is concerned with such corrections in the case where (1) the wavelength is small but not negligible compared with the dimensions of the apparatus and (2) the radiating aperture subtends at least one Fresnel zone from the mid point of the travelling mirror. An expression is obtained giving the correction to be applied to the observed wavelength in terms of the antenna pattern of the radiator, an experimentally observable quantity. A discussion is also given of the sources and effects of multiple paths of propagation as they would influence

phase velocity measurements. Methods for their reduction and correction are suggested. (Contractor's abstract)

NBS. 21:018

National Bureau of Standards, Washington, D. C.

ELECTRONIC ANALOG-TO-DIGITAL CONVERSION, by M. L. Kuder and L. A. Marzetta. Mar. 31, 1956, 27p. incl. illus. (NBS rept. no. 4647; supersedes NBS rept. no. 1117) [CSO-640-55-9] AD 111631
Unclassified

As a prelude to the development work reported herein, the general field of analog-to-digital conversion was reviewed. It was apparent that in all these systems, it is the analog elements which permit errors to accrue in the parameter conversions. Therefore, the two elements in all of these converter systems which seemed worthy of the most attention were the comparison-voltage generator, and the balance detector. The latter element is sometimes referred to as the end-point resolver. This report covers some unique details of these two critical digitizing elements, as well as several schemes for their utilization in high speed converter systems. Methods for digital read-out and multichannel sampling are discussed. The high sampling rates can result in upwards of 500 complete 3-digit conversions per second.

NBS. 21:019

National Bureau of Standards, Washington, D. C.

ELECTRONIC ANALOGUE OF SUPERSONIC FLOW, by L. S. G. Kovasznay and N. Newman. Dec. 1956 [43]p. incl. illus. diagrs. refs. (NBS rept. no. 4893) (Sponsored jointly by Air Force Office of Scientific Research under CSO-640-55-9, Office of Naval Research under NAonr 21-48, and Atomic Energy Commission)
AD 139062 Unclassified

Supersonic flow of a perfect fluid obeys a second order nonlinear partial differential equation termed a "quasi-linear hyperbolic equation." The principal tool for solving such equations is the method of characteristics. An electronic analogue device has been constructed that simulates the method of characteristics not only in the case when the characteristics are fixed (linearized equation) but also when the location of the characteristics depends on the solution itself (nonlinear equations). In the latter case, however, the simplest type of nonlinearity was chosen purely for electronic convenience. The electronic equipment is built around a cathode ray tube flying spot scanner and is so arranged that the scan lines form the characteristics of the differential equation. The boundary conditions are fed into the machine as an opaque mask and the solution (flow pattern) is obtained as an image on a second cathode ray tube (monitor). The experiment has served only to demonstrate feasibility of the approach and has not been carried beyond that stage. (Contractor's summary)

NBS. 22:001

National Bureau of Standards, Washington, D. C.

SOME ASPECTS OF THE TWO-FLUID MODEL OF SUPERCONDUCTIVITY (Absiract), by E. Maxwell and P. M. Marcus. Jan. 22, 1953 [2]p. [CSO-670-53-8] Unclassified

Presented at meeting of the Amer. Phys. Soc., Cambridge, Mass., Jan. 22-24, 1953.

Published in Phys. Rev., v. 90: 346-347, Apr. 15, 1953.

The two-fluid model of a superconductor has derived added support from the recent observation that the threshold curves for a family of superconducting isotopes are geometrically similar curves, a fact consistent with the model. This is true for any two-fluid model in which the normal fluid alone contributes entropy. The detailed shape of the threshold field curve is determined by the particular form chosen for the entropy (or for the free energy) of the superconducting state. One specific form (α-model) was proposed by Gorter and Casimir (Physik. Z., v. 35: 963, 1934) on heuristic grounds, another by Koppe (Ann. Physik, v. 1: 405, 1947). Precise measurements on Sn, Hg, Tl, and in support the critical field equations calculated from the α-model:

$$\left(\frac{H}{H_0}\right)^2 = 1 - \frac{1}{\alpha}\left(\frac{T}{T_c}\right)^2 + \frac{1-\alpha}{\alpha}\left(\frac{T}{T_c}\right)^{2/(1-\alpha)},$$

where α is a parameter characteristic of each superconductor. (Contractor's abstract)

NBS. 22:002

National Bureau of Standards, Washington, D. C.

TWO FLUID MODELS OF SUPERCONDUCTIVITY WITH APPLICATION TO ISOTOPE EFFECTS, by P. M. Marcus and E. Maxwell. [1953] [26]p. incl. diagrs. refs. (NBS rept. no. 2496) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under CSO-670-53-8) AD 11494
Unclassified

Also published in Phys. Rev., v. 91: 1035-1042, Sept. 1, 1953.

A general form of the two fluid model of a superconductor, which includes all previous forms, is set up and the underlying assumptions examined in the light of the lattice vibration theory of superconductivity. Thermodynamic relations are derived and their consistency with the observed isotope effects indicated. Specialization to the α-model of Casimir and Gorter

NBS. 22:003 - NBS. 22:006

permits fitting recent precise critical field data and evaluation of the parameter α characterizing different superconductors. Comparison is made with Koppe's form of the two fluid model, which is shown not to fit all the data, and simplified and limiting forms of his equations are given. (Contractor's abstract)

NBS. 22:003

National Bureau of Standards, Washington, D. C.

THRESHOLD FIELD PROPERTIES OF SOME SUPERCONDUCTORS, by E. Maxwell and O. S. Lutes. Feb. 23, 1954 [32]p. incl. illus. tables. (NBS rept. no. 3146) ([AF]OSR-TN-54-45) (CSO-670-53-8)
AD 30277 Unclassified

Also published in Phys. Rev., v. 95: 333-338, July 15, 1954.

Some refined measurements of the critical field curves for tin, thallium, indium, and mercury have been completed and the results compared with the specific predictions of the Gorter-Casimir and the Koppe versions of the two-fluid model of superconductivity. Neither version is completely adequate, although each has points in its favor. The Koppe prediction of a universal critical field curve for all superconductors is not verified. The Gorter-Casimir α-model has greater flexibility than the Koppe model and, although it is capable of giving a fair description of the critical field data, it is in some respects also inconsistent with the data. The isotope effect in thallium has been observed and is consistent with the half-power law. (Contractor's abstract)

NBS. 22:004

National Bureau of Standards, Washington, D. C.

FACTORS AFFECTING THE PRECISION AND ACCURACY OF AN ABSOLUTE NOISE THERMOMETER, by E. W. Hogue. July 1954, 62p. incl. diagrs. (NBS rept. no. 3471) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-53-8], and Atomic Energy Commission) AD 46864
Unclassified

Evaluation was made of factors affecting the precision and accuracy of an absolute thermometer which uses thermally generated noise in conductors as a measure of temperature. An accuracy of at least 0.1% is required for measurements to be useful as a primary standard from 1000°K and up. Consideration was given to a thermometer designed by Garrison and Lawson (Rev. Scient. Instruments, v. 20: 785-794, 1949) which had synchronous rectifier and an electronic integrator added to the original circuit. The precision of measurement depended upon the sensitivity of the circuit to small differences in the average amplitude of the noise fluctuations. Study indicated that, even with a perfectly disturbance-free synchronous switch system, an observation time of 8 min was required for each adjustment of the standard resistor toward noise balance near the balance point of 0.1% temperature measurement precision. Noise balance stability sufficient for 0.05% precision could not be achieved.

NBS. 22:005

National Bureau of Standards, Washington, D. C.

SUPERCONDUCTING TRANSITIONS IN TIN WHISKERS, by O. S. Lutes and E. Maxwell. Mar. 15, 1955 [3]p. incl. diagrs. [AFOSR-TN-55-151] [CSO-670-53-8]
Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 97: 1718-1720, Mar. 15, 1955.

The superconducting resistance transitions of several tin whiskers have been observed in the liquid-helium temperature range. The results are compared with those for larger wires and significant differences are found. In particular the transitions in a transverse magnetic field are discontinuous at temperatures substantially lower than the zero-field transition temperature. This result differs from that for larger wires, which show intermediate resistance at these temperatures. (Contractor's abstract)

NBS. 22:006

National Bureau of Standards, Washington, D. C.

HYSTERESIS IN SUPERCONDUCTING TIN WHISKERS (Abstract), by O. S. Lutes and E. Maxwell. [Oct. 1955] [1]p. ([AF]OSR-TN-55-395) [CSO-670-53-8]
Unclassified

Presented at N. S. F. Conference on Low Temperature Physics and Chemistry, Baton Rouge, La., Dec. 29, 1955.

The superconducting transitions of tin whiskers oriented parallel to a magnetic field show size effects with respect to both critical field and hysteresis behavior. In addition the hysteresis is observed to have a strong temperature dependence. The whisker diameters ranged from 0.7 to 2.7 microns. For the smallest whisker the critical field was greater that that of bulk tin by a factor of 2.9 at 3.5°K. For the largest whisker this ratio was reduced to 1.2. Even for the latter the critical fields near T_c were considerably greater than predicted by the London theory. The hysteresis exhibited by all the whiskers was negligibly small above 3.5°K. In the case of the largest whisker $\frac{\Delta H_c}{H_c}$ increased to 20 per cent at 2.2°K, but for the smallest whisker it was only 2 per cent at the same temperature. The shape of the resistance transition appears to depend on the amount of hysteresis observed, being nearly

discontinuous when the hysterests ts sizable but somewhat soread out when the hysterests ts small, t.e., near T_c. (Cortractor's abstract)

NBS. 22:007

National Bureau of Standards, Washington, D. C.

SUPERCONDUCTIVITY OF MICROSCOPIC TIN FILAMENTS, by O. S. Lutes. Nov. 9, 1956 [38]p. tncl. tllus. dtagrs. refs. (NBS rept. no. 4931) (AFOSR-TN-56-525) (CSO-670-53-8) AD 110348 Unclassified

Also published in Phys. Rev., v. 105: 1451-1458, Mar. 1, 1957.

An expertmental determination has been made of the magnetic fteld necessary to tnduce the superconductng transition tn mtcroscoptc tin ftlaments called "whtskers." For temperatures near the zero-fteld transition temperature, T_c, the results are unambtguous, and tn this regton the crttical fteld are stgnificantly higher than those of a bulk superconductor. At lower temperatures, the crttical fteld curve splits tnto two parts, the upper curve gtvtng the field for destruction of superconductivtty and the lower curve the fteld for restoration. The temperature dependence of the crttical field is compared wtth the predtctions of the London and Ginsburg-Landau theortes of superconductivtty. It ts found that the London theory ts tnadequate to describe the data over the whole useful range, whereas the Ginsburg-Landau theory provtdes a satisfactory fit. The disappearance of hysterests occurs at a temperature for which $2.0 \leq h_c/H_c \leq 2.4$, where h_c/H_c ts the ratio of whisker to bulk critical fields. This is tn reasonable agreement with the Ginsburg-Landau-Stlin condttion for the onset of second order transitions. An effective value of λ_0, the penetratton depth at 0°K, is dertved from the data for each whisker. λ_0 shows a strong dependence on the normal electrtcal conductivity, as estimated from the change tn reststance at the transition. At long mean free path, the results are in agreement with those obtained from bulk spectmen measurements, but at short mean free path the present λ_0 values are higher (Contractor's abstract)

NBS. 23:00t

National Bureau of Standards, Washington, D. C.

DETERMINATION OF SINUSOIDAL ACCELERATION AT PEAK LEVELS NEAR THAT OF GRAVITY BY THE "CHATTER" METHOD, by C. W. Kissinger. Sept. t954 [29]p. incl. illus. diagrs. tabte. (NBS rept. no. 3339) (Sponsored jotnly by Air Force Office of Scientiftc Research under CSO-670-53-10, Office of Naval Research under NAonr 21-48, Atomic Energy Commission, and Bureau of Aeronautics) AD 46276 Unclassified

An accelerometer is descrtbed, in which a loose mass bounces, or "chatter," when the peak acceleration of a vertical sinusoidal motion exceeds the acceleration due to gravity. The device is useful, for example, tn settng the acceleration level of vtbration generators used tn the calibration of vtbration ptckups. A theoretical relation ts dertved between the amount by which peak acceleration exceeds ± 1 g, and the point tn the cycle at which the loose mass, after havtng separated, again contacts that part of the accelerometer on which tt was resting. Ustng this relation tn conjunction wtth the accelerometer descrtbed, acceleration levels from about 1.01 g to 1.04 g may be set with an accuracy of approximately ± 0.5% at frequenctes up to 60 cps, and wtth somewhat decreased accuracy to about 150 cps. In the accelerometer descrtbed, a clamping screw ts provided, by means of which the chatter of the loose mass may be prevented when desired. This allows the accelerometer to be used as a self-caltbrating secondary standard for levels of acceleration other than + 1g, and at frequenctes up to about 1200 cps. (Contractor's abstract)

NBS. 23:002

National Bureau of Standards, Washington, D. C.

INTERIM REPORT ON RG-138U (.040 x .080 INCH) WAVEGUIDE COMPONENTS, by E. S. Dayhoff. Sept. 1954, 10p. illus. diagrs. (NBS rept. no. 3679) (Sponsored jotntly by [Atr Force Office of Sctentific Research under CSO-670-53-10], Offtce of Naval Research under NAonr 21-48, and Atomtc Energy Commisston) AD 46566 Unclassifted

A brtef descrtption ts given of the present status of two types of waveguide components for use in the 100,000 mc tnterferometer. The ftrst ts a crystal recttfier harmonic generator which converts K-band power at a lev[illegible] of a few hundred mtlltwatts to tts fourth harmonic frequency. The second ts a hybrtd tee junction. Constructton tnformation and sample performance are gtven as far as posstble. (Contractor's abstract)

NBS. 24:00t

National Bureau of Standards, Washington, D. C.

ELASTIC MODULI OF INDIUM ANTIMONIDE, by R. F. Potter. Apr. 24, t956 [26]p. tncl. diagrs. tables, refs. (NBS rept. no. 4356) (AFOSR-TN-56-t42) (CSO-670 53-12) AD 86020 Unclassified

Also published in Phys. Rev., v. t03: 47-50, July 1, t956.

Using the composite resonator technique, the elastic moduli of InSb have been measured as a function of temperature between 77° and 700°K. The results give good agreement with the Born-Smith dynamic lattice theory, if nearest neighbor interactions alone are considered. The mean Debye characterlstic temperature, θ_D = 20t°K, is evalu[illegible]ed using Sutton's method. High temperature behavior of the constants is discussed. (Contractor's abstract)

NBS. 24:002 - NBS. 25:004

NBS. 24:002

National Bureau of Standards, Washington, D. C.

INDIRECT TRANSITIONS IN INDIUM ANTIMONIDE, by R. F. Potter. [1956] [2]p. incl. diagrs. refs. [CSO-670-53-12] Unclassified

Published in Phys. Rev., v. 103: 861-862, Aug. 15, 1956.

An interpretation of published infrared absorption data for InSb is made. It is proposed that the absorption beyond the main optical edge is due to indirect transitions involving both optical mode and low-energy acoustical mode phonons. (Contractor's abstract)

NBS. 25:001

National Bureau of Standards, Washington, D. C.

DESIGN FEATURES OF A MAGNETIC DRUM MEMORY FOR THE NATIONAL BUREAU OF STANDARDS WESTERN AUTOMATIC COMPUTER (SWAC), by R. Thorensen. Apr. 30, 1952, 7p. (NBS rept. no. 1635) [CSO-670-54-7] Unclassified

Presented at Electronic Computers Symposium, Calif. U., Los Angeles, Apr. 30-May 2, 1952.

A magnetic drum memory has been designed for the SWAC having a capacity of over 6000 binary digit word. Primary consideration has been given to simplicity of design together with maximal efficiency in transfer of information between the new magnetic drum memory and the existing electrostatic memory. A system is used in which the waiting time for access to the memory is almost completely eliminated. This system is being constructed of less than a dozen different types of basic single-tube plug-in units. These units have been developed to a high degree of stability under a variety of conditions of loading and aging. It is estimated that the entire magnetic drum, involving amplifiers, selection matrices, and control equipment necessary for the tie-in with the SWAC will contain only 250 vacuum tubes.

NBS. 25:002

National Bureau of Standards, Washington, D. C.

A MAGNETOSTRICTION MAGNETOMETER, by T. A. Perls. May 1952, 17p. incl. diagrs. tables, refs. (NBS rept. no. 1632) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) ATI 154524 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Abstract published in Phys. Rev., v. 87: 230, July 1, 1952.

Several interesting magnetic effects have been observed, including large changes in the magnetostrictively excited vibration amplitude of long rods with changes in the externally applied steady magnetic field. It was found that these changes in amplitude could not be accounted for by independently observed changes in the resonant frequency and damping of the rod, but rather were related to changes in slope of the curve of magnetostriction vs. intensity of magnetization. Proposed investigations are described, including a specimen-stabilized oscillator, a determination of the most favorable annealing procedure, and the possible use of fine wires rather than long rods. (Contractor's abstract)

NBS. 25:003

National Bureau of Standards, Washington, D. C.

STRESS-INDUCED NOISE IN CABLES (Abstract), by T. A. Peris. [1952] [1]p. (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 31, Feb. 1-2, 1952.

Published in Phys. Rev., v. 86: 613, May 15, 1952.

Stress-induced cable noise interferes with the transmission of signals in many different types of measurement, control, detection, and communication. The present investigation was undertaken in connection with the design and evaluation of very small barium titanate transducers for acceleration and pressure measurements. A quantitative theory of the mechanism of noise generation predicts a triboelectric separation of charge as a result of intermittent contact between the insulating dielectric and either of a pair of conductors. The necessary redistribution of charge produces a current pulse through the terminating network. Quantitative predictions of this theory are verified by a series of simple experiments. Stress-induced noise is practically eliminated in cables having conductive coatings both inside and outside of the insulating dielectric. Comparison of such an experimental, light, flexible, coaxial cable, 0.07 in. od, with a standard microphone cable of similar dimensions, shows a reduction in signals caused by twisting and squeezing by a factor of at least 200. There appears to be no limitation on arrangement and number of conductors, or on size and flexibility of cables made by this method. An industrially applicable method of construction will be suggested. (Contractor's abstract)

NBS. 25:004

National Bureau of Standards, Washington, D. C.

TRANSIENT RESPONSE OF LINEAR SYSTEMS (Abstract), by J. F. Koenig. [1952] [1]p. (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and

Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., May 1-3, 1952.

Published in Phys. Rev., v. 87: 231, July 1, 1952.

In the design of an nth order linear system it is desired that the transient response, for given initial conditions, be of a specified form. Criteria are presented for obtaining specified transient responses, for various initial conditions, in linear systems described by nth order characteristic equations. The author's results are presented in the form of theorems which relate the roots and coefficients of the characteristic equation to the transient response, for various initial conditions. One of the theorems gives the conditions on the roots of the nth order characteristic equation such that there will be no overshoot for a step function input to the linear system. Closely related work recently reported by Z. S. Bloch is summarized. (Contractor's abstract)

NBS. 25:005

National Bureau of Standards, Washington, D. C.

INSTRUMENTATION LITERATURE AND ITS USE. A GUIDE AND SOURCE LIST, by J. F. Smith. Oct. 1952, 129p. refs. (In cooperation with Library of Congress, Technical Information Div.) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 6956 Unclassified

This report undertakes to tell users of instrumentation literature what sources to consult, and how to find the shortest sure path through these sources to any desired information. Most of the recipients are interested Government research and development agencies, or their contractors. Hence, some attention is given to Government technical reports and unpublished records in Government files. Problems of security classification are discussed briefly, but this report is concerned with unclassified or declassified matter.

NBS. 25:006

National Bureau of Standards, Washington, D. C.

A DIAPHRAGM-TYPE, CAPACITANCE-TYPE, MICROMANOMETER FOR VERY LOW DIFFERENTIAL PRESSURES, by T. A. Perls, W. H. Kaechele, and D. S. Goalwin. Jan. 1953 [13]p. incl. illus. diagrs. refs. (NBS rept. no. 2165) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 3650 Unclassified

A series of calibration tests shows that a thin diaphragm may be combined with a capacitance-type pickup and Resonant Bridge Carrier System to provide a method of measuring differential pressures which may be as low as 0.001 to 1 micron Hg. (Contractor's abstract)

NBS. 25:007

National Bureau of Standards, Washington, D. C.

ON THE ZEROS OF POLYNOMIALS AND THE DEGREE OF STABILITY OF LINEAR SYSTEMS, by J. F. Koenig. Jan. 13, 1953 [7]p. incl. illus. tables, refs. (In cooperation with Illinois U. Electrical Engineering Research Lab.) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) Unclassified

Published in Jour. Appl. Phys., v. 24: 476-482, Apr. 1953.

A method is presented for finding zeros of the nth degree real or complex polynomial as its coefficients (or their parameters) are varied. Several new theorems are presented. The method is based on new theorems, some concerning determinants, and on known theorems. It is applied to characteristic equations of linear physical systems with or without feedback. Root trajectories in the complex plane can be visualized without plotting them from "root trajectory diagrams" which show curve families for real or complex roots of a polynomial equation in a plane having two coefficients of the polynomial equation as coordinates. The diagrams can be used in the converse manner to determine the coefficient values corresponding to a desired dominant complex pair or real root. (Contractor's abstract)

NBS. 25:008

National Bureau of Standards, Washington, D. C.

CATHODE-RAY-OSCILLOGRAPH BEAM INTENSIFICATION, by J. H. Park and H. N. Cones. Feb. 1953 [19]p. incl. illus. diagrs. (NBS rept. no. 2281) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 3986 Unclassified

A method has been developed for momentarily intensifying the electron beam obtained from a cold-cathode discharge tube. This momentary intensification is about fifty times its steady state value. The utilization of this method of beam intensification for obtaining very high writing speeds with a CRO has been described in R. P. No. 2231. This intensification phenomena is not dependent to any very great extent on the gas used in the discharge tube. The material surrounding the discharge at and near the cathode must be a dielectric such as glass and not a conductor if intensification by superposed small pulses is to be obtained. When full voltage is suddenly applied to the discharge tube an intensified beam is obtained at times, but results are usually not repeatable. A satisfactory theoretical explanation for this beam intensification phenomena was not obtained. Such an explanation will probably not be attained until the steady state mechanism of the discharge in a high-voltage cold-cathode tube is completely understood. Although such discharge tubes have

NBS. 25:009 - NBS. 25:012

been tn use for over thirty years there is still no expertmentally vertfied theory for exptaining their behavtor. Continued studies of exactly what happens when full voltage ts suddenly applted to the electrodes might eventually yield a satisfactory theory. The most tmportant objective of this work which was to learn enough about the tntenstfication phenomena so that tt could be used to obtain very high writing speeds with the CRO has been achieved. The CRO, wtth tntenstfication, has already been used tn an tnvestigation of tnsulator puncture using surges with rates of voltage rtse up to 11,000 kv per mtcrosecond. It ts now betng used to study front of wave measurements on rapidly rising voltage surges. (Contractor's summary)

NBS. 25:009

National Bureau of Standards, Los Angeles, Calif.

AN IMPROVED CATHODE RAY TUBE STORAGE SYSTEM, by R. Thorensen. Feb. 6, I953, I6p. tncl. illus. (NBS rept. no. 2275) [CSO-670-54-7] Unclasstfied

A short revtew ts made of the prtnctple of storing dtgttal tnformation as charge patterns on the phosphor screens of cathode ray tubes tn the dot-dash storage system, both under normal operating conditions and as affected by spot interaction or spillover. An improved storage system is described which enhances discrimination between dot and dash types of signal by retardation of the inspection pulse and modification of the storage patterns of the two signals. Positioning of the roster to give minimum amplitude for the negative peak of the dash signal improved storage charactertstics on some flaw areas of the phosphor screen although flaw areas were noted which would not store signals tn etther system. Tests on stngle cathode ray tube units tndicated the tmproved system to be supertor to the conventional system wtth respect to sptllover and reststance to flaws.

NBS. 25.010

National Bureau of Standards, Washington, D. C.

A BARIUM-TITANATE ACCELEROMETER WITH WIDE FREQUENCY AND ACCELERATION RANGES, by T. A. Perls and C. W. Kissinger. Apr. 1953, 1v. incl. illus. diagrs. refs. (NBS rept. no. 2390) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 14154 Unclassified

A barium-tttanate accelerometer wtth wide frequency and acceleration ranges has been designed, built and tested. It combtnes small stze and mass, a range of ± 50,000 g, a natural frequency of 90,000 cps, good shieldtng, very low cable notse, small transverse response and several other destrable charactertstics. A number of factors influenctng sensitivtty, such as effects of stze of crystals, method of polarizatton, shock, vibration, method of mounting, temperature and agtng still remain to be more fully tnvestigated. In connection wtth performance tests on this accelerometer, several expertmental techniques were developed or improved, particularly for the determination of transverse response and for obtaining accurate calibration at high levels of acceleration. (Contractor's abstract)

NBS. 25:011

National Bureau of Standards, Washington, D. C.

MULTICHANNEL PULSE-HEIGHT ANALYZER USING A STORAGE TUBE (Abstract), by J. A. Cunningham. Apr. 30, 1953 [1]p. [CSO-670-54-7] Unclassifted

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 437, July 15, 1953.

A stmple and reltable electronic pulse-hetght analyzer permtttng the use of many channels has been developed for pulsed accelerator applttcations. The voltage pulses to be analyzed are tntroduced to the verttcal plates of a selected 3 JPI CRO tube, on whose outer face a wtre screen ts mounted. Durtng the accelerator off-time, a sawtooth sweep voltage is applied to the same deflection plates. The output pulses of the storage tubes are then analyzed during the sweep. The time differences between the sweep start and the output pulses determine the heights of the original input pulses. A simple time gate-scaler device enables the use of a large number of channels. Tests on spectrum analyses have proven the followtng dtstinct advantages: (t) voltage pulses whose peak values were maintained for a period as short as 0.05 microsecond have been analyzed. The minimum time response of the storage tube has not yet been checked. (2) Ttme dtfferences and thus pulse-height measurements are tndependent wtthin 0. I% of analyzer supply voltage changes of t5%. (3) Wtth the available storage tubes tt is eastly practical to obtain 100 channels. A large ratio of the resolving power to the number of channels being used permits a small error due to boundary effects. (Contractor's abstract)

NBS. 25:012

National Bureau of Standards, Washington, D. C.

THE SWAC-DESIGN FEATURES AND OPERATING EXPERIENCE, by H. D Huskey, R. Thorensen and others. June 15, I953, t4p. incl. dtagrs. (NBS rept. 258t) [CSO-670-54-7] Unclassified

Also published in Proc. Inst. Radto Engineers, v. 41: t294-t299, Oct. t953.

The SWAC ts an ultra-high-speed digital computer utilizing a Willtams tube memory, an auxiliary magnetic drum memory and a punched card tnput-output system. A general descrtption of the functtonal organization of the computer is gtven together with a brief dtscusston

of the various commands and the manner in which they are executed. Some of the special engineering features of the computers are described, in particular, those relating to the electrostatic and magnetic drum memories. In addition, a short survey of the types of problems solved by the computer during the last year is presented. (Contractor's summary)

NBS. 25:013

National Bureau of Standards, Washington, D. C.

PROCEEDINGS OF SYMPOSIUM ON BARIUM TITANATE ACCELEROMETERS, HELD IN WASHINGTON, D. C., MAY 14-15, 1953, comp. by T. A. Perls. Aug. 1953, 228p. incl. illus. (NBS rept. no. 2654) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 17137 Unclassified

The Symposium was divided into the following sections: (1) properties of barium titanate and titanate mixtures; (2) design factors and performance tests for $BaTiO_3$ accelerometers; and (3) instrumentation associated with $BaTiO_3$ accelerometers.

NBS. 25:014

National Bureau of Standards, Washington, D. C.

AN INTEGRATING AND DIFFERENTIATING BAR-MAGNET VELOCITY METER FOR USE IN BALLISTOCARDIOGRAPHY, by T. A. Perls and C. W. Kissinger. Sept. 1953 [23]p. incl. illus. diagrs. table, refs. (NBS rept. no. 2735) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 17138 Unclassified

Also published in Rev. Scient. Instruments, v. 25: 983-988, Oct. 1954.

An integrating and differentiating bar-magnet velocity meter is described. Design criteria are presented for integrators and differentiators to meet given specifications of frequency response. In the design of the differentiator, use is made of a small amount of resonance magnification in a suitably damped series-resonant circuit. Test procedures are described in detail for determinations of frequency response, sensitivity, and linear range of the instrument. Detailed examples are given of sensitivity adjustment and installation procedures for use of this instrument in ballistocardiography, in accordance with suggestions by J. E. Smith, M.D., Chief Medical Standards, Civil Aeronautics Administration. A "60 cps Hum Compensator" is used to cancel out any objectionable 60-cycle pickup from the power line. (Contractor's abstract)

NBS. 25:015

National Bureau of Standards, Washington, D. C.

SURVEY OF MILLIMICROSECOND OSCILLOGRAPHY, by J. H. Park. Sept. 1953, 18p. illus. refs. (NBS rept. no. 1769) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 17180 Unclassified

CRO methods and instruments for recording high-speed transient voltages in the $m\mu$ sec time range are reviewed. Factors affecting the accuracy of high-speed recording with CRO's included the beam intensity or writing speed, deflection error resulting from electron-beam transit time, errors resulting from deflecting plate circuit, sweep generators, and signal amplifiers. Comparative data are presented for available high-speed oscillographs and CRT's.

NBS. 25:016

National Bureau of Standards, Washington, D. C.

DOCUMENTATION IN INSTRUMENTATION, by W. A. Wildhack, J. Stern, and J. F. Smith. Apr. 1954 [25]p. incl. illus. refs. (NBS rept. no. 3276) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 30276 Unclassified

The problem of documentation of the literature of instrumentation has been studied. The problem is analyzed into a number of phases. A partial solution to the problem is proposed and its treatment of each of the phases is discussed. An experimental application of the proposed system is described. An appendix provides a description of devices which have been developed for punching reference serial number codes into subject cards and for subsequently translating the resulting perforations back into serial number identification of the references. Sufficient information is given to permit the reader to build these devices. (Contractor's abstract)

NBS. 25:017

National Bureau of Standards. Radiation Physics Lab., Washington, D. C.

A MULTI-CHANNEL PULSE HEIGHT ANALYZER USING A CR STORAGE TUBE, by J. A. Cunningham. Apr. 1954 [16]p. incl. illus. diagrs. (NBS rept. no. 3258) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research under [CSO-670-54-7], and Atomic Energy Commission) AD 30275 Unclassified

The pulse height analyzer described in this paper has been designed for use with pulsed accelerators such as

the 50 mev betatron and the 180 mev synchrotron at the National Bureau of Standards. The analyzer utilizes the technique of storing the voltage pulses during the short output duration of the accelerators and then analyzing the information during the dead time. Pulse heights were converted into time intervals by means of an ordinary 3KP1 cathode ray tube used as a storing device. Simple time gates permitted the construction of a relatively compact multi-channel analyzer. (Contractor's abstract)

NBS. 25:018

National Bureau of Standards, Washington, D. C.

HIGH-RANGE ACCELEROMETER CALIBRATIONS, by T. A. Perls and C. W. Kissinger. June 1954 [26]p. incl. illus. diagrs. table. (NBS rept. no. 3299) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 36647 Unclassified

The need for calibrations at high levels of acceleration is discussed. The theory is presented for a method of obtaining such calibrations by impact methods, using an electrical integrator. The method does not require a knowledge of either the pulse shape or the pulse width, although the latter is limited from both above and below by practical considerations related to the integrator and to the accelerometer under test. Three actual test schemes are described, including the use of a simple ballistic pendulum, an air gun, and an inclined trough. Preliminary data are also presented on a method for obtaining linearity data from steady-state resonant vibrations at levels, so far, up to 1090 g. The steady-state tests established the linearity of one of the NBS 33-14 accelerometers within ± 2% up to 1090 g, and were used for calibration of a commercially available piezoelectric accelerometer within ± 4% up to 665 g. The results of the transient high-g tests on one of the NBS 33-14 accelerometers showed that it becomes strongly nonlinear at -48,000 g, while it has good linearity to at least +40,000 g and -30,000 g.

NBS. 25:019

National Bureau of Standards, Washington, D. C.

STABILITY OF NONLINEAR FEEDBACK CONTROL SYSTEMS, by J. F. Koenig. Aug. 1954, 18p. incl. diagrs. refs. (NBS rept. no. 3619) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research under [CSO-670-54-7], and Atomic Energy Commission) AD 47005 Unclassified

A general method based on a continued-fraction expansion of the coefficients of a complex differential equation is presented for the determination of the stability of nonlinear feedback control systems. Each nonlinear system is expressed mathematically as a characteristic equation having complex coefficients. The method determines whether all roots have negative real parts as required for stability. The method is applied to 2 relay servomechanisms with hysteresis. The deviation of a general method to obtain stability boundary curves is illustrated by its application to a relay servomechanism with hysteresis. A parametric stability diagram shows the distance any stable nonlinear system is from instability in terms of any 3 parameters of the system. The continued-fraction theorems of Frank (Bull. Amer. Math. Soc., v. 52: 144-157, 1946) are applied to the determination of the stability of induction motors with series capacitors.

NBS. 25:020

National Bureau of Standards, Washington, D. C.

A BASIC METHOD OF DETERMINING THE DYNAMIC CHARACTERISTICS OF ACCELEROMETERS IN ROTATION, by W. A. Wildhack and R. O. Smith. Rev. Mar. 1955, 4p. incl. illus. (Paper no. 54-40-3) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research under [CSO-670-54-7], and Atomic Energy Commission) AD 118806 Unclassified

The earth's gravitational field furnishes a convenient sinusoidal forcing function for a vibrating system (e.g., an accelerometer) rotating in a vertical plane. The centrifugal field decreases the restoring force on the vibrating mass. Resonance occurs at lower frequencies and with greater amplitudes than in the case of excitation by linear vibration. The response ratio (vibration amplitude/static displacement caused by gravity) is greater than unity for all damping ratios up to unity. The resonant frequency for zero damping occurs at 0.707 times the natural undamped frequency. From measurements of the maximum response ratio, and of the frequency at which this ratio decreases to unity, one may determine both the damping ratio and the undamped natural frequency of any system whose damping ratio is less than unity. The response equation for the rotational excitation is given, and the solutions are presented in graphic form. Experimental test results obtained by this method are included. (Contractor's abstract)

NBS. 25:021

National Bureau of Standards, Washington, D. C.

A METHOD FOR STEADY-STATE ACCELEROMETER CALIBRATIONS UP TO ± 4000 g AND TEST RESULTS ON TWO ACCELEROMETERS, MODEL A314-T MANUFACTURED BY THE GULTON MANUFACTURING CORP., METUCHEN, N. J., by T. A. Perls, C. W. Kissinger, and D. R. Paquette. Mar. 1955, 17p. incl. illus. tables. (NBS rept. no. 3924) (Sponsored jointly by Ordnance Corps., Office of Naval Research, [Air Force Office of Scientific Research under CSO-670-54-7], and Atomic Energy Commission) AD 77944 Unclassified

Two Gulton accelerometers, Model A-314, Serial Nos. 280 and 281 have been calibrated by a new steady-state method at peak accelerations up to ± 2200 g. Within the accuracy of the method (the average scatter of the sensitivity data was ± 1.5%), the two accelerometers were linear up to the highest acceleration tested. Another Gulton accelerometer of a similar, possibly somewhat less rugged, type (Model A-314), was found to be linear within ± 2% up to ± 4000 g. The average sensitivity at room temperature of the accelerometers, Serial 280 and 281, as received, was 1.16 ± .01 mv/g and 1.19 ± .01 mv/g, respectively, in excellent agreement with the values given by the manufacturer. Incidental data were also presented on temperature dependence of capacitance and voltage sensitivity, over a small range of temperatures, on cable-loading and mounting-strain effects, and on transverse response of the two Model A-314T accelerometers. Resonant-frequency data were included for the accelerometer Model A-314.

NBS. 25:022

National Bureau of Standards, Washington, D. C.

A BARIUM-TITANATE ACCELEROMETER WITH WIDE FREQUENCY AND ACCELERATION RANGES. DATA OBTAINED SINCE APRIL 1953, by T. A. Perls and C. W. Kissinger. June 1955 [35]p. incl. illus. tables. (NBS rept. no. 2330a) [Sponsored jointly by Office of Naval Research under NAonr 21-28, Air Force Office of Scientific Research under CSO-670-54-7, and Atomic Energy Commission] AD 68070 Unclassified

The additional investigations performed with the NBS 33-14 accelerometer are described together with the modifications which are incorporated in the models NBS 33-17, 18, and 19 accelerometers. A special test jig was designed and built in which single crystals could be investigated under different orientations and under asymmetrical loading with a controlled orientation with respect to both the crystal and the base of the test jig. The cable connection to the body of the accelerometer was modified to eliminate the set screw and cable shim. The new connector consists of a compression nut and lead washer which fit into a tapped hole in the side of the accelerometer body. Attempts were made to verify experimentally the predicted lowering of the resonant frequency by shock exciting the test accelerometer while mounted in an 80-g small steel block. The observed mounted resonant frequencies varied only slightly with the mass which loaded the crystals and were all between 40 and 50 kc. A steady-state frequency-response test was performed with the NBS 33-17 accelerometer by comparison with the output of a sensitive displacement measuring system. The accelerometer was mounted on a steel plate which was attached to the end of a piezoelectric vibration generator. Four additional accelerometers were also mounted on the steel plate at 90° intervals in the plane transverse to the direction of vibration as a means of measuring the transverse motion.

NBS. 25:023

National Bureau of Standards, Washington, D. C.

A LARGE BARIUM-TITANATE ACCELEROMETER FOR SHOCK-VELOCITY MEASUREMENTS, by T. A. Perls and C. W. Kissinger. June 1955, 9p. illus. (NBS rept. no. 4121) (Sponsored jointly by Office of Naval Research under NAonr 21-48, [Air Force] Office of Scientific Research under CSO-670-54-7, and Atomic Energy Commission) AD 68484 Unclassified

The instrument has sufficient charge sensitivity to permit integration with a passive network and still retain output voltage so that an impulsive change of velocity of 5 fps can be recorded with good amplitude on any high-impedance 10-mv recorder. To achieve the highest possible resonant frequency, the accelerometer base, the $BaTiO_3$ disks, and the loading mass must be in contact over their entire mating surfaces so that the assembly will act as a compression spring. When the accelerometer is mounted on a heavy object the theoretical resonant frequency should be about 0.7 times the unmounted resonant frequency; this assumes perfect coupling between the base of the accelerometer and the surface to which it is mounted. With a reasonably flat mounting surface and 3 mounting bolts tightened with a 40- to 70-lb-ft torque, the resonant frequency of the accelerometer with commercially flat crystals is 4900 c when it is mounted on a 22-lb mass and 4600 c on a 62-lb mass. These frequencies are about 10% lower than those theoretically expected from the unmounted resonant frequency together with the loading mass and total weight of the accelerometer. By extrapolation, the resonant frequency of the accelerometer when mounted on an infinite mass should be about 4400 c. The advantages and disadvantages of the present integrating accelerometer over the seismic-type velocity meter are discussed.

NBS. 25:024

National Bureau of Standards, Washington, D. C.

A CALORIMETER FOR MEASURING THE POWER IN A HIGH-ENERGY X-RAY BEAM, by J. McElhinney, B. Zendle, and S. Domen. June 1, 1955 [8]p. incl. illus. diagrs. tables. (Research paper no. 2642) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research under [CSO-670-54-7], and Atomic Energy Commission) AD 116371 Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 56: 9-16, Jan. 1956.

The design and calibration of a calorimeter to measure the power in x-ray beams having peak energies between 1 and 180 million electron volts are described. The calorimeter included two thermally balanced lead cylinders, 4 centimeters in diameter by 7.5 centimeters

NBS. 25:025 - NBS. 26:003

long, one trradtated by an x-ray beam. The lead cyltnder was large enough to absorb almost completely the x-ray beam. The absorbed energy resulted in an unbalance of temperature of the two cyltnders, whtch was measured by the change in reststance of embedded thermistors. Calibration of the calortmeter conststed tn observing the temperature rtse due to a mcasured quantity of electric energy dtsstpated tn the same cyltnder. The results are gtven for ftve caltbration runs, each ustng about 70 mtcrowatts of power for approxtmately 20 mtnutes. The probable error of the mean was about ± 1 percent. Separate reports of measurements of x-ray beam powers at 1.4 and 36 mtllion electron volts are tn preparation. (Contractor's abstract)

NBS. 25:025

National Bureau of Standards, Washington, D. C.

FREQUENCY RESPONSE OF SECOND-ORDER SYSTEMS WITH COMBINED COULOMB AND VISCOUS DAMPING, by T. A. Perls and E. S. Sherrard. Apr. 3, 1956 [20]p. incl. diagrs. (Research paper no. 2693) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research under [CSO-670-54-7], and Atomic Energy Commission) AD 112811 Unclassified

Also published in Jour. Res. Nat'l. Bur. Standards, v. 57: 45-65, July 1956.

Curves obtained with an analog computer are presented for the magnification factor versus frequency ratio of second-order systems with combined coulomb and viscous damping. The ranges of the parameters are as follows: vtscous damptng ratio from 0.05 to 5.0, tn 15 steps; coulomb damptng ratio from 0 to 0.9, tn 11 steps; and frequency ratio from 0 to 2.0. Boundarles between regtons wtth 0, 1, and 2 stops per half-cycle are also shown. (Contractor's abstract)

NBS. 26:001

National Bureau of Standards, Washington, D. C.

MICROWAVE SPE. TROSCOPY OF LABILE MOLECULES. I. TRANSITION TYPES, FREQUENCIES, AND INTENSITIES, by R. J. Kurland and D. E. Mann. Mar. 1956, 43p. incl. diagrs. tables, refs. (NBS rept. no. 4649) (AFOSR-TN-56-241) (CSO-680-56-19) AD 88361 Unclassified

The avatlable data for a number of labtle diatomtc and some trtatomtc molecules have been revtewed and summartzed tn order to classtfy thetr expected mtcrowave spectra by type, frequency, and tntenstty. Estimates are given for ⊥- and ∥-type multtplet transtttons as welt as for the pure rotational spectra expected to fall tn a readtly accesstble regton of the mtcrowave spectrum. Some dtscusston ts also gtven of methods of preparation of certatn unstable spectes suttable for nicrowave tnvesttgattons. (Contractor's abstract)

NBS. 26:002

National Bureau of Standards, Washtngton, D. C.

THE FIELD EMISSION X-RAY MICROSCOPE, by R. A. Schrack. July 13, 1956, 1v. tncl. tllus. diagrs. refs. (NBS rept. no. 4775) (AFOSR-[T]R-56-27) [CSO-680-56-19] AD 90012 Unclassifted

The ftrst utilizalion of fteld emtssion electron source in an electron optical system was accomplished in this x-ray shadow mtcroscope. The mtcroscope was constructed prtnctpally of glass and brass. The separate parts are fttted together wtth rubber O-ring seals and stopcock grease. Ustng a 20 l/sec glass otl diffuston pump and a liquid N cold trap, an operating vacuum of better than 5×10^{-6} mm Hg was obtained in 2 hr. A strong field created at the surface of a very small point by applying a potential of about 10,000 v to 125 μ W wire, allows the emission of electrons. The electrons are focused by an electrostatic electron lens into a small area on a thin target of Au. X-rays are produced by the electron impact (Bremmstrahlung) in a very small volume in the target. The generated x-rays are transmitted through the target and used to produce a shadow image on photographic film. The HV pulse supplies the electron lens through a phase-compensated voltage divider which allows adjustment of the focal length of the electron lens to produce focusing conditions at all times during the electron emission pulse. The W field emitter is raised to 2000°K to remove C contamination, and is operated at about 1400°K to preclude contamination. Design requirements for the lens system indicated a 3-element unlvoltage electrostatic lens. Results showed the best photographs taken with the x-ray mlcroscope indicated at resolution on the order of 5μ.

NBS. 26:003

National Bureau of Standards, Washington, D. C.

A FIELD EMISSION X-RAY PROJECTION MICROSCOPE (Abstract), by R. A. Schrack, R. C. Placious, and L. Marton. [1956] [1]p. [CSO-680-56-19] Unclasstfted

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 167, Apr. 26, 1956.

Electrons from a fteld emission source are focused by an electron optical system to a small spot to produce a small bremsstrahlung source for x-ray projection mtcroscopy. A ftne tungsten potnt ts operated as a fteld emtsston source at elevated temperature, termed T-F emisston by Dyke and hts coltaborators. The elevated temperature maintains a clean tungsten surface tn a dynamtc vacuum system operattng at a pressure of 2×10^{-7} mm Hg. The voltage supply is pulsed 60 cps wtth a ten percent duty cycle. The pulse current

is about 100 microamps for 10-kv pulse voltage. About 3×10^{-3} of the total current is focused to a spot to produce x-rays. Exposure time for a density of 1 is about 10 min for the above current and voltage and fast no-screen x-ray film without cover. Details on target and resolution are presented. (Contractor's abstract)

NBS. 27:001

National Bureau of Standards, Washington, D. C.

EXCITATION AND SEPARATION OF PURE HIGH-ORDER MODES IN LARGE HIGH-Q CAVITIES, by C. T. Zhan and W. G. Schweitzer, Jr. Apr. 5, 1956 [9]p. incl. diagrs. (Bound in its NBS rept. no. 5673; AFOSR-TR-56-94; AD 136740) (CSO-680-57-9) AD 136740(a) Unclassified

Also published in Jour. Appl. Physics, v. 27: 929-937, Aug. 1956.

In order to extend the range of cavity resonance techniques, a successful method has been developed for the suppression of undesired modes of a densely populated cavity spectrum. It is based on the nodal properties of the usual simple solutions of the wave equation. The analytic continuation of any such solution may be regarded as a master mode pattern which defines an infinite variety of elementary cavities or cells all having one frequency in common. These properties provide the basis for a novel principle in the design of cavity-coupling systems. By suitable choice of a "complex" of these elementary cells, devices can be obtained with remarkable transducing, filtering, or suppressing properties. An experimental test of the foregoing ideas has been made in which it was possible to excite a well-separated very high order TE_{0mv} mode in a large cylindrical cavity, at a frequency of 20,000 mc. The observed Q for this preferred mode was of the order of one million. As an additional test quantitative experiments have been performed on a special type of complex cavity in which the number of elementary cells could be varied. (Contractor's abstract)

NBS. 28:001

National Bureau of Standards, Washington, D. C.

PHOTOEMISSION FROM SILVER INTO SODIUM CHLORIDE, THALLIUM CHLORIDE, AND THALLIUM BROMIDE, by W. T. Turner. [Dec. 2, 1955] [8]p. incl. diagrs. refs. (AFOSR-TN-55-444) (CSO-670-53-19) AD 140140 Unclassified

Published in Phys. Rev., v. 101: 1653-1660, Mar. 15, 1956.

The photoelectric work function for the transfer of electrons from a metal directly into an insulating crystal has been investigated for Ag on samples of NaCl, TlCl, and TlBr. The results obtained do not confirm the existence of this process in the samples studied although the apparatus had a current sensitivity of 1×10^{-17} amp. Mott and Gurney have suggested that the work function of the metal-insulator contact would be less than the vacuum work function of the metal by an amount equal to the electron affinity of the insulator. Previous experimental evidence supporting this picture of the contact appears less conclusive in the light of the results of this investigation. During the investigation of the Tl halides, photosignals were observed far beyond the intrinsic edge (0.38μ for TlCl and 0.46μ for TlBr at -150°C). Intrinsic irradiation at low temperature appreciably enhanced the long-wavelength photoresponse. The enhanced response could be bleached by heating the sample to room temperature. It was established that the photoresponse was a property of the crystal rather than photoemission from Ag into the crystal. (Contractor's abstract)

NRC. 01:001

National Research Council. Biology Council, Washington, D. C.

SYMPOSIUM ON EMBRYONIC NUTRITION, Brown Univ. (July 23-24, 1956), ed. by D. Rudnick. Univ. of Chicago Press, 1958, 113p. incl. diagrs. tables, refs. (The Developmental Biology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52) Unclassified

The eventual goal of chemical embryologists is to discover how the growing embryo converts food energy into the differential morphology of its species. The present state of knowledge, however, as summarized in this conference, permits descriptions of measurements rather than of the mechanisms involved. The 6 papers presented are considered to contain important contributions to the store of information on nutritional requirements and metabolism of the embryo, enzyme formation and activity, protein synthesis and the use of antigens as tracers. Their specific titles are: embryonic energy exchange; metabolic patterns in the sea-urchin embryo; yolk utilization in fishes; antigens as tracers of embryonic synthesis; nutrient necessities in chick development; and enzymes — formation and growth.

NRC. 01:002

National Research Council. Biology Council, Washington, D. C.

SYMPOSIUM ON REGENERATION IN VERTEBRATES, Brown Univ. (July 23-24, 1956), ed. by C. S. Thorton. Univ. of Chicago Press, 1959, 108p. incl. illus. diagrs. refs. (The Developmental Biology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52) Unclassified

This field has known great advances in research and methodology. The 6 papers of the symposium

NRC. 0t:003 - NRC. 01:006

concentrated on those vertebrate structures whtch have been most tntensively studied – the eye, the tatl, and the limbs. The participants in the conference also discussed the influence of nerves and hormones on regeneration and irradiation as a tool for studying the relationship between the local and organismic aspects of the regenerating system. The following presentations were offered: regeneration of the retina, iris and lens; the development of mesodermal axial structures in regeneration and embryogenesis; the cellular basis of limb regeneratton; the influence of nerves on regeneration; the role of hormones in regeneration; and the effect of x-rays on regenerative capacity.

NRC. 01:003

National Research Council. Biology Council, Washington, D. C.

INTERNATIONAL SYMPOSIUM ON CYT[illegible]FFERENTIATION, Brown Univ. (July 27-3t, t95[illegible]), ed. by D. Rudnick. Univ. of Chicago Press, t95[illegible], 148p. tncl. tllus. dtagrs, tables, refs. (The Deve'opmental Btology Conference Sertes, 1956; sponsored tn part by Atr Force Office of Sctenttftc Research under MIPR-680-56-52) Unclasstfied

The participants in this conference discussed cytodifferentiation from many viewpoints: the constancy of cellular identity, as contrasted with tendencies to revert to earlier forms or adapt to environmental change; latitude of expression of cells in keeping up environment; cellular behavior in a culture; cellular structure as governed by its chemistry and the milieu of other cells around tt. The conference consisted of 5 discussions partictpated tn by a chatrman and 6 to t0 panel members. The specific titles were: cytodifferentiation and genic endowment; chemical and morphological indices of cytodifferentiation; special instances of cytodifferentiation including myogenesis and fibrogenesis; the internal mtlteu tn cytodifferenttatton; and cancer, growtl, and cytodtfferentiatton. A brief review of evaluatton and perspectives follows.

NRC. 01:004

Nattonal Research Councti. Btology Council, Washington, D. C.

CONFERENCE ON ENVIRONMENTAL INFLUENCES ON PRENATAL DEVELOPMENT, Bar Harbor, Me. (Aug. 2-4, 1956), ed. by B. Mintz. Univ. of Chtcago Press, t958, 87p. tncl. tllus. diagrs. tables, refs. (The Developmental Btology Conference Sertes, t956; sponsored in part by Air Force Offtce of Sctentiftc Research under MIPR-680-56-52) Unclasstfted

Prenatal development ts influenced to some extent by both genetics and envtronment. Whether environmental factors accelerate or retard growth, cause anomalies, and produce temporary or long-term effects depends upon complex timing and upon the tnteraction of the maturing systems in the embryo. In this conference repre sensative cases tn whtch alteration of the embryo has been effected in utero by subjectng the mother to x-rays, dietary limitations or vitamin deficiencies were discussed. The discussion topics were: experimental alteration of morphogenesis; specificity of teratogenic agents; extragenic factors causing variations in development; interaction between the early embryo and its environment; multiplicity of effects of teratogenic agents: nutritional requirements for morphogenesis: interaction of areas of growth; and developmental relationships and interactions in time and space.

NRC. 0t:005

National Research Council. Biology Council, Washington, D. C.

CONFERENCE ON IMMUNOLOGY AND DEVELOPMENT, Bar Harbor, Me. (Aug. 7-9, 1956), ed. by M. V. Edds, Jr. Univ. of Chicago Press, 1958, 59p. incl. tables, refs. (The Development Biology Conference Series, t956; sponsored in part by Air Force Office of Sctentific Research under MIPR-680-56-52) Unclasstfied

The partictpants tn this conference discussed how the techniques of tmmunology can be used to demonstrate specifictty at all levels – molecular, tissue, and organ. While recommendtng that their method be used in conjunction with other experimental procedures, they pointed out the value of immunology in studying the fate of specific substances under experimental controls, its function in changing the course of development by administration of tissue extracts, its role in wound healing, and its importance in the analysis of the immunochemical properties of the cell in protein synthesis. Finally, they speculated as to the probable future uses of tmmunological methods for studying nucleic acid and nucleo-proteins. The discussion topics were: clarification and definition of terms; progressive transformations of individual molecular species; essentialness of antigens in growth and development; localization and cytotoxtcity; acqutred tolerance; homografts; prolongatton of graft survtval; effect of anttsera on tumors; effects of ttssues and antisera on normal tissue; cell-surface reacttons during development; and antigen-antibody systems tn tnvertebrates.

NRC. 0t:006

Nattonal Research Councti. Biology Councti, Washtngton, D. C.

CONFERENCE ON PHYSIOLOGY OF INSECT DEVELOPMENT, MacDonald College, Canada (Aug. 14-16, 1956), ed. by F. t. Campbell. Univ. of Chtcago Press, t959, 167p. tncl. tllus. diagrs. tables, refs. (The Devetopmental Biology Conference Series, t956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52) Unclassified

Thts was the only one of the conference sertes to deal princtpally wtth one class of antmals. It was not tntended to be an entomological conference but rather one that would pay partticular attentton to insects in relation

to general problems of developmental biology. The objectives of the conference were to achieve such benefits as: a fresh exposition of the basic problems in the field; resolution of larger problems into tangible and practically approachable issues; clarification of concepts, terms and facts; identification of areas where information is lacking or inadequate and notions of how such areas could be profitably investigated. The conference was comprised of sessions on the following: embryology; larval development and tissue culture; metamorphosis and diapause; histolysis and tumors; and regeneration.

NRC. 01:007

National Research Council. Biology Council, Washington, D. C.

CONFERENCE ON DYNAMICS OF PROLIFERATING TISSUES, Upton, N. Y. (Sept. 5-8, 1956), ed. by D. Price. Univ. of Chicago Press, 1958, 96p. incl. illus. diagrs. tables, refs. (The Developmental Btology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52)
Unclassified

Proliferating tissues may be part of the over-all growth of an organism or of local growth; they may provide replacement of worn-out parts, as in molting or shedding, or may constantly renew adult tissues, such as skin and blood. A tissue must reproduce itself as well as carry out its specific function; in both cases its dynamics are affected by its physical and chemical environment. In this conference the variables involved in proliferation and differentiation, requirements and upsetting factors, rates and ratios, and the different methods for studying tissue growth and function were discussed. The following specific topics were discussed: renewal systems; methods for estimating the rate of proliferation; methods for estimating production and delivery of white blood cells; methods for estimating cell loss; examples of renewal systems; factors influencing the rate of cell production and cell loss in renewal systems; blood cell-producing organs; and factors influencing blood cell production.

NRC. 01:008

National Research Council. Biology Council, Washington, D. C.

SYMPOSIUM ON ENDOCRINES IN DEVELOPMENT, Shelter Island, N. Y. (Sept. 11-13, 1956), ed. by R. L. Watterson. Univ. of Chicago Press, 1959, 142p. incl. illus. diagrs. tables, refs. (The Developmental Biology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52)
Unclassified

The objective of this conference was to re-examine the various aspects of the relation between endocrines and development, including the nature of the reactions which hormones release in the terminal receptors in light of the recent advances in the purification, crystallization and synthesis of hormones. The conference consisted of 12 presentations as follows: introduction; ontogeny of selected endocrine glands — thyroid, adrenals, gonads, parathyroids; endocrine organs of arthropods; ontogeny of selected endocrine receptors; conditioning effect on end organs; ontogeny of selected hormone-dependent receptors; synergistic action of hormones; integration of the endocrine system; and mode of action of hormones.

NRC. 01:009

National Research Council. Biology Council, Washington, D. C.

SYMPOSIUM ON MITOGENESIS, Lemont, Ill. (Sept. 24-26, 1956), ed. by H. S. Ducoff and C. F. Ehret. Univ. of Chicago Press, 1959, 114p. incl. illus. diagrs. tables, refs. (The Development Biology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52)
Unclassified

This conference concerned itself with the initiation of mitotic division rather than with mitosis itself. One of the principal concerns in studying mitogenesis is to attempt to discover what makes cells divide both in normal growth and in abnormalities such as cancer. The following specific topics were discussed: premitotic growth; amitosis; growth promoters and inhibitors; elements of mitosis; the mitotic spindle; the time element and synchronization; mitotic triggers and endogenous stimuli of mitosis; cell interactions and environmental factors; differentiation and division; origin of diversity; degrees of differentiation; and radiation sensitivity of division versus differentiation.

NRC. 01:010

National Research Council. Biology Council, Washington, D. C.

SYMPOSIUM ON WOUND HEALING AND TISSUE REPAIR, New York (Oct. 2-4, 1956), ed. by W. B. Patterson. Univ. of Chicago Press, 1959, 83p. incl. illus. diagrs. refs. (The Developmental Biology Conference Series, 1956; sponsored in part by Air Force Office of Scientific Research under MIPR-680-56-52)
Unclassified

Healing starts at the moment a wound is inflicted and continues until a state of tissue integrity is reached. The various aspects of healing discussed at this conference included: the process simplified, as studied in lower animals; techniques by which the cellular changes of tissue reconstruction can be observed; the biochemistry of healing, both at the cellular level and as the body as a whole reacts with endocrine activity and metabolic change; and an analysis of certain abnormalities of healing. The conference consisted of 7 presentations as follows: biological aspects of wound healing; cellular components of the wound; the ground substance;

NRC. 02:00t - NEB. 01:002

wound healing and sulfur metabolism; systemic factors acting on the healing wound; the healing of bone; and abnormal healing.

NRC. 02:001

National Research Council. Committee on Solids, Washington, D. C.

STRUCTURE AND PROPERTIES OF SOLID SURFACES. A CONFERENCE ARRANGED BY THE NATIONAL RESEARCH COUNCIL, LAKE GENEVA, WISCONSIN, SEPTEMBER 1952, ed. by R. Gomer and C. S. Smith. Chicago, Univ. of Chicago Press, 1953, 491p. incl. illus. diagrs. tables, refs. (AF 18(600)354) Unclassified

An attempt is made to find some common denominators for some of the diverse problems existing in the field of surface studies. Fourteen papers are presented which cover the following main categories: (1) thermodynamics and theories of surface forces; (2) the structure of a surface and means of determining it; (3) growth processes of and on surfaces; and (4) processes on surfaces which leave them relatively unaltered. The book opens with a concise and critical review of the thermodynamics of surfaces and the potentialities of the thermodynamic approach. Each paper is followed by a discussion which interrelates the common aspects of the 4 categories mentioned. A combined author and subject index is included.

NOL. 01:00t

Naval Ordnance Lab., Corona, Calif.

AN INFRARED RAPID SCANNING SPECTROMETER AND ITS USE IN THE MEASUREMENT OF THE SPECTRA OF SHORT-LIVED MOLECULES (Abstract), by K. N. Tanner and R. L. King. [1956] [1]p. [MIPR-670-55-40] Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956. p. 57.

A rapid scanning infrared spectrometer has been designed and constructed to search for certain fundamental bands of the free radicals NH_2, CH_3, and CH_2. The monochromator uses the same off-axis parabola design as the Perkin-Elmer Mod. 12, but the Littrow mirror has been replaced by a Littrow-Wadsworth combination in which the Littrow mirror rotates continuously. The detector is a cooled lead telluride photoconductive cell. The spectrum is presented on a double beam oscilloscope. An "optical vernier" system synchronizes the oscilloscope sweep and also generates a set of linear fiductary marks, each corresponding to about 4 minutes of Littrow mirror rotation, which are presented on the second trace of the oscilloscope. The radicals are generated by flash photolysis in one meter quartz absorption cell. This spectrometer is capable of scanning the 3μ band of ammonia in about 4 msec with essentially no loss in resolution from conventional slow speed, narrow band scanning, in about 2 msec with slight loss, and in less than one msec with somewhat greater resolution loss. The results of using this instrument to search for the 3μ bands of NH_2, CH_3, and CH_2 are presented.

Naval Supersonic Lab., Cambridge, Mass. <u>See</u> Massachusetts Inst. of Tech. Naval Supersonic Lab., Cambridge.

NEB. 01:00t

Nebraska U., Lincoln.

ON CONDITIONS FOR THE STABILITY OF SOLUTIONS OF PENDULUM-TYPE EQUATIONS, by J. C. Lillo and G. Seifert. Nov. 8, 1954, 6p. (Rept. no. 1) ([AF]OSR-TN-54-312) (AF 18(600)1112) AD 53191 Unclassified

<u>Also published in</u> Jour. Appl. Math. and Phys. (ZAMP), v. 6: 239-243, 1955.

The equation $\ddot{\theta} + \alpha f(\theta)\dot{\theta} = g(\theta)$, where $f(\theta)$ and $g(\theta)$ are twice differentiable functions of period 2π in θ, $f(\theta) > 0$, $\int_0^{2\pi} g(\theta)d\theta > 0$, and $g(\theta)$ has simple zeros, has for sufficiently small α a solution $\theta(t)$ such that $\theta = \gamma(\theta)$ is a non-negative function of period 2π in θ. It is also known that if no such solution exists, each solution of this equation tends to some fixed value θ_j, a zero of $g(\theta)$, as $t \to +\infty$. In this note, bounds on a critical value α_c are obtained, this critical value being such that $\alpha \leq \alpha_c$ implies the existence of a periodic $\gamma(\theta)$, while $\alpha > \alpha_c$ implies nonexistence of such a $\gamma(\theta)$. (Contractor's abstract)

NEB. 01:002

Nebraska U., Lincoln.

ON STABILITY QUESTIONS FOR PENDULUM-TYPE EQUATIONS, by G. Seifert. Mar. 31, 1955, 14p. incl. diagr. (Rept. no. 2) ([AF]OSR-TN-55-92) (AF 18-(600)1112) AD 70032 Unclassified

<u>Also published in</u> Jour. Appl. Math. and Phys. (ZAMP), v. 7: 238-247, 1956.

The differential equation $\ddot{\theta} + f(\theta, \alpha)\dot{\theta} = g(\theta)$, where f and g are functions having continuous derivatives everywhere, $\alpha > 0$, $f(\theta + 2\pi, \alpha) = f(\theta, \alpha)$, $g(\theta + 2\pi) = g(\theta)$, and $g(\theta) = 0$ has simple roots, is considered. Conditions are given under which each solution coincides

with or asymptotically approaches a periodic solution; here periods 0 and $+\infty$ are allowed if a solution of period zero is interpreted as a constant and solution of period $+\infty$ are solutions $\theta(t)$ for which $\theta(t) \to \theta_0$, a finite constant, for $t \to +\infty$ and $t \to -\infty$. Conditions are also given under which solutions exist which are not asymptotically stable in the sense given above. A special example is given to illustrate the possibility of satisfying all conditions given above such that $f(\theta, \alpha)$ has negative values for each $\alpha > 0$. (Contractor's abstract)

NEB. 01:003

Nebraska U., Lincoln.

STABILITY OF SOLUTIONS OF PENDULUM-TYPE EQUATIONS, by G. Seifert and J. C. Lillo. May 31, 1955, 6p. (Rept. no. 3) ([AF]OSR-TN-55-158) (AF 18-(600)1112) AD 65891 Unclassified

The behavior as $t \to t + \omega$ of solutions $\theta(t)$ of a differential equation of the type $\ddot{\theta} + f(\theta, \alpha)\dot{\theta} = g(\theta)$, where f and g have continuous derivatives with respect to θ everywhere, f is continuous in α, $g(\theta)$ has zeros, all of which are simple, and $f(\theta + 2\pi, \alpha) = f(\theta, \alpha)$, $g(\theta + 2\pi) = g(\theta)$ hold for all θ, is studied. Conditions, involving primarily the dependence of f on the parameter α, under which all solutions exhibit types of stability as $t \to +\infty$ are derived. The existence and behavior of certain types of periodic solutions of this equation which affect stability questions are also studied with respect to explicit conditions on f and g. (Contractor's abstract)

NEB. 01:004

Nebraska U., Lincoln.

ON PENDULUM-TYPE EQUATIONS AND ROTATED VECTOR FIELDS, by G. Seifert. Aug. 20, 1955, 8p. (Rept. no. 4) ([AF]OSR-[TN]-55-217) (AF 18(600)-1112) AD 75906 Unclassified

The behavior as $t \to +\infty$ of solutions $v(t)$ of $\ddot{v} + f(v, \alpha)\dot{v} = g(v)$, where f and g have continuous derivatives with respect to v everywhere, f is continuous in α, $g(v)$ has zeros, all of which are simple, and $f(v + 2\pi, \alpha) = f(v, \alpha)$, $g(v + 2\pi) = g(v)$ hold for all v, is first studied. Conditions, involving primarily the dependence of f on the parameter α, under which all solutions exhibit types of stability as $t \to +\infty$ are derived. The existence and behavior of certain types of periodic solutions of this equation which affect stability questions are also studied with respect to explicit conditions on f and g. In the second part of this project, systems were considered ($\dot{x} = P(x, y, \alpha)$, $\dot{y} = Q(x, y, \alpha)$) where P and Q satisfy Lipschitz conditions in x and y, have continuous derivatives P_α and Q_α, and $\begin{vmatrix} P & Q \\ P_\alpha & Q_\alpha \end{vmatrix} \geq 0$ for (x, y) in a domain D and α in an interval I, the equality holding for at most an isolated set of points in D; the critical points of the system are isolated and independent of α. It was found that cycles of the system, which were asymptotically stable, vary monotonically and continuously at values of α for which such cycles exist. A result concerning the existence of other cycles for a system having an unstable critical point and a cycle surrounding it is obtained and application of this is made to the existence of cycles for systems arising from second order equations of the form $\ddot{x} + f(x, \dot{x})\dot{x} + g(x) = 0$. (Contractor's abstract)

NEL. 01:001

Nelson, W. C., Ann Arbor, Mich.

[PREPARATION OF MONOGRAPH ON WIND TUNNELS FOR AGARD] by W. C. Nelson. Final rept. Feb. 16, 1955, 2p. (AFOSR-TR-55-6) (AF 18(600)953) Unclassified

A list of 11 reports received by the author which is to be incorporated into an AGARDograph monograph on wind tunnel design, operation, and test techniques along with his comments on each paper is presented.

NHU. 01:001

[New Hampshire U., Durham]

RECURSIVE REAL NUMBERS, by H. G. Rice. [1953] [12]p. (Technical rept. no. 1) (AF 18(600)480) AD 25697 Unclassified

Also published in Proc. Amer. Math. Soc., v. 5: 784-791, Oct. 1954.

Four equivalent definitions are given for the concept of recursive real numbers. A proof is presented that if $a_0, a_1, a_2, \ldots$ is a recursively enumerable, recursively convergent sequence of rational numbers with the limit a, and b is any rational number where $b \neq a$, then there exists an effective method for deciding whether $b > a$ or $b < a$. However, there exists no effective general method for deciding, given 2 recursive real numbers a and b, whether or not $a = b$. The recursive real numbers are demonstrated to form a field, $\mathcal{C}$, and the set $\mathcal{C}(i)$ is stated to be algebraically closed. However, the analog of the Bolzano-Weierstrass theorem, that every bounded recursively enumerable set of numbers of $\mathcal{C}$ has a limit point in $\mathcal{C}$, does not hold. (ASTIA abstract)

NHU. 01:002

[New Hampshire U., Durham]

RECURSIVELY ENUMERABLE SEQUENCES, by H. G. Rice. [1953] [28]p. (Technical rept. no. 2) (AF 18-(600)480) AD 17839 Unclassified

NHU. 01:003 - NYU. 02:002

Recursively enumerable (RE) convergent sequences of sets of nonnegative integers are studied. The sets are drawn from the class of recursive sets, and from other classes generated from the recursive sets by adjoining limits of sequences. The main theorem connects the structure obtained with the Borel class structure generated over the recursive sets by RE sums and products. Concepts which appear as generalizations of recursive characteristic function and recursive enumerating function are introduced to prove this theorem. Similar concepts are applied to sequences of functions to obtain a structure with analogies to the Baire classification. Properties of certain Boolean algebras are discussed. An application to real numbers is developed. (ASTIA abstract)

NHU. 01:003

New Hampshire U., Durham.

INVESTIGATIONS IN RECURSION THEORY, by H. G. Rice. Final repl. Jan. 28, 1954, 8p. ([AF]OSR-TR-54-4) (AF 18(600)480) AD 52943 Unclassified

The work reported may be grouped under 3 headings. I. Recursive Real Numbers. The definitions of Specker are used, with general in place of primitive recursive functions. The recursive real numbers form a field closed under recursively convergent sequences. The recursive complex field is algebraically closed. Decision procedures for "=" and "<" are discussed. II. The Structure Over the Recursive Sets. A theorem is given connecting recursively enumerable (RE) sequences of sets with RE unions and intersections. Some properties of the resulting structure are discussed, and some applications made to reduction of decision problems. A Baire-like classification of functions is displayed. III. Recursive Distinguishability. The concept, due to McNaughton, is mentioned and a conjecture is stated. (Contractor's abstract)

New York State Coll. of Ceramics, N. Y. see Alfred U. New York State Coll. of Ceramics, N. Y.

New York U., N. Y.

N6ort-10503 and N6ort-1102, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) Item nos. PRI. 11:113-PRI. 11:125.

NYU. 01:001

New York U., N. Y.

ELECTRON-ELECTRON SCATTERING, by M. H. Shamos. Jan. 1-Mar. 31, 1954. 5p. incl. diagr. (Project no. R-357-10-13) (AFOSR-TR-54-15) (AF 18(600)950) Unclassified

This status report describes the progress during the period Jan. 1, 1954 to Mar. 31, 1954 on the experiment designed to examine the low energy scattering of free electrons by free electrons.

New York U. Coll. of Engineering, N. Y.

N6ori-1102 and [N6ori-10503], Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) Item no. PRI. 11:126.

NYU. 02:001

New York U. Coll. of Engineering, N. Y.

PURE QUADRUPOLE SPECTRUM OF METHYL IODIDE VAPOR, by F. Sterzer and Y. Beers. Jan. 15, 1954, 1p. [Report no. 289.1] ([AF]OSR-TN-54-9) (AF 18(600)968) Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit, Mich., Mar. 18-20, 1954.

Published in Jour. Chem. Phys., v. 22: 2094, Dec. 1954.

In a symmetric top molecule, transitions can take place between quadrupole hyperfine levels of the same J and K provided that K = 0. Because of its large quadrupole coupling constant, CH_3I^{127} has several lines of this type with computed intensities sufficient for observation in the uhf region. Using the spectrometer reported previously, we have observed the following lines: J = K = 3, F = 11/2 $\longrightarrow$ 9/2, 444.76 ± 0.10 mc/sec; J = K = 4, F = 13/2 $\longrightarrow$ 11/2, 481.05 ± 0.10 mc/sec; J = K = 5, F = 15/2 $\longrightarrow$ 13/2, 503.05 ± 0.15 mc/sec. The identities of the first two lines were confirmed from Stark splittings. These measured frequencies are perfectly consisted with the quadrupole coupling constant obtained from microwave rotational spectra if second order theory is employed.

NYU. 02:002

New York U. Coll. of Engineering, N. Y.

THE LINE WIDTH PARAMETER OF HDO AT LOW FREQUENCIES, by Y. Beers, G. Herrmann, and F. Sterzer. Aug. 12, 1954, 4p. (Rept. no. 289.2) ([AF]OSR-TN-54-204) (AF 18(600)968) AD 40179 Unclassified

The relative line width parameters of the $6_1 \longrightarrow 6_2$ and $3_2 \longrightarrow 3_3$ lines at respectively 2394.56 mc/sec and 826.64 mc/sec was determined as 1.0 ± 0.1, and the absolute value of the parameter of these lines was measured as 0.41 cm^{-1} at one atmosphere. The latter value is in good agreement with work by Strandberg (Jour. Chem. Phys., v. 17: 901, 1949) in the conventional microwave region. Therefore no basis was found to support any hypothesis that the discrepancy between calculated and measured values of the absorption

of radiation in the atmosphere by water is due to a variation in the line width parameter. (Contractor's abstract)

NYU. 02:003

New York U. Coll. of Engineering, N. Y.

THE DISCREPANCY IN THE ROTATIONAL CONSTANTS OF BROMOFORM, by G. Herrmann. Aug. 25, 1954, 4p. (Rept. no. 289.3) ([AF]OSR-TN-54-218) (Sponsored jointly by Office of Naval Research under Nonr-62100 and [Air Force] Office of Scientific Research under AF 18-(600)968) AD 43894 Unclassified

Also published in Jour. Chem. Phys., v. 22: 2093, Dec. 1954.

In the determination of the rotational constants of bromoform a large unexplained discrepancy was found between the results of Williams and Gordy (Jour. Chem. Phys., v. 20: 1524, 1952) working in the K-band and of Kojima et al. (Jour. Chem. Phys., v. 20: 804, 1952) in the S-band. In the present experiment an attempt was made to repeat the S-band measurements of Kojima with a spectrometer having a greater sensitivity. This sensitivity has been verified by measurements on other molecules. No bromoform lines could be observed, and it must be concluded that they are too weak to be detected. Therefore the results of Kojima must be rejected as being due to some spurious effect. (Contractor's abstract)

NYU. 02:004

New York U. Coll. of Engineering, N. Y.

THE J = 0 ⟶ 1 ROTATIONAL TRANSITION OF TRIFLUOROIODOMETHANE, by F. Sterzer. Aug. 25, 1954, 3p. incl. table. (Rept. no. 289.4) ([AF]OSR-TN-54-220) (AF 18(600)968) AD 43893 Unclassified

Also published in Jour. Chem., v. 22: 2094, Dec. 1954; Erratum. Jour. Chem. Phys., v. 23: 762, Apr. 1955.

From the measurements of the J = 0 ⟶ 1 transition of CF_3I, values of the rotational constant and iodine quadrupole coupling constant, respectively, of 1523.42 ± .15 mc/sec and of -2143.8 ± 2 mc/sec were obtained. These values are in good agreement with the results obtained by Sheridan and Gordy in the K-band. In the present work, unusually large corrections due to second order perturbation theory had to be employed. From measurements of the Stark effect, a value of 1.0 ± 0.1 x 10^{-18} esu cm was obtained for the dipole moment. (Contractor's abstract)

NYU. 02:005

New York U. Coll. of Engineering, N. Y.

PURE QUADRUPOLE SPECTRA OF CH_3I AND CF_3I VAPORS, by F. Sterzer and Y. Beers. Apr. 28, 1955 [30]p. incl. diagrs. tables, refs. (Rept. no. 289.5) ([AF]OSR-TN-55-109) (AF 18(600)968) AD 63422 Unclassified

Also published in Phys. Rev., v. 100: 1174-1180, Nov. 15, 1955.

The theory of $\Delta J = 0$, $\Delta F = \pm 1$ transitions of symmetric top molecules having a nucleus with a large quadrupole moment on the axis is presented first. Then, the manner in which the gaseous state spectrum converge on the pure quadrupole solid state spectrum as J becomes infinite is discussed in detail. An experiment is described in which 6 quadrupole lines of CH_3I and 1 of CF_3I were observed in the region between 290 and 520 mc/sec. The experiment yielded values of the quadrupole coupling constants of - 1933.99 ± 0.25 mc/sec and - 2142.5 ± 1.8 mc/sec, respectively, for CH_3I and CF_3I. These values are in agreement with previous values obtained elsewhere from rotational transitions. (Contractor's abstract)

NYU. 02:006

New York U. Coll. of Engineering, N. Y.

LOW-FREQUENCY ROTATIONAL SPECTRUM OF HDO, by S. Weisbaum, Y. Beers, and G. Herrman. Sept. 1955 [5]p. incl. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)968) and Office of Naval Research) Unclassified

Published in Jour. Chem. Phys., v. 23: 1601-1605, Sept. 1955.

In the region between 475 and 3500 mc/sec one P-branch and five Q-branch lines in the spectrum of HDO were completely measured and identified. These data contributed materially to an evaluation of the structural constants of the molecule. From the data obtained by this and other microwave spectroscopy projects, the principal moments of inertia were computed, respectively, as having the values of 1.1982, 3.0862, and 4.3887 in units of gm cm^2 x 10^{-40}. In addition, the shape of the 3_2 ⟶ 3_3 line at 824.64 mc/sec was extensively studied. At low pressure the wings of the line were shown to be wider than is consistent with the Lorentz line shape probably due to the presence of satellite lines arising from the hyperfine splitting of the energy levels by the quadrupole moment of the deuteron. The observed effects are consistent with a quadrupole coupling constant of 272 ± 90 kc/sec with respect to an axis along the O – D bond. (Contractor's abstract)

NYU. 02:007

New York U. Coll. of Engineering, N. Y.

THE INVERSION SPECTRUM OF ND_3, by G. Herrmann. June 28, 1956, 60p. incl. diagrs. tables, refs. (Rept.

NYU. 02:008 - NYU. 03:002

no. 289.6) (AFOSR-TN-56-291) (AF 18(600)968)
AD 90003 Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Also published in Bull. Amer. Phys. Soc., Series II, v. 1: 13, Jan. 30, 1956.

The inversion spectrum of the ground vibrational state of ND_3 has been investigated in the frequency region from 1520 to 1600 mc. From the 17 rotational fine structures observed, 8 were identified from their hyperfine structure. The revised, semi-empirical formula predicting the lines yielded the values a = 5.12 mc and b = 2.62 mc for the fine structure constants, and ν_0 = 1591.44 mc for the unperturbed ground inversion frequency. Splitting of K = 3 lines was observed for J = 3, J = 4, and J = 5, and found in good agreement with theoretical predictions based on infrared data. Nitrogen satellites were observed in the, 1, 1; 2, 2; 3, 3; 4, 3; and 5, 3 lines. Separations were within 10 kc of calculated values. A best fit was obtained by assigning the N quadrupole moment the value $(eQq)_N$ = 4080 ± 3 kc which is slightly smaller than its value in NH_3, and the magnetic coupling constant a, the value 2 ± 2 kc. The hyperfine structure of K = 1 lines was observed for J = 1, J = 2, and J = 3. This hyperfine structure is a result of the lifting of the K degeneracy by interactions arising from the deuterons. Line shapes were brought into agreement with theory by the method of contour fitting. The structure was found to depend primarily on the deuteron quadrupole coupling constant which was assigned the value $(eQq)_D$ = 200 ± 20 kc and on the magnetic parameter ϵ, (representing coupling of deuteron magnetic moments with molecular rotation) which was assigned the value ϵ = -1.9 ± 0.5 kc. In deriving the quadrupole moments, the usual assumption of cylindrical symmetry about bonds was made. The value of $(eQq)_D$ is in agreement with values obtained in other molecules. The value of ϵ is smaller by a factor of 2 than the value derived theoretically from known values of the magnetic constants in NH_3. (Contractor's abstract)

NYU. 02:008

New York U. Coll. of Engineering, N. Y.

DIRECT ℓ-TYPE DOUBLING TRANSITIONS IN ClCN, by L. Yarmus. Oct. 18, 1956 [5]p. incl. diagr. tables. (Rept. no. 289.8) (AFOSR-TN-56-505) (AF 18(600)968) AD 110320 Unclassified

Also published in Phys. Rev., v. 105: 928-929, Feb. 1, 1957.

Direct ℓ-type doubling transitions have been observed in $Cl^{35}C^{12}N^{14}$ for J = 17, 18, 19 and 23. A formula has been constructed for the ℓ-line doubling constant: $q = 7.467467 - 1.327 \times 10^{-5}J(J+1)$. The absolute value of the asymmetry parameter ϵ was determined to be 0.0101 ± 0.0004. (Contractor's abstract)

NYU. 02:009

New York U. Coll. of Engineering, N. Y.

HYPERFINE STRUCTURE IN THE ℓ-TYPE DOUBLING SPECTRUM OF HCN, by L. Yarmus. July 1, 1956. 6p. incl. diagr. tables, refs. (Rept. no. 289.7) (AFOSR-TN-56-506) (AF 18(600)968) AD 110321 Unclassified

Also published in Phys. Rev., v. 104: 365-367, Oct. 15, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 13, Jan. 30, 1956.

Direct ℓ-type transitions for HCN have been observed for J = 1, 2, 3, 4, and 5. Values obtained of the asymmetry parameter η = -0.082 ± 0.005 and the magnetic coupling constant c_l = 13 ± 5 kc/sec are in good agreement with previous work. For N^{14} the value eq_mQ = -4.81 ± 0.02 mc/sec is 5% higher than that obtained in the ground vibrational state. This change in eq_mQ can be explained by a decrease in the hybridization of the σ bond. (Contractor's abstract)

NYU. 03:001

New York U. Coll. of Engineering, N. Y.

A PRACTICAL APPROACH TO THE PROBLEM OF STALL FLUTTER, by C.-T. Wang, R. J. Vaccaro, and D. F. De Santo. June 1955 [12]p. incl. diagrs. tables. (Rept. no. 354-1) ([AF]OSR-TN-55-98) (AF 18(600)1372) AD 86237 Unclassified

A method is presented by which the real part of the dynamic moment coefficient may be obtained from a flutter test on a single blade oscillating in torsion alone in the stall region. The data may be used to predict the critical flutter velocity and frequency of a blade with the same geometrical properties oscillating with 2 degrees of freedom and having arbitrary elastic and inertial properties. The method could possibly be applied to cantilever blades by using either a representative section or a Rayleigh-type analysis. Flutter experiments were carried out in the 7- by 10-ft wind tunnel by using the NACA 0012 airfoil section and an airfoil section with a circular-arc mean chamber line of 25° included angle and NACA 0007 thickness distribution. The Reynolds number range for the tests was about 1 to 3 x 10^5.

NYU. 03:002

New York U. Coll. of Engineering, N. Y.

FLUTTER VELOCITY AND AMPLITUDE PREDICTIONS ON ISOLATED BLADES IN STALLED FLOW BY SINGLE-DEGREE-OF-FREEDOM ANALYSIS, by R. J. Vaccaro. Jan. 1957 [106]p. incl. illus. diagrs. tables.

(Rept. no. 354-2) (AFOSR-TN-56-592) (AF 18(600)-1372) AD 115019 Unclasstfied

The stall flutter problem for isolated compressor blades is investigated by experimental means without an attempt at application of information from the classical theory. Consequently, significant aerodynamic data are sought in the stall region. A method is proposed whereby airforces may be computed, using the equations of motion, from a single degree of flutter test. These airforces take the form of a real and an imaginary part of the moment coefficient versus k for given values of initial angle of attack, elastic axis location, and airfoil shape. Prediction of flutter speeds and frequencies and estimates of torsional amplitudes of cantilever blades installed flow can then be made.

NYU. 04:001

New York U. Coll. of Engineering, N. Y.

NEGATIVE ION EFFECT IN HALOGEN QUENCHED GEIGER COUNTERS, by H. Sherman. Aug. 8, 1956, 1v. incl. diagrs. tables, refs. (AFOSR-TR-56-32) (AF 18-(600)1460) AD 95807 Unclassified

Using pulsed x-rays as a source of ionization, measurements of time lags have been made in Geiger counters filled with the following gases: Ne and Cl_2; Ne, A, and Cl_2; A and I_2; Ne and I_2; and Kr and I_2. The values of time lags observed range from 13 to 0.3μ sec depending upon the concentration of halogen gas in the counter and the overvoltage. It is shown that the delays cannot be due to negative ions, but are probably caused by the relatively long time that it takes for the halogen molecules to de-excite the noble gas metastables formed in the avalanche. Assuming that negative ions are formed in the counters, Shinohara and Akuisu (Jour. Sci. Res. Inst. (Tokyo), v. 47: 80, 1953) have given a quantitative description of the variation in counter efficiency as a function of the radial distance of the ionizing event from the central wire. Using a collimated beam of x-rays to excite the counter, the above theory has been tested, and good agreement of theory and experiment has been found. In particular, it has been shown that the formation of negative ions may sharply reduce the efficiency of a counter near the cathode. An extension of the above theory indicates that another effect of negative ions is to increase the plateau slopes of these counters. Detailed observations of plateau slopes support this conclusion. (Contractor's abstract)

NYU. 05:001

New York U. Coll. of Engineering, N. Y.

PHOTO-THERMOELASTICITY: AN EXPLORATORY STUDY, by G. Gerard and A. C. Gilbert. May 1956 [37]p. incl. illus. diagrs. tables. (Technical rept. no. SM 56-11) ([AF]OSR-TN-56-237) (AF 18(600)-1471) AD 88357 Unclassified

The optical and physical properties of the photoelastic plastic, Paraplex P-43 were determined from 70° to -40°F. This castable polystryrene resin is free from the time-edge effect and can be cemented with relative ease. The techniques and equipment described were developed to obtain the modulus of elasticity, the material fringe value, and the thermal expansion coefficient as a function of temperature. Procedures are recommended for the embedding of thermocouples in P-43 that do not cause disturbances in the observed fringe pattern. Satisfactory correlation was obtained between the observed and the theoretically determined fringe distributions in disk and long beam models which were representative of the interference and the thermal gradient type of thermal stress fields, respectively. For short beams, severe end effects were observed which extended for a distance about equal to the beam depth. During the initial stages of sudden temperature application, the thermal stress field at the upper edge and free end regions were independent of the beam dimensions.

NYU. 05:002

New York U. Coll. of Engineering, N. Y.

NOTE ON PHOTOTHERMOELASTICITY, by G. Gerard and A. C. Gilbert. [1956] [1]p. incl. illus. [AF 18(600)1471] Unclassified

Published in Jour. Aeronaut. Sciences, v. 23: 702-703, July 1956.

Investigation has been made into the use of photoelastic techniques to determine thermal stresses arising from transient temperature gradients. Since photoelastic materials generally creep when exposed to elevated temperatures, the temperature gradient was established by refrigeration. The temperature gradient was applied to the upper surface of a beam, and fringe photographs were taken of the model in a polariscope at successive time intervals. Thermocouples were used to monitor the temperature distribution. The first picture was taken at time of maximum fringe order. The succeeding pictures taken showed that the fringe order decreased as the temperature gradients became less severe.

NYU. 06:001

New York U. [Inst. of Mathematical Sciences] N. Y.

INFINITE DETERMINANTS IN THE THEORY OF MATHIEU'S AND HILL'S EQUATIONS, by W. Magnus. Feb. 1953, 37p. refs. (Research rept. no. BR-1) (AF 18(600)367) AD 9954 Unclassified

Also published in Pacific Jour. Math., v. 5: 941-951, 1955.

The existence of even or odd solutions of Mathieu's

NYU.06:002 - NYU.06:005

equation with period π or 2π depends on the vanishing of certain infinite determinants. These determinants were expressed in terms of the values of the even or odd solutions at $x = \pi/2$, where x is the independent variable. The method applied uses theorems about the order of growth of the solutions with respect to both x and the parameters. A representation of the solutions as a finite Fourier integral was also derived by the method. An indication is given as to how far the results can be extended to the case of more general equations of Hill's type. The periodic solutions of the inhomogeneous Mathieu equations were constructed by using an inversion formula for certain infinite matrices. The connection between Hill's equation and the construction of transparent layers is reviewed.

NYU.06:002

New York U. [Inst. of Mathematical Sciences] N. Y.

THE SCOPE OF THE IMAGE METHOD, by J. B. Keller. Apr. 1953, 10p. incl. illus. (Research rept. no. BR-2) (AF 18(600)367) AD 11888 Unclassified

Also published in Communications on Pure and Appl. Math., v. 6: 505-512, Nov. 1953.

The image method is defined for regions in Euclidean n-space bounded by planes, and all the regions to which it applies are determined for every boundary-condition choice. The boundary conditions considered include $G = 0$, $\partial G/\partial n = 0$, and $\partial G/\partial n + hG = 0$, where G represents Green's function and h is a constant. The method is also applicable to differential equations on the surface of a sphere and to regions bounded by great circles. All the regions on the sphere to which the method applied are obtained. The main difficulty in extending the method to Riemann surfaces is the construction of the Green's function for full space. An extension is also possible to regions bounded by an even number of pair-wise parallel planes with the boundary condition of periodicity. For certain regions only a finite number of images occur, and the sums used in defining the Green's function are finite. Convergence of the sums must be examined for other cases.

NYU.06:003

New York U. [Inst. of Mathematical Sciences] N. Y.

ALGEBRAIC ASPECTS IN THE THEORY OF SYSTEMS OF LINEAR DIFFERENTIAL EQUATIONS, by W. Magnus. June 1953, 35p. refs. (Research rept. no. BR-3) (AF 18(600)367) AD 14714 Unclassified

Also published in Communications on Pure and Appl. Math., v. 7: 649-673, Nov. 1954.

A discussion is presented of the connection between the Baker-Hausdorff formula and systems of linear differential equations. A proof is given of an algebraic theorem which characterizes Lie-elements in a free non-commutative ring, and analytic criteria are derived for the existence of solutions of systems of linear differential equations in terms of a finite number of quadratures. The range of validity is discussed for the representation of solutions in the form of an exponential function of a matrix. The case corresponding to a second-order differential equation is studied in detail. (ASTIA abstract)

NYU.06:004

New York U. Inst. of Mathematical Sciences, N. Y.

EIGENFUNCTION EXPANSIONS ASSOCIATED WITH A NON-SELF-ADJOINT DIFFERENTIAL EQUATION, by B. Friedman and L. I. Mishoe. Jan. 1954, 29p. (Research rept. no. BR-4) ([AF]OSR-TN-54-24) (AF 18(600)367) AD 18195 Unclassified

Also published in Pacific Jour. Math., v. 6: 249-270, 1956.

Consideration is given to the problem of expanding a function of bounded variation in terms of the eigenfunctions of a non-self-adjoint differential system, $u'' + q(x)u + \lambda[p(x)u - u'] = 0$, where $u(0) = u(1) = 0$. Restrictions which were previously imposed were eliminated. A proof is given of the theorem: Let $F(x)$ be a function of bounded variation for $0 \leq x \leq 1$ and let $u_n(x)$ be the eigenfunctions of the system $(A + \lambda B)u = 0$, $u(0) = u(1) = 0$, where A is the operator $\frac{d^2}{dx^2} + q(x)$ and where B is the operator $-\frac{d}{dx} + p(x)$. Further, let $v_n(x)$ be the eigenfunctions of the system adjoint to $(A + \lambda B)u = 0$, $u(0) = u(1) = 0$; and let $C(\lambda)e^{\lambda x}$ be the Wronskian of the equation $(A + \lambda B)u = 0$. If

$$F(0+) + \exp\left[-\int_0^1 p\,dt\right] F(1-) = 0(I),$$

then the series

$$\sum_{-\infty}^{\infty} u_n(x) \int_0^x F(\xi)\left[\frac{p(\xi)v_n(\xi) + v_n'(\xi)}{C'(\lambda_n)}\right] d\xi \quad (II)$$

converges to $F(x)$ at every point where $F(x)$ is continuous in $0 < x < 1$. At all other points, the series converges to $\frac{1}{2}F(x + 0) + \frac{1}{2}F(x - 0)$. If $F(x)$ does not satisfy the boundary conditions I, then the series II converges to

$$\tfrac{1}{2}F(x + 0) + \tfrac{1}{2}F(x - 0) - \tfrac{1}{2}\exp\left[\int_0^x p\,dt\right]\left[F(0+) + \exp\left[-\int_0^x p\,dt\right] F(1-)\right].$$

NYU.06:005

New York U. Inst. of Mathematical Sciences, N. Y.

THE BEHAVIOR OF THE SOLUTIONS OF $\Delta U = F(x, U)$ IN THE NEIGHBORHOOD OF A POINT, by M. Müller. Mar. 1954, 18p. (Research rept. no. BR-5) ([AF]OSR-TN-54-52) (AF 18(600)367) AD 32487 Unclassified

Also published in Communications on Pure and Appl. Math., v. 7: 505-515, Aug. 1954.

The solution of the equation $\Delta u + k^2 U = 0$, where the function k^2 is bounded and not necessarily analytic and Δ is the p-dimensional Laplacian, is shown to vanish identically if it vanishes at a point more strongly than any power of the distance from that point. An analogous theorem is proved for the equation $\Delta u = F(x, u)$, where F satisfies a Lipschitz condition. (Contractor's abstract)

NYU. 06:006

New York U. Inst. of Mathematical Sciences, N. Y.

INFINITE DETERMINANTS ASSOCIATED WITH HILL'S EQUATION, by W. Magnus. June 1954, 16p. (Rept. no. BR-6) ([AF]OSR-TN-54-141) (AF 18(600)367) AD 40175 Unclassified

Also published in Pacific Jour. Math., v. 5, Suppl. 2: 941-951, 1955.

The analytic character of the transcendental function whose zeros determine the periodic solutions of Hill's equation is investigated. This is done by a study of the elements of the factors of the infinite determinant which occurs in this transcendental function. (Contractor's abstract)

NYU. 06:007

New York U. Inst. of Mathematical Sciences, N. Y.

DETERMINATION OF COEFFICIENTS OF CAPACITANCE OF REGIONS BOUNDED BY COLLINEAR SLITS AND OF RELATED REGIONS, by B. Epstein. Aug. 1954, 13p. incl. diagrs. table. (Research rept. no. BR-7) ([AF]OSR-TN-54-195) (AF 18(600)367) AD 43984 Unclassified

Also published in Quart. Appl. Math., v. 14: 125-132, July 1956.

A number of formulas are derived for the coefficients of capacitance of a domain which consists of the entire plane minus any finite number of collinear slits. It is shown that any of a broad class of domains possessing a certain symmetry property is conformally equivalent to such a "slit-domain," and that the problem of determing the conformal correspondence is essentially one of mapping simply-connected domains rather than multiply-connected ones. As an illustration, the coefficients of capacitance of a "bi-filar shielded cabel" are computed. (Contractor's abstract)

NYU. 06:008

New York U. Inst. of Mathematical Sciences, N. Y.

A FOURIER THEOREM FOR MATRICES, by W. Magnus. Oct. 1954, 20p. (Research rept. no. BR-8) ([AF]OSR-TN-54-308) (AF 18(600)367) AD 50774 Unclassified

Also published in Proc. Amer. Math. Soc., v. 6: 880-890, Dec. 1955.

A Fourier theorem is proved which establishes a one-to-one correspondence between n x n matrices depending on a real parameter and n x n matrices depending on the elements of a variable hermitian matrix and satisfying certain differential equations. The analogue of the Plancherel formula is shown to be true of this Fourier theorem.

NYU. 06:009

New York U. Inst. of Mathematical Sciences, N. Y.

A CONVERGENT ASYMPTOTIC REPRESENTATION FOR INTEGRALS, by J. Franklin and B. Friedman. Dec. 1954, 18p. (Research rept. no. BR-9) ([AF]OSR-TN-54-342) (AF 18(600)367) AD 50658 Unclassified

Also published in Proc. Cambridge Philos. Soc. (England), v. 53: 612-619, 1957.

A new method is presented for obtaining an asymptotic representation for integrals of the form

$\int_0^\infty e^{-px} x^{c-1} f(x)dx$ when p is large. It is shown that if f(x) satisfies certain conditions this representation is also convergent. Numerical calculations seem to show that the first term of the representation gives a close approximation to the value of the integral for a wide range of values of p. (Contractor's abstract, modified)

NYU. 06:010

New York U. Inst. of Mathematical Sciences, N. Y.

LIE ALGEBRAS ARISING FROM SYSTEMS OF LINEAR DIFFERENTIAL EQUATIONS, by M. J. Heliman. 1954, 10p. (AF 18(600)367) Unclassified

The n x n matrix A(t), a function of t, is used to study the characteristics of a general system of n homogeneous linear differential equations of the first order for n unknown functions with $A' = \frac{dA}{dt}$ as its matrix of coefficients. A solution of $\frac{dY}{dt} = A'Y$, where Y is an n x n matrix whose column vectors are a set of n linearly independent solutions of $\frac{dy_\nu}{dt} = \sum_{\mu=1}^{n} a_{\nu,\mu}(t) y_\mu$, $A' = (a_{\nu,\mu})$, $\nu = 1, 2, \ldots, n$, is shown to be most simply $\Omega = \exp A_{(t)}$, if the commutator relation $[A'(t), A(t)] = A'(t) A(t) - A(t) A'(t) = 0$ is valid. If this is so, a test is provided for integrability in finite terms which works

NYU. 06:011 - NYU. 06:014

in some non-irivial cases. The Lie ring is relaied to the hypothetical one generated by the matrices A_ν.

NYU. 06:011

New York U. Insi. of Maihematical Sciences, N. Y.

ON THE EXPONENTIAL SOLUTION OF DIFFERENTIAL EQUATIONS FOR A LINEAR OPERATOR, by W. Magnus. [1954] [25]p. [AF 18(600)367] Unclassified

Also published in Communications on Pure and Appl. Math., v. 7: 649-673, Nov. 1954.

The first pari of the paper gives a proof and applications oi a characierization oi the Lie elemenis in a iree associative algebra R with n free generators $x_1, \ldots, x_n$ over a field f_0 with zero characieristic applied by Friedrichs in his quantum-mechanical investigaiions (same Communications, v. 6: 1-72, 1953). An element of R can be uniquely wriiien as a linear combination $F(x_1, \ldots, x_n)$ of power producis $x_{\nu_1}^{\alpha_1} \ldots x_{\nu_m}^{\alpha_\nu}(\nu_1 \neq \nu_2 \neq \ldots \neq \nu_m; m = 0, 1, \ldots)$ with coefficienis from f_0 or, in an exiended sense, as a formal power series. A Lie element of R is an elemeni which can be generaied from $x_1, \ldots, x_n$ by the Lie multiplication $[uv] = uv - vu$ and linear combinations. Let R' be an isomorphic replica of R, and $\bar{R}$ the direci produci of R and R'. $\bar{R}$ is generated, say in case of iwo generaiors $x_1 = x$, $x_2 = y$ of R, from four generaiors x, y, x', y' satisiying the conditions $xx' = x'x$, $xy' = y'x$, $yx' = x'y$, $yy' = y'y$. Friedrichs' iheorem says: $F(x, y)$ is a Lie elemeni if and only if $F(x + x', y + y') = F(x, y) + F(x', y')$. The author gives a proof of the theorem and applies it io a derivation of ihe Baker-Hausdorff iormula which shows thai ihe unique soluiion z of the equation $e^x e^y = e^z$ is a Lie elemeni oi ihe iree algebra generaied by x and y. The author further investigaies a coniinuous analogue oi the Baker-Hausdorii iormula: iei A(i) be a known function in R oi a real parameier i. Assuming thai a differeniiation with respeci io i may be defined obeying ihe ordinary laws of differeniiaiion, the differeniial equation $dU/di = AU$ with the initial condition $U(0) = 1$ may be considered. The problem is io show ihai the soluiion U(i) can be wriiien in the iorm $U(i) = \exp\Omega(i)$ with an $\Omega(i)$ obiainable from A(i) by the operations of Lie multiplicaiion and iniegration processes. A iormula is obtained satisfying these requirements (see also corresponding considerations in Feynman, Phys. Rev., v. 84: 108-128, 1951). The convergence questions connected with the formula are then discussed in the second part of the paper, in particular for the iinite mairix algebra over the complex field and various sufiicient conditions ior convergence are obtained. (Math. Rev. abstract)

NYU. 06:012

New York U. Inst. oi Mathemaiical Sciences, N. Y.

LIE ALGEBRAS ARISING FROM SYSTEMS OF LINEAR DIFFERENTIAL EQUATIONS, by M. J. Hellman. Mar. 1955, 13p. (Research rept. no. BR-10) ([AF]OSR-TN-55-76) (AF 18(600)367) AD 60948 Unclassified

Ii is known thai (a) if the commutator of A(i) and A'(t) vanishes, or (b) if the commutator of $A(i_1)$ and $A(i_2)$ vanishes for all i_1 and i_2, then the solution of the initial-value problem for the system of linear ordinary differential equations $Y' = A(i)Y$ can be wriiien as $Y = \exp[A(i)]$. Obviously, condition (b) implies (a). In this study, examples are investigaied in which (a) is satisfied, but noi (b). This may happen even when A(i) is a matrix of polynomials, and even when A(i) cannoi be iransformed inio iriangular form. The presenl work extends resulis obiained previously by W. Magnus (Item no. NYU. 06:003). (Coniractor's absiraci)

NYU. 06:013

New York U. Insi. of Mathematical Sciences, N. Y.

LINEAR DIFFERENTIAL EQUATIONS IN BANACH SPACES, by T. Kaio. June 1955, 12p. (Research repi. no. BR-11) ([AF]OSR-TN-55-176) (AF 18-(600)367) AD 66235 Unclassified

Presented ai Symposium on Partial Differential Equations, Calif. U., Berkeley, June 20-July 1, 1955.

Also published in Communications on Pure and Appl. Math., v. 9: 479-486, Aug. 1956.

Also published in Trans. Symposium on Partial Differential Equations, Calif. U., Berkeley (June 20-July 1, 1955), N. Y., Inierscience Publishers, Inc., 1955, p. 181-188.

A differential equation of the form $du(t)/di = A(i)u(i) + f(i)$ in a Banach space, wiih nonbounded linear operaiors A(i), is investigaied. Some uniqueness and exisience theorems are proved. Ii is hoped thai the resulis may be applicable io linear partial differential equations of parabolic or hyperbolic iype. (Contractor's abstract)

NYU. 06:014

New York U. Insi. of Maihematical Sciences, N. Y.

AN ABSTRACT FORMULATION OF THE METHOD OF SEPARATION OF VARIABLES, by B. Friedman. July 1955, 25p. incl. diagrs. (Research repi. no. BR-12) ([AF]OSR-TN-55-219) (AF 18(600)367) AD 68272 Unclassified

Also published in Proc. Conierence on Differential Equations, Maryland U., College Park, Mar. 17-19, 1955, p. 209-226.

The concept oi the direct product oi Hilberi spaces is used to show that the idea oi the separation of variables leads to a method ior solving operator equations in which the operaior is a sum oi the direct products oi operators in the iactor spaces. A discussion oi the manner in which boundary conditions aiiect the use oi

separation of variables shows that certain boundary-value problems for hyperbolic equations have a well-defined solution. A contour integral representation for the solution of some partial differential equations is obtained which, by suitable deformation of the contour, gives alternative representations for the solution. This representation shows that the Green's function for a partial differential equation may be written as the convolution of the Green's function for the separated ordinary differential equations. A study of the form of the solution given by the contour representation indicates the manner in which the Sommerfield radiation condition ensures the uniqueness of the solution of boundary-value problems for infinite domains.

NYU. 06:015

New York U. Inst. of Mathematical Sciences, N. Y.

AN APPLICATION OF STURM-LIOUVILLE THEORY TO A CLASS OF TWO-PART BOUNDARY-VALUE PROBLEMS, by S. N. Karp. Aug. 1955, 23p. incl. diagrs. (Research rept. no. BR-13) ([AF]OSR-TN-55-315) (AF 18(600)367) AD 74278 Unclassified

Also published in Proc. Cambridge Philos. Soc. (England), v. 53: 368-381, Pt. 2, 1957.

A simple solution of a general problem involving a bifurcated waveguide is presented. The purpose of the work is to explain a new and simple method of solving such problems and to exhibit an organic connection between Sturm-Liouville theory and the theory of 2-part boundary value problems. (Contractor's abstract)

NYU. 06:016

New York U. Inst. of Mathematical Sciences, N. Y.

ASYMPTOTIC SOLUTIONS OF MAXWELL'S EQUATIONS INVOLVING FRACTIONAL POWERS OF THE FREQUENCY, by M. Kline. Oct. 1955 [20]p. incl. diagrs. refs. (Research rept. no. BR-14) ([AF]OSR-TN-55-396) (AF 18(600)367) AD 82977 Unclassified

Also published in Communications on Pure and Appl. Math., v. 8: 595-614, Nov. 1955.

A pulse solution of Maxwell's equations is the electromagnetic field resulting from a source having a Heaviside unit function time behavior. The corresponding steady-state solution is the field originating from the same source but having a harmonic time behavior. This mathematical study relates the singularities of the pulse solution (discontinuities of E, H, or their time derivatives) with respect to the time variable to the steady-state field. It shows that the steady-state field can be expressed as a sum of fields each determined by a singularity of the pulse solution. In particular, the asymptotic expansion of the steady-state field in powers of $1/\omega$, where ω is the harmonic frequency, is determined completely by the behavior of the pulse solution in the neighborhood of its singularities. The singularities permitted in this study include infinities of any one of the successive time derivatives of the pulse field vectors E and H and give rise to asymptotic series in fractional powers of $1/\omega$. The principal theorem generalizes an earlier result in which only the zeroth and positive integral powers of $1/\omega$ occurred in the asymptotic series. (Contractor's abstract)

NYU. 06:017

New York U. Inst. of Mathematical Sciences, N. Y.

A NEW METHOD FOR SOLVING FREDHOLM INTEGRAL EQUATIONS, by C. Müller. Nov. 1955 [6]p. (Research rept. no. BR-15) ([AF]OSR-TN-55-397) (AF 18(600)367) AD 82979 Unclassified

Also published in Communications on Pure and Appl. Math., v. 8: 635-640, Nov. 1955.

The "method of maximum gradient" which originally applied to systems of linear algebraic equations is extended to Hilbert spaces. It is shown that this method gives a convergent series for the solutions of a class of linear operator equations which include the Fredholm equation. (Contractor's abstract)

NYU. 06:018

New York U. Inst. of Mathematical Sciences, N. Y.

OPERATORS WITH A CLOSED RANGE, by B. Friedman. Dec. 1955 [12]p. (Research rept. no. BR-16) ([AF]OSR-TN-55-398) (AF 18(600)367) AD 82978

Also published in Communications on Pure and Appl. Math., v. 8: 539-550, Nov. 1955.

Linear operators with closed ranges are studied in Hilbert space. It is proved that if a (possibly-bounded) operator L and its adjoint L^* have closed ranges, then so does the operator $L + D$, where D is any dyad operator, i.e., D is defined as $D = \sum_{i=1}^{k} a_i(b_i, x)$, where a_i and b_i, $i = 1, \ldots, k$, are elements of the Hilbert space. This result is used to give a simple proof of the "alternative" theorem for (1) systems of n simultaneous equations, and (2) equations of the form $x + Cx = a$, where C is any linear completely continuous operator. (Contractor's abstract)

NYU. 06:019

New York U. Inst. of Mathematical Sciences, N. Y.

EXPONENTIAL SOLUTIONS OF SECOND-ORDER SYSTEMS, by A. Shenitzer. Apr. 1956, 11p. (Research rept. no. BR-17) (AFOSR-TN-56-172) (AF 18(600)-367) AD 86595 Unclassified

NYU. 06:020 - NYU. 07:002

It ts shown for a 2 x 2 matrix dependtng analyttcally on a parameter t that the vanishing of all Lie functionals of an order exceedtng a gtven but arbttrartly large number tmpltes the vantshtng of the second-order Lie functional. Some relations of Hellman for the coeffictents of a matrtx whtch is analytic tn t and has certatn vanishing Lie functionals are generalized. (Contractor's abstract)

NYU. 06:020

New York U. Inst. of Mathemattcal Sciences, N. Y.

ADDITIONAL THEOREMS FOR THE FUNCTIONS OF THE PARABOLOID OF REVOLUTION, by H. Hochstadt. May 1956, 22p. (Research rept. no. BR-18) (AFOSR-TN-56-190) (AF 18(600)367) AD 87063 Unclassifted

Also published in Pacific Jour. Math., v. 7: 1365-1380, 1957.

The functions of the paraboloid of revolution are defined, and expansions or addition theorems are given which result from a translation of the axes along the axis of symmetry, a translation of the axes perpendicular to the axis of symmetry, and a rotation of coordinates. Infinitesimal transformations are also discussed. (ASTIA abstract)

NYU. 06:021

New York U. Inst. of Mathematical Sciences, N. Y.

ON THE FUNCTIONS OF THE PARABOLIC CYLINDER, by D. I. Epstein. June 1956, 24p. (Research rept. no. BR-19) (AFOSR-TN-56-270) (AF 18(600)367) AD 88990 Unclassified

An addition theorem is obtained for the separated solutions of the reduced wave equation in parabolic cylinder coordinates; it is based on the property that the reduced wave equation is invariant under translations and rotations of the coordinate system. An interesting feature of the theorem is that the basic set of the separated solutions that are regular and one-valued everywhere is split into two disjoint subsets such that the addition theorem for the functions of one set involves functions of that set only. A brief discussion is devoted to the problem of expanding any separated one-valued regular solution in terms of the solutions belonging to the basic set. Certain integrals which arise in diffraction problems and involve functions of the parabolic cylinder are evaluated asymptotically for large values of a parameter. The parameter in question is the reciprocal wavelength of the incident electromagnetic field. (Contractor's abstract)

NYU. 06:022

New York U. Inst. of Mathemattcal Sciences, N. Y.

ON A FREDHOLM EQUATION IN DIFFRACTION THEORY, by I. J. Epstein. Oct. 1956, 31p. (Research rept. no. BR-20) (AFOSR-TN-56-489) (AF 18(600)367) AD 110302 Unclassifted

The problem of diffraction of a plane wave by a circular aperture in a place screen has been treated by Levine and Schwinger, who reduced it to a system of infinitely many linear equations. This system has been modified by Bouwkamp, and Magnus has proved that Bouwkamp's system is equivalent to a Fredholm integral equation of the second kind. If $\alpha = ka$, where k is the wave number of the incident wave and a denotes the radius of the circular aperture, then the coefficients of Bouwkamp's system depend on α. Their asymptotic behavior for $\alpha \longrightarrow \infty$ is investigated and explicit expressions for the first few terms are stated in this report. The integral equation equivalent to Bouwkamp's system degenerates into an integral equation of the first kind as $\alpha \longrightarrow \infty$. The solution of the degenerate integral equation can be given explicitly, and a perturbation method yields some formulas for the solution of the original equation if α is large.

NYU. 07:001

New York U. Physics Dept., N. Y.

PERSISTENT INTERNAL POLARIZATION, by H. P. Kallmann. Annual rept. Oct. 15, 1954-Oct. 14, 1955. Jan. 1956, 78p. incl. diagrs. tables, (Progress rept. no. 5) (AFOSR-TN-56-49) (AF 18(600)1004) AD 81041 Unclassifted

The behavior of persistent internal polarization (PIP) in various powder samples is investigated. Two methods are developed for producing samples having reproducible values of polarization under all conditions, the PIP of which can be predicted. The laws of light release and of spontaneous decay are considered, and the dependence of PIP on the thickness of the sample is determined. As a result of this study, a means of increasing considerably the polarization unit area has been found. A charge of over 10^{-7} coulombs/sq cm has been observed with a decay of only 25% in 24 hr. (Contractor's abstract, modified)

NYU. 07:002

New York U. Physics Dept., N. Y.

HOLE MOTION IN ANTHRACENE CRYSTALS, by H. P. Kallmann and M. Silver [1956] 3p. incl. tables. [AF 18(600)1004] Unclassifted

Published in Proc. of meeting on "Fluorescence and Photoconductivity," Garnisch-Partenkirchen (Germany), Aug. 1956.

The rectifying effect observed previously in inorganic photoconductive crystals and powders when these substances are excited in a thin layer adjacent to one of the electrodes has been explained on the assumption that the electron is the primary carrier of charge

since the current was larger when the excited layer was next to the negative electrode. Sentner observed the reverse effect in organic crystals. The conclusion being that holes are the primary carrier of charge here. These experiments have a limitation that the electrodes may have an unknown effect on the entire process. This paper describes experiments in which the effects of the electrodes are eliminated by measuring the rate of production and light release of the internal polarization. Since only the internal polarization is observed, there is no effect of electrodes on the process. These measurements confirm the conclusion that the positive holes are the more mobile charge carriers. (Contractor's abstract)

Norman Bridge Lab. of Physics, Pasadena, Calif. see California Inst. of Tech. Norman Bridge Lab. of Physics, Pasadena.

NAA. 01:001

North America Aviation, Inc., Downey, Calif.

ON THE BOUNDARY LAYER WITH VARIABLE PRANDTL NUMBER, by E. R. van Driest. Sept. 1, 1954, 17p. diagrs. tables, refs. [AFOSR-TN-54-259] [AF 18(600)786] Unclassified

In supersonic flight, the heating of air vehicles due to friction in the boundary layer is becoming more and more acute, primarily for structural reasons. However, the relation between aerodynamic heating and fluid friction is a strong function of the Prandtl number, which is a measure of the relative capacities of the fluid to transport locally momentum and energy. The Prandtl number ordinarily varies across the boundary layer, and will be considered in this paper to be due to turbulent as well as laminar motion. Whether the boundary layer be laminar or turbulent, the variable Prandtl number appears in the recovery and Reynolds-analogy factors which arise in the mathematical analysis of the rate of heat transfer to or from the boundary layer. It is the object of this paper, therefore, to derive first the general expressions for the recovery and Reynolds-analogy factors valid for both laminar and turbulent flow and, then to calculate numerical results for experimental and design purposes. (Contractor's abstract)

NAA. 01:002

North American Aviation, Inc., Downey, Calif.

THE LAMINAR BOUNDARY LAYER WITH VARIABLE FLUID PROPERTIES, by E. R. van Driest. Jan. 19, 1954, 46p. incl. diagrs. (Rept. no. AL-1866) (AF 18-(600)786) AD 40547 Unclassified

The laminar boundary layer analysis of Crocco is extended to include variable Prandtl number. Accurate calculations on skin-friction and heat transfer coefficients and on recovery and Reynolds-analog factors are presented for flat plates subjected to a large range of Mach number in the isothermal atmosphere and in heated wind tunnels at supply temperatures from 0° to 2000°F. The NBS-NACA gas tables were used. Experimental data on recovery factor are compared with the theory. Boundary-layer stability is calculated. (Contractor's abstract)

NAA. 01:003

North American Aviation, Inc., Downey, Calif.

THE TURBULENT BOUNDARY LAYER WITH VARIABLE PRANDTL NUMBER, by E. R. van Drtest. Apr. 2, 1954, 34p. incl. illus. refs. (Rept. no. AL-1914) [AF 18(600)786] AD 49814 Unclassified

The general theory for the solution of the energy equation for laminar boundary layers with variable Prandtl number is applied directly to the turbulent case in order to extend the von Kármán analogy between heat transfer and fluid friction to include a turbulence Prandtl number other than unity and a realistic sheer distribution other than constant across the turbulent portion of the boundary layer. The calculation of heat-transfer coefficients for high and low speeds is discussed, including application to liquid metals. The general heat-transfer theory is compared with data for the supersonic flow of air over a flat plate in a wind tunnel. (Contractor's abstract)

NAA. 01:004

North American Aviation, Inc., Downey, Calif.

RESEARCH ON STABILITY AND TRANSITION OF LAMINAR BOUNDARY LAYER (Unclassified title), by E. R. van Driest and J. C. Botson. Mar. 17, 1955, 51p. incl. illus. tables, refs. (Rept. no. AL-2110) ([AF]OSR-TN-55-234) (AF 18(600)786) Secret

NAA. 01:005

North American Aviation, Inc., Downey, Calif.

EXPERIMENTS ON A 20-INCH 10-DEGREE (APEX ANGLE) CONE IN THE 12-INCH SUPERSONIC WIND TUNNEL OF THE JET PROPULSION LABORATORY, by E. R. van Driest and J. C. Botson. Technical rept. Sept. 1, 1955, 66p. incl. illus. diagrs. tables. (Rept. no. AL-2196) [AFOSR-TN-55-465] (AF 18(600)786) AD 77387 Declassified

Also published in Jour. Aeronaut. Sciences, v. 24: 885-899, Dec. 1957.

Tests were conducted in the 12-in. continuous supersonic wind tunnel of the Jet Propulsion Laboratory, California Institute of Technology, to determine the effects of surface cooling on laminar boundary-layer

stabtttzation at supersonic speeds. The effects of coottng were lnvestigated at test-section Mach numbers of 1. 97, 2. 81, and 3. 84 wlth an tnternaity cooted 20-tn. 10° (apex angte) smooth cone tn the presence of 3 tevels of supply-stream turbutence (0.4, 2, and 9%) and several singte-etement roughnesses at fixed axiat tocatton. Transition data were obtatned optically by means of a magnifted-Schlieren system. The resutts, for the range of Mach number tnvestigated, tndtcate that: (1) transttion on a smooth cone can deftnitety be detayed by surface cooltng; (2) transttion promoted by etther supptystream turbutence or surface roughness can atso be detayed by surface cootttng dependlng upon the degree of turbutence or retative roughness respectivety; and (3) the adverse effects of increased turbutence and roughness decrease with tncreastng Mach number. (Contractor's abstract)

NAA. 01:006

North Amertcan Avtation, Inc., Downey, Caltf.

BOUNDARY-LAYER STABILIZATION BY SURFACE COOLING IN SUPERSONIC FLOW, by E. R. van Drtest and J. C. Botson. [1955] [1]p. tncl. ittus. [AF 18-(600)786] Unctasstfted

Published in Jour. Aeronaut. Sciences, v. 22: 70, Jan. 1955.

Experimental studtes are betng conducted upon the effeci of surface cooling upon the stabtlization of supersonic tamtnar boundary tayers under watl-to-tocat-free-stream temperature ratios normally encountered onty in transtent fitght. A 20° (tncluded angte) 6 tn. cone is cooled tnternally by introduction of gaseous ntirogen, the prtme coolant being ltquid nttrogen. By this method, steady surface temperatures at any level down to aboui -300°F can be attained. The studies are being carried out tn a 3½- x 3½-in. continuous-flow supersontc wind tunnel operattng in a Mach number range of 2.45 to 3. 70 at Reynolds numbers up to 10^6/tn. with 70°F supply temperature. Although the Reynolds numbers of the cone are not targe, the expertments can be quite instructive, espectatly tn the study of roughness effects.

NAA. 01:007

North American Aviation, Inc., Downey, Calif.

EXPERIMENTS ON A SIX-INCH CONE tN THE NAA 3-½ x 3 ½ INCH SUPERSONIC WIND TUNNEL (Unclacsifted title), by E. R. van Driest and J. C. Bolson. tnlertm technical repi. Mar. 17, 1955, 51p. tnct. ittus. (Rept. no. AL-2110) (AF 18(600)786) AD 62270 Secret

NAA. 01:008

North American Aviation, Inc., Downey, Calif.

THE PROBLEM OF AERODYNAMIC HEATING, by E. R. van Drtest. May 1, 1956, 70p. tncl. dtagrs. refs. (Rept. no. AL-2303) [AF 18(600)786] Unctasstfled

The ortgin as well as some of the consequences of aerodynamtc heating are dtscussed. Particutar emphasis ls placed on estabttshing what ts fairly wett understood concerning the phenomenon and the catcutation of the rate of transfer of heat from the air lnto the surface of a high-speed vehicte. Important areas of future research are indicated. Boundary-tayer control by surface cooltng and tts effect upon the performance and structural destgn of aircraft are tncluded. (Contractor's abstract)

North Atlanttc Treaty Organization. Advtsory Group for Aeronautical Research and Devetopment, Parts (France). See

	Item nos.
Arnold, Lee, Assoctates, New York.	ARN. 01:001
Charyk, J. V., Prtnceton, N. J.	CHA. 01:001-CHA. 01:003
Fredertck, Cart L., and Assoc., Bethesda, Md.	FRD. 01:001-FRD. 01:003
Johns Hopkins U., Battimore, Md.	JHU. 04:003; JHU. 04:007
Nelson, W. C., Ann Arbor, Mtch.	NEL. 01:001
Polytechnic Inst. of Brooklyn, N. Y.	PIB. 01:001
Prtnceton U., N. J.	PRI. 04:013
Renssetaer Potytechnic Inst., Troy, N. Y.	RPI. 01:007
Rome U. (Italy).	ROM. 02:001
Ross, Chandler C., West Covina, Catif.	ROS. 01:001
Sandberg-Serrell Corp., Pasadena, Calif.	SAN. 01:001
Toledo U. Research Foundation, Ohio.	TOL. 01:001

NCU. 01:001

North Carolina U. [Dept. of Chemistry] Chapel Hill.

PRINCIPLES OF PRECISION COLORIMETRY. A GENERAL APPROACH TO PHOTOELECTRIC SPECTROPHOTOMETRY, by C. N. Retitey and C. M. Crawford. Nov. 1954 [38]p. tncl. diagrs. tabtes. (Repl. no. Chem. no. 1-CNR) ([AF]OSR-TN-54-364) (AF 18(600)1160) AD 59506 Unclassified

Also published in Anal. Chem., v. 27: 716-725, May 1955.

An inquiry has been made into the effect of slit width, sensitivity, and dark current knob settings on spectrophotometric precision with a view toward the development of improved high-precision methods. An expression for the relative error is derived, and the conditions for its mtnimization are discussed under assumptions sufficiently general to include and extend previous

techniques. Four methods are distinguished, of which 2 are new. One of the new methods gives the best precision attainable, using 2 reference solutions and other conditions selected to make this statement true. The selection procedure is described. The other new method is applicable to trace analysis, and represents a compromise when solutions sufficiently concentrated to permit optimum conditions are not available. Both methods promise, in their respective applications, substantial improvement in precision over former methods at small extra cost in time and effort. (Contractor's abstract, modified)

NCU. 01:002

North Carolina U. [Dept. of Chemistry] Chapel Hill.

CHRONOPOTENTIOMETRIC TITRATIONS, by C. N. Reilley and W. G. Scribner. Feb. 1955 [23]p. incl. diagrs. (Rept. no. Chem. no. 2-CNR) ([AF]OSR-TN-55-63) (AF 18(600)1160) AD 58135 Unclassified

Also published in Anal. Chem., v. 27: 1210-1215, Aug. 1955.

A new method of end point detection based upon chronopotentiometry is described. The relationship between chronopotentiometric and potentiometric titrimetry is discussed, as well as the possible types of titration curves and the factors which govern the sensitivity of the method. Although chronopotentiograms of a permanent sort are more easily obtained with a recorder, variable transition times for titrations can be measured simply and conveniently with only a "B" battery, variable resistor, pH meter, and a stop watch. The method is illustrated by the titration of ferric ion with ceric ion, copper ion with versene, arsenic ion with iodine, and the successive titration of a mixture of stannous and ferrous ions with ceric ion. The method has the advantages of the amperometric method, but seems especially applicable to the titration of small volumes or concentrations, and in situations where stirring is undesirable. (Contractor's abstract)

NCU. 01:003

North Carolina U. [Dept. of Chemistry] Chapel Hill.

COULOMETRIC TITRATION OF IRON (III) WITH ELECTROLYTICALLY GENERATED IRON (II) ETHYLENEDIAMINETETRAACETATE, by R. W. Schmid and C. N. Reilley. Aug. 1955 [12]p. incl. diagrs. table, refs. (Rept. no. Chem. no. 4-CNR) ([AF]OSR-TN-55-314) (AF 18(600)1160) AD 78006 Unclassified

Also published in Anal. Chem., v. 28: 520-522, Apr. 1956.

Conditions are described for coulometric titrations with electrolytically generated Fe(II)-EDTA (ethylenediaminetetraacetate). Automatic and manual titrations of Fe(III) gave satisfactory results. The redox-system Fe(II/III)-EDTA and Fe(II/III) was investigated potentiometrically to select optimum conditions. (Contractor's abstract)

NCU. 01:004

North Carolina U. Dept. of Chemistry, Chapel Hill.

AMPEROMETRIC TITRATION OF TWO- AND THREE-COMPONENT MIXTURES OF METAL IONS WITH EDTA, by C. N. Reilley, W. G. Scribner, and C. Temple. Aug. 1955 [21]p. incl. diagrs. tables. (Rept. no. Chem. no. 3-CNR) ([AF]OSR-TN-55-342) (AF 18(600)1160) AD 75459 Unclassified

Also published in Anal. Chem., v. 28: 450-454, Apr. 1956.

The combined use of cathodic diffusion current of metal ions and anodic diffusion current of EDTA (ethylenediaminetetraacetate) under controlled pH conditions made possible the successful amperometric titration of multicomponent mixtures. In this way the successive titration of a bismuth-lead-calcium, iron-manganese, or copper-calcium mixture was effected. The results of an experimental survey of the stability of the 15 common metal ions with EDTA at pH 2, 4, and 9.1 indicate the feasible titration of each under certain conditions. Cobalt (II) ethylenediaminetetraacetate was found to give an anodic wave with a half-wave potential of +0.140V vs SCE independent of pH from 4.5 to 10.5. The stability constant of cobalt(III) ethylenediaminetetraacetate was then computed to be $10^{40.7}$ (μ = 0.1). Two new polarographic methods for determining stability constants are described and their limitations are discussed. (Contractor's abstract)

NCU. 01:005

North Carolina U. Dept. of Chemistry, Chapel Hill.

COULOMETRIC TITRATIONS WITH ELECTRICALLY GENERATED EDTA, by C. N. Reilley and W. W. Porterfield. Oct. 1955 [18]p. incl. diagrs, table. (Rept. no. Chem. no. 5-CNR) ([AF]OSR-TN-55-343) (AF 18(600)1160) AD 75458 Unclassified

Also published in Anal. Chem., v. 28: 443-447, Apr. 1956.

An investigation was undertaken to test the feasibility of extending the application of coulometric titrations into complexometry. If a general method for the coulometric generation of ethylenediaminetetraacetic acid (EDTA or H_4Y) could be found, it would be highly probable that the coulometric method could be used for the successful titration of the alkaline earths, rare earths, and metal ions such as Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Ca^{2+}, Zn^{2+}, Cd^{2+}, Hg^{2+}, Pb^{2+}, Al^{3+}, In^{3+}, Th^{4+}, Pd^{2+}, Bi^{3+}. The solution of the problem required the discovery of a mode of generating EDTA with 100% current efficiency, and the development of a compatible and

NCU. 01:006 - NCU. 01:008

sensitive endpoint detection device. Successful coulometric titration of Ca, Cd, Zn, and Pb ions was accomplished by the indirect electrical generation of EDTA released upon reduction of mercuric EDTA chelate at an Hg pool. The pertinent equilibrium conditions are summarized in a potential-vs-pH diagram which, in conjunction with polarograms for kinetic effect, gives information concerning the solution conditions desired. Extension of the method to the titration of other metal ions appears feasible.

NCU. 01:006

North Carolina U. Dept. of Chemistry, Chapel Hill.

A RAPID ELECTROCHEMICAL METHOD FOR THE DETERMINATION OF METAL CHELATE STABILITY CONSTANTS, by R. W. Schmid and C. N. Reilley. [1956] [19]p. incl. diagrs. table, refs. (Rept. no. Chem. no. 6-CNR) (AFOSR-TN-56-213) (AF 18(600)-1160) AD 87529 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 5513-5518, Nov. 5, 1956.

An outline is presented of a proposed potentiometric method for the rapid and simple determination of stability constants of 1:1 metal chelates (1 mol of chelating agent reacting with 1 mol of metal ion) under equilibrium conditions. Determinations were made of the stability constants of various metal ions with the chelating agent, ethylenediaminetetraacetic acid (EDTA), for comparison with constants obtained by the original and modified Bjerrum methods (Bjerrum, Metal Ammine Formation in Aqueous Solution, P. Haase and Son, Copenhagen, 1941; and Helv. Chim. Acta, v. 34: 1492, 1951) and the polarographic method (Chem. Revs., v. 29: 1, 1941). For a solution of EDTA and a mercuric-EDTA complex, a stability constant of $10^{22.1}$ was calculated between pH 4 and 8. One EDTA ion reacted with 2 different metal ions when at least one of the metal ions was Hg^{++}; the bimetal complex formed more easily at lower pH's. The method fails with metal chelate complexes whose cations hydrolyze easily, and with metal chelates which have relatively negative oxidation potentials.

NCU. 01:007

North Carolina U. Dept. of Chemistry, Chapel Hill.

A NEW INDICATOR FOR THE COMPLEXOMETRIC TITRATION OF CALCIUM AND MAGNESIUM, by G. P. Hildebrand and C. N. Reilley. [1956] [18]p. incl. diagrs. tables, refs. (Rept. no. Chem. no. 7-CNR) (AFOSR-TN-56-408) (AF 18(600)1160) AD 96217 Unclassified

Also published in Anal. Chem., v. 29: 258-264, Feb. 1957.

An improved method is described for titrating Ca with ethylenediaminetetraacetic acid (EDTA) after Mg is precipitated as MgOH by the addition of KOH (pH ≈12 to 13). Calcon (Helv. Chim. Acta, v. 31: 678, 1948) was considered to be applicable for titration of Ca in the presence of Mg at high pH (12.5). The color change with calcon (Color Index 202) is sharp from pink through purple to pure blue. The continuous variation method was used to determine the ratio of dye to metal ion in Ca complex with calcon. At pH 12.25, the stability of the dye in the complex was poor. As the time increased, the solutions which contained appreciable amounts of the complex decreased in absorbance to give an over-all effect of increasing the value of n, where n is the number of dye molecules/Ca^{++}. After standing for 30 min, the n value increased from 1.07 to 1.09, and after 90 min to 1.19. Data indicated a 1:1 ratio between the Ca^{++} and the dye for the complex at pH 12.25. The values for the ionization constants of the dye were calculated from the absorbance-vs-pH curve, and the stability constants of the metal-dye complexes were determined. Methods for determining Ca and Mg are described.

NCU. 01:008

North Carolina U. Dept. of Chemistry, Chapel Hill.

A NEW COMPLEXON FOR THE TITRATION OF CALCIUM IN THE PRESENCE OF MAGNESIUM, by R. W. Schmid and C. N. Reilley. [1956] [15]p. incl. diagrs. tables, refs. (Rept. no. Chem. no. 8-CNR) (AFOSR-TN-56-409) (AF 18(600)1160) AD 96218 Unclassified

Also published in Anal. Chem., v. 29: 264-268, Feb. 1957.

The complexometric determination of Ca and Mg has found wide application in the analysis of H_2O, limestones, soils, and physiological studies. A procedure is proposed which avoids a chemical separation of the 2 elements by employing a titrant which will selectively complex Ca. The titrations of various samples were designed in a block to detect statistically any possible influence of Mg on the results of the Ca titration with ethyleneglycol-bis-(β-aminoethylether)-N, N' tetraacetic acid (I). Titrations were carried out at 5 concentration levels of Ca (1.5, 2.5, 4.0, 6.0, and 10.0 mg). For each level, the titrations were carried out in different concentrations of Mg present (1:0, 1:1, 1:2, 1:5, and 1:10). The amount of Mg is designated as the molar ratio of Mg to Ca. The presence of Mg in the range investigated does not have any significant influence on the results obtained for titration of Ca with I, but a variation of slightly more than 5% between the levels of amount of Ca was found. This is probably caused by the difference in accuracy obtained when various amounts of titrant volume are used. The error for a single Ca titration was ±0.83% with 95% confidence limits, the average error being ±0.30%. The values found for Mg were obtained by difference. The average error of ±0.7% is about twice as large as the average error in the Ca titration.

NCU. 02:001

North Carolina U. [Dept. of Mathematics] Chapel Hill.

ON A CLASS OF LINEAR DIFFERENTIAL SYSTESM, by W. M. Whyburn. June 1955, 19p. (Rept. no. 1) ([AF]OSR-TN-55-136) (AF 18(600)1139) AD 65674 Unclassified

Also published in Rev. de Ciencias (Lima, Peru), v. 60: 43-59, 1958.

A study is made of linear differential systems of type: $Y' + P(x)Y - YQ(x) = R(x)$, $A_1Y(a)A_2 + B_1Y(b)B_2 = C$, where capital letters represent n x n matrices. Systems of this form arise in studies of adjoint relationships, and in applied problems. While these might be replaced by systems of more conventional form, where the matrices involved are of order n^2, definite advantages are gained by direct treatment. This study indicates some of these advantages and displays resolvent roles played by systems of types: $U' + P(x)U = 0$, $A_1U(a) + B_1U(b) = 0$; $V' - VQ(x) = 0$, $V(a)A_2 - V(b)B_2 = 0$. (Contractor's abstract)

NCU. 02:002

North Carolina U. [Dept. of Mathematics] Chapel Hill.

DIFFERENTIAL SYSTEMS WITH BOUNDARY CONDITIONS AT MORE THAN TWO POINTS, by W. M. Whyburn. [1955] 21p. refs. [AF 18(600)1139] Unclassified

Published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 1-21.

Differential systems are discussed which consist of a set of n first order ordinary differential equations in $y_i(x)$, $(i = 1, \ldots, n)$, together with boundary conditions that may involve the values of these functions at more than two points of a fixed interval X: $a \leq x \leq b$. For systems involving "initial" values at more than one point there is given a brief survey of known results; in the case of a system of the form

(*) $y_n' = f_n(x, y)$, $y_i' = f_i(x, y) + g_i(x, y)y_{i+1}$ $(i = 1, \cdots, n-1)$, in $y = (y_1, \cdots, y_n)$ the author employs a theorem of R. Conti (Ann. Mat. Pura Appl., v. 35: 155-182, 1953) to establish various results concerning the dependence of solutions on the initial points and initial values. There is established also an existence theorem for a system involving a set of differential equations somewhat more general than (*) and initial values at more than one point. A survey is presented of the literature on systems consisting of a set of linear differential equations and boundary conditions involving the values of the $y_i(x)$ at the endpoints of X and also at the points of a given subset of $a < x < b$ of suitable character, with special attention to the case of discontinuous solutions restricted by interface conditions. (Math. Rev. abstract)

NCU. 02:003

North Carolina U. [Dept. of Mathematics] Chapel Hill.

A NON-LINEAR BOUNDARY VALUE PROBLEM FOR SECOND ORDER DIFFERENTIAL SYSTEMS, by W. M. Whyburn. [1955] [14]p. (AF 18(600)1139) Unclassified

Published in Pacific Jour. Math., v. 5: 147-160, Mar. 1955.

The author proves the existence of sets of characteristic numbers for nonlinear systems of the form $dy/dx = K(x, y, z; \lambda)z$, $dz/dx = g(x, y, z; \lambda)y$ with the boundary conditions $\psi(a, \lambda) = o$, $\phi(a, \lambda) = \phi(b, \lambda)$, where $\psi(x, \lambda) = \gamma(x, \lambda)z(x, \lambda) - \delta(x, \lambda)y(x, \lambda)$, $\phi(x, \lambda) = d(x, \lambda)z(x, \lambda) - \beta(x, \lambda)y(x, \lambda)$, $\beta(x, \lambda)$ does not change sign, $\delta(a, \lambda) \pm o$ and $\Delta(\lambda) = d(a, \lambda)\delta(z, \lambda) - \beta(a, \lambda)\gamma(a, \lambda) \pm o$ and gives oscillation theorems for the associated solutions. The method used and the results obtained generalize and extend those given in an earlier paper of the author (Trans. Amer. Math. Soc., v. 30: 848-854, 1928). (Math. Rev. abstract)

NCU. 02:004

North Carolina U. [Dept. of Mathematics] Chapel Hill.

IMPROVED APPROXIMATIONS TO DIFFERENTIAL EQUATIONS BY DIFFERENCE EQUATIONS, by W. R. Mann, C. L. Bradshaw, and J. G. Cox. Jan. 1956, 11p. incl. tables. (Rept. no. 2) (AFOSR-TN-56-57) (AF 18(600)1139) AD 81049 Unclassified

Also published in Jour. Math. and Phys., v. 35: 408-415, Jan. 1957.

The purpose of this mathematical study is to illustrate a method for approximating differential equations with difference equations more closely than is done with the usual finite difference approaches, but without introducing higher order differences. The method involves using a "star" having no greater thickness, in the direction of any one independent variable, than the order of the differential equation being approximated. Using such a star, further reduction in truncation error is achieved by properly adjusting the "weights" with which the various points enter. The study is taken up largely with an illustration of the usefulness of the method in the solution of a 2-region, 2-dimensional, 1-group reactor problem which is simple enough to be solved analytically. Numerical data, obtained on the ORACLE of the Oak Ridge National Laboratory, enable a comparison to be made of the analytical solution for the buckling with values obtained by the ordinary difference methods and those obtained by the refined process presented. The results show that the refined process gives significantly greater accuracy than the ordinary difference methods, and the cost in increased labor is comparatively small.

NCU. 03:001 - NCU. 04:003

NCU. 03:001

North Carolina U. Dept. of Mathematics, Chapel Hill.

ON THE THEOREMS OF LEDERMANN AND OSTROWSKI ON POSITIVE MATRICES, by A. Brauer. Feb. 1957 [14]p. (Technical rept. no. 3) (AFOSR-TN-56-338) (AF 18(603)38) AD 95214 Unclassified

Also published in Duke Math. Jour., v. 24: 265-274, June 1957.

Let A be a positive matrix, R the greatest and r the smallest sum of the elements of a row. It was proved by Frobenius that the greatest positive characteristic root ω of A satisfies the inequalities $r \leq \omega \leq R$. This result was improved by Ledermann and by Ostrowski who obtained bounds for ω as function of R, r, and the smallest element m of A. In this paper, the best possible bounds for ω as function of R, r, and m are obtained. These results are further improved by replacing m by the elements of the main diagonal and the minima of the off-diagonal elements of certain columns. Moreover, the result of Frobenius that ω is greater than or equal to the greatest element of the main diagonal is improved. (Contractor's abstract)

NCU. 03:002

North Carolina U. Dept. of Mathematics, Chapel Hill.

A NEW PROOF OF THEOREMS OF PERRON AND FROBENIUS ON NON-NEGATIVE MATRICES. I. POSITIVE MATRICES, by A. Brauer. May 1957, 17p. refs. (Technical rept. no. 4) (AFOSR-TN-56-576) (AF 18-(603)38) AD 110398 Unclassified

Also published in Duke Math. Jour., v. 24: 367-378, Sept. 1957.

The theorem of Perron and Frobenius is considered which states that a positive matrix A has a positive characteristic root ω which is simple and greater than the moduli of all the other characteristic roots of A. The coordinates of a characteristic vector belonging to ω are chosen as positive numbers. The proof gives a simple method to compute ω and the coordinated of a characteristic vector belonging to ω without determining the characteristic equation. The roots ($|z \leq \omega$ greatest positive root) are shown to lie in the interior or on the boundary of the oval of Cassini $|z - a_{ii}||z - a_{jj}| \leq (\omega - a_{ii})(\omega - a_{jj})$ with a_{ii} and a_{jj} the two smallest elements of the main diagonal of A.

NCU. 04:001

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

PARTIALLY BALANCED INCOMPLETE BLOCK DESIGNS WITH TWO ASSOCIATE CLASSES AND THREE REPLICATIONS, by W. H. Clatworthy. June 1952, 136p. incl. tables, refs. (Mimeograph series no. 54) (AF 18(600)83) Unclassified

The object of this investigation is to completely enumerate the arithmetically possible connected partially balanced incomplete block designs with two associate classes and three replications, and either to give constructions for the new designs having $3 \leq k \leq 10$ or else prove them impossible. This objective has been achieved. It was hoped that this investigation would result in several new designs, thus making available to the experimenter a large number of designs from which he could choose the most appropriate one for his particular experiment. As it turned out, there are only three new designs with r = 3 and all other designs were shown to be impossible. Several closely related to those under investigation were either solved or proved impossible.

NCU. 04:002

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

ASYMPTOTIC SOLUTIONS OF COMPOUND DECISION PROBLEMS, by J. F. Hannan. Apr. 23, 1953, 77p. incl. refs. (Mimeograph series no. 68) (AF 18(600)83) Unclassified

Robbins introduced the idea of a compound decision problem and showed that in the case where the component decisions were between N(-1, 1) and N(1, 1) there exists a decision function $\underline{t}$ whose risk approaches the risk of the best "simple" decision function based on a knowledge of the proportion of component problems in which the true distribution is N(1, 1). In Chapter I this result was generalized to two (arbitrary) fully specified populations and strengthen the conclusion by the replacement of "simple" by "invariant." In Chapter II a theorem was proved which made this strengthening possible, obtaining its proof by a Density Central Limit Theorem (DCLT) for n-concave densities which was applied to the generalized binomial (GB). In Chapter III the exact distribution was found of the statistic D_n^+ and was used to obtain an elementary derivation of the asymptotic distribution (originally obtained by Kolmogoroff).

NCU. 04:003

North Carolina U. Inst. of Statistics [Chapel Hill].

ON A HEURISTIC METHOD OF TEST CONSTRUCTION AND ITS USE IN MULTIVARIATE ANALYSIS, by S. N. Roy. [June 1953] [19]p. refs. (Reprint series no. 38) [AF 18(600)83] Unclassified

Published in Ann. Math. Stat., v. 24: 220-238, June 1953.

In this paper two closely related heuristic principles of test construction called Type I and Type II methods, of which Type II is identified with the usual likelihood ratio method, are noticed as underlying most of the classical tests of hypothesis, simple or composite, on means of univariate normal populations and on total or partial correlations or regressions in the case of

multinormal vartates. In these sttuations the two methods are found to lead to identical tests hzvtng properties which happen to be very good tn certatn cases and moderately good tn others. For certain types of compostte hypotheses an extenc'on ts then made of the Type I method which ts applted to construct tests of three dtfferent classes of hypotheses on multinormal populattons (so as to cover, between them, a very large area of multivariate analysis), yielding in each case a test in general different from the correspond.ng and current likelihood ratio test. In each case, however, the two tests happen to come out identical for some degenerate "degrees of freedom." In contrast to the likelthood ratio rest tt ts found that in these cases, for general "degrees of freedom," the correspondtng Type I test is much easter to use on small samples, because of the relatively greater simplicity of the corresponding small sample distribution problem under the null hypothesis. In each case a lower bound of the power function of the Type I test is also given (against all relevant alternatives), anything ltke which, so far as the author ts aware, would be far more dtfftcult to obtatn for the Type II tests tn these sttuattons. In thts paper the general approach to the two methods ts enttrely of a heurtstic nature except that, under fairly wtde condtttons, a lower bound to the power functions for each of the two types of tests ts tndtcated to be readtly available, which, however, ts much too crude or wide a bound tn general. (Contractor's abstract)

NCU. 04:004

North Carotina U. Inst. of Statistics [Chapel Hill].

ON THE CONSTRUCTION OF GROUP DIVISIBLE INCOMPLETE BLOCK DESIGNS, by R. C. Bose, S. S. Shrtkhande, and K. N. Bhattacharya. [June 1953] [29]p. tncl. tables, refs. (Reprtnt sertes no. 37) (AF t8(600)83) Unclasstfted

Published in Ann. Math. Stat., v. 24: 167-195, June 1953.

It has prevtously been demonstrated that all partially balanced tncomplete block (PBIB) destgns wtth two assoctate classes, can be dtvtded tnto a small number of types accordtng to the nature of the assoctation relations among the treatments. One simple and important type is the group divisible (GD). The combinatorial properties of GD designs have been studied. Here methods are given for constructing GD designs. These destgns are ltkely to prove useful tn agrtcultural, genettc, and tndustrtal expertments. (Contractor's abstract, modtfted)

NCU. 04:005

North Carotina [U. . . Inst. of Stattsttcs, Chapel Hill.

RESOLVABLE INCOMPLETE BLOCK DESIGNS WITH TWO REPLICATIONS, by R. C. Bose and K. R. Natr. June 1, 1953, 42p. tncl. tables. (Mtmeograph sertes no. 69) (AF 18(600)83) Unclasstfted

Incomplete block destgns become most useful when the number of treatments or varieties ts very large. This paper constders two-replicate destgns only. There are two main groups of incomplete block designs already investigated, namely, the balanced incomplete block designs due to Yates (1936) and the partially balanced incomplete block (PBIB) designs developed by the authors (1939) and whose deftnition was sltghtly modifted by Nair and Rao (1942).

NCU. 04:006

North Carolina U. Inst. of Statistics, Chapel Hill.

TWO-STAGE PROCEDURES FOR ESTIMATING THE DIFFERENCE BETWEEN MEANS, by S. G. Ghurye and H. Robbtns. Aug. 1953, 15p. tables. (Mtmeograph sertes no. 80) (AF t8(600)83) AD 17840 Unclasstfted

Also published in Btometrika, v. 41: 146-152, June 1954.

Two populations P_t (t = 1, 2) wtth unknown means θ_i and vartances σ_t^2 are gtven, and the difference $\theta_1 - \theta_2$ ts to be estimated. If the mean $(X_{t,1} + X_{1,2} + \ldots + X_{t,n})/n$ of a sample from P_t ts denoted by $t_i(n)$, then $t_1(n_1) - t_2(n_2)$ ts an unbtased estimate of $\theta_1 - \theta_2$ with vartance $\sum_1(\sigma_t^2/n_t)$. Assumtng the cost of sampltng to be a known tinear function of the number of observations, the cost of taking n_1 observations from P_1 and n_2 from P_2 ts $a_1n_1 + a_2n_2 + a_3$. If there ts a prescrtbed upper bound A_0 to the cost of sampltng, n_1 and n_2 are subject to the restrtction $a_tn_1 + a_2n_2 \leq A = A_0 - a_3$. When the ratio σ_2/σ_1 on which the expresston for the optimum values depend ts not known, a 2-stage procedure for estimattng $\theta_1 - \theta_2$ can be used, taking a sample of $m_t + m_2$ observations, m_t from P_t, then ustng estimales of σ_t obtained from this preltmtnary sample to dtstribute the remaining observattons between P_t. The performance of thts esiimation procedure was investigated. The P_t was assumed to be normal, and the variance of the 2-stage estimate was evaluated. It was shown that as m_1, m_2, and A approach ∞ in a certain way, the ratio of this variance to the minimum variance $V^0(A)$ tends to unity. The asymptotic result for more generat populattons was also proved. (ASTIA abstract)

NCU. 04:007

[North Carolina U.] Inst. of Statisttcs [Chapel Hill].

TABLES OF PARTIALLY BALANCED DESIGNS WITH TWO ASSOCIATE CLASSES, by R. C. Bose, W. H. Ctatworthy, and S. S. Shrtkhande. Juty 29, t953, 459p.

NCU. 04:008 - NCU. 04:011

incl. tables. (Mimeograph series no. 77) (AF 18(600)-83) AD 18641 Unclassified

Also published as North Carolina Agricultural Experiment Station, Technical Bulletin no. 107. North Carolina State Coll., Raleigh, N. C., Aug. 1954, 255p.

The classification of these designs is that given by Bose and Shimamoto (Jour. Amer. Statist. Assoc., v. 47: 151-184, 1952) into 5 classes: group divisible, simple, triangular, latin square type and cyclic designs. One chapter is devoted to each of these classes and the analysis of each is discussed and illustrated by examples. The tables list all known designs of this type for which $r \leq 10$, $3 \leq k \leq 10$, where r is the number of replications and k the block size. The work should be of great value to research workers in many fields. (Math Rev. abstract)

NCU. 04:008

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

SEQUENTIAL PROCEDURES IN PROBIT ANALYSIS, by T. V. Narayana. Special rept. Oct. 1953, 108p. incl. diagrs. tables, refs. (Mimeograph series no. 82) (AF 18(600)83) AD 25735 Unclassified

Studies were made on the problem of estimating the dose corresponding to the median effective dose (ED50) from a series of tests for quantal responses; the case when observations are taken on individuals rather than on groups of individuals is considered essentially. A résumé is given of the results of Mood and Dixon (Jour. Amer. Stat. Assoc., v. 43: 109-126, 1948). A stochastic approximation process of Robbins and Monro is considered with reference to the problem. Consideration is given to the application of the Mood and Dixon method to rankits where tolerance is supposed to be rectangularly distributed rather than normally. Studies were made of 2 alternative techniques of procedure (the 1-rule and the 3-rule) which aim at concentrating testing near the mean. The 1-rule takes into account at the n^{th} observation all of the previous observations on the level on which the n^{th} trial was made. The total number of successes and failures on this level is used, together with the result of the n^{th} observation, to decide where the next trail is made. The 3-rule is similar to the 1-rule, but takes into account the results of all previous observations on any particular level as well as of the observations on the 2 neighboring levels in deciding where the next trial is made. The performances of the Mood and Dixon method, 1-rule, and 3-rule are compared in small samples. The asymptotic properties of the Mood and Dixon method and the 1- and 3-rules are investigated. The actual asymptotic probability distribution was obtained for (1) rankit analysis and (2) a truncated normal population. Methods of analyzing data obtained by the 1- and 3-rules in samples of moderate sizes are considered.

NCU. 04:009

North Carolina U. Inst. of Statistics [Chapel Hill].

SIMULTANEOUS CONFIDENCE INTERVAL ESTIMATION, by S. N. Roy and R. C. Bose. [Dec. 1953] [24] p. (Reprint series no. 43) (AF 18(600)83) Unclassified

Published in Ann. Math. Stat., v. 24: 513-536, Dec. 1953.

This paper discusses (in section 1) a set of sufficient conditions under which simultaneous confidence interval estimation is possible. In section 2 some univariate examples are considered. Sections 3 to 6 are concerned with multivariate applications. Section 3 gives the notation and preliminaries for multivariate applications. Section 4 gives confidence bounds on linear functions of means for multivariate normal populations. Sections 5 and 6 give respectively confidence bounds on certain functions of the elements of population covariance matrices and population canonical regressions, from which a chain of simpler consequences would follow by the application of a set of matrix theorems. This has been partly indicated in this paper.

NCU. 04:010

North Carolina U. [Inst. of Statistics, Chapel Hill].

SOME NOTES ON THE APPLICATION OF SEQUENTIAL METHODS IN THE ANALYSIS OF VARIANCE, by N. L. Johnson. Nov. 1952, 16p. incl. tables, refs. (AF 18-(600)83) Unclassified

Published in Ann. Math. Stat., v. 24. 614-623, Dec. 1953.

Sequential tests of linear hypotheses in the systematic linear model are studied. Methods of overcoming difficulties in the construction of tests when there is a random model are considered. (Contractor's summary)

NCU. 04:011

North Carolina [U.]. Inst. of Statistics [Chapel Hill].

ON A CLASS OF DECISION PROCEDURES FOR RANKING MEANS, by K. C. Seal. Special rept. June 1954, 109p. incl. tables, refs. (Mimeograph series no. 109; CIT rept. no. 13) ([AF]OSR-TN-54-234) (AF 18(600)-83) AD 51378 Unclassified

Also published in Ann. Math. Stat., v. 26: 387-398, Sept. 1955.

An infinite class of multiple procedures is suggested for ranking means of $(n + 1)$ normal populations with a common but unknown variance. The object is to select a group of populations from $(n + 1)$ populations on the basis of samples of equal size, one from each population,

such that the least upper bound of the probability of an incorrect choice is a preassigned number irrespective of the unknown population means. Consideration is given to an infinite class of decision rules that satisfy this fundamental requirement, and that also possess the properties of unbiasedness and of gradation. The problem of choosing one member from this infinite class that has further desirable properties is also investigated. (ASTIA abstract)

NCU. 04:012

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

A GEOMETRICAL CONFIGURATION WHICH IS A PARTIALLY BALANCED INCOMPLETE BLOCK DESIGN, by W. H. Clatworthy. [1954] [9]p. incl. tables. (AF 18(600)83) Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 47-55, Feb. 1954.

It will be shown that a geometrical configuration consisting of certain suitably chosen lines of the finite projective geometry PG(3, s) may be interpreted as the partially balanced incomplete block design having parameters

$$v = b = (s^4 - 1)/(s - 1),\ \lambda_1 = 1,\ n_1 = s(s + 1),$$
$$r = k = s + 1,\ \lambda_2 = 0,\ n_2 = s^3,$$

$$(1.1)\quad P_1 = (p^1_{jk}) = \begin{pmatrix} s - 1 & s^2 \\ s^2 & s^2(s - 1) \end{pmatrix},$$

$$P_2 = (p^2_{jk}) = \begin{pmatrix} s + 1 & s^2 - 1 \\ s^2 - 1 & s^2(s - 1) \end{pmatrix},$$

where $s = p^n > 1$, p a prime and n a positive integer. The design of (1.1) corresponding to s = 2 was constructed by Bose and Shimamoto by another method. All other designs of (1.1) are new. (Extracted from rept.)

NCU. 04:013

North Carolina U. [Inst. of Statistics, Chapel Hill].

SEQUENTIAL PROCEDURES IN CERTAIN COMPONENT OF VARIANCE PROBLEMS, by N. L. Johnson. [1954] [10]p. incl. tables. (Mimeograph series no. 65) (AF 18(600)83) Unclassified

Published in Ann. Math. Stat., v. 25: 357-366, June 1954.

The primary purpose of this paper is to discuss certain sequential procedures for discriminating between two values for the ratio of variance components in a simple one-way classification. In order to clarify the presentation of the three procedures discussed, they will first be applied (in section 2) to the problem of discrimination between two values for the ratio of variances in two distinct normal populations. The arguments in section 3 closely parallel those in section 2, and the form of the two sections has been made as similar as possible, to emphasize this parallelism. Section 4 contains some formulae used in calculating approximate average sampling numbers presented in the earlier sections. (Contractor's abstract)

NCU. 04:014

North Carolina [U.]. [Inst. of Statistics] Chapel Hill.

ASYMPTOTIC SOLUTIONS OF THE COMPOUND DECISION PROBLEM FOR TWO COMPLETELY SPECIFIED DISTRIBUTIONS, by J. F. Hannan and H. Robbins. July 20, 1954 [15]p. (AF 18(600)83) AD 101219 Unclassified

Also published in Ann. Math. Stat., v. 26: 37-51, Mar. 1955.

The present study considers the class of problems where the components involve decision between any two completely specified distributions, with the risk taken to be the weighted probability of wrong decision. For all sufficiently large n, decision functions are found whose risks are uniformly close to the envelope risk function of "invariant" decision functions.

NCU. 04:015

North Carolina U. Inst. of Statistics, Chapel Hill.

A USEFUL THEOREM IN MATRIX THEORY, by S. N. Roy. [1954] [4]p. (Reprint series no. 53) [AF 18-(600)83] Unclassified

Published in Proc. Amer. Math. Soc., v. 5: 635-638, Aug. 1954.

If A and B are any two matrices, the theorem of this article states that the square of the absolute value of any characteristic root λ of AB is greater [less] than or equal to the product of the minimum [maximum] characteristic root of AA^* by the minimum [maximum] characteristic root of BB^*. A short proof is the following. First, if F is hermitian, and x is a variable unit vector, $xx^* = 1$, the minimum of xFx^* is equal to the minimum characteristic root ρ_1 of F.

$$(F = U \cdot \mathrm{diag}(\rho_1, \ldots, \rho_n) \cdot U^*,$$
$$UU^* = I \longrightarrow xFx^* = y_1\rho_1\bar{y}_1 + \cdots + y_n\rho_n\bar{y}_n$$

with $y = xU$, $yy^* = 1$. Second, the minimum characteristic root of $(AB)(AB)^*$ is less than or equal to the square of the absolute value of any characteristic root λ of AB. ($zz^* = 1$, $z(AB) = \lambda z \longrightarrow z(AB)(AB)^*z^* = \lambda\bar{\lambda}$; apply first statement with $F = (AB)(AB)^*$.). Third, the characteristic roots of $(AB)(AB)^*$ and A^*ABB^* are the same. Fourth, the minimum characteristic root of the product of two hermitian matrices, as A^*A, BB^*, is greater than or equal to the product of the respective minimum characteristic roots of the factors. (Math. Rev. abstract)

NCU. 04:016 - NCU. 04:021

NCU. 04:016

North Carolina U. Inst. of Statistics, Chapel Hill.

SOME FURTHER RESULTS IN SIMULTANEOUS CONFIDENCE INTERVAL ESTIMATION, by S. N. Roy. [1954] [10]p. (Reprint series no. 58) [AF 18(600)-83] Unclassified

Published in Ann. Math. Stat., v. 25: 752-761, Dec. 1954.

Let Σ_1 and Σ_2 denote the dispersion matrices of two p-variate normal populations. Simultaneous confidence bounds are gotten for all the characteristic values of Σ, and of $\Sigma_1\Sigma_2^{-1}$. Consider a (p + q)-variate normal population ($p \leq q$), and let Σ_{11}, Σ_{22}, Σ_{12} stand respectively for the dispersion submatrix of the first p variate, the last q, and that between the p-set and the q-set. Simultaneous confidence bounds are gotten for all bilinear compounds of $\beta = \Sigma_{12}\Sigma_{22}^{-1}$, the p x q matrix of regression of the p-set on the q-set. All bounds have confidence coefficients greater than or equal to a preassigned level. This paper is a continuation of another by the author and R. C. Bose [Ann. Math. Stat., v. 24: 513-536, 1953]. (Math. Rev. abstract)

NCU. 04:017

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

SOME PROBLEMS OF OPTIMUM SAMPLING, by P. N. Somerville. Apr. 15, 1953, 78p. incl. tables, refs. (Mimeograph series no. 66) (AF 18(600)83) Unclassified

Also published in Biometrika, v. 41: 420-429, Dec. 1954.

This research attempts to apply some of Wald's theory of statistical decision functions and in particular minimax methods to problems of optimum sample sizes.

NCU. 04:018

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

A REPORT ON SOME ASPECTS OF MULTIVARIATE ANALYSIS, by S. N. Roy. Dec. 30, 1954, iv. refs. (Mimeograph series no. 121; CIT rept. no. 15) ([AF]OSR-TN-55-25) (AF 18(600)83) AD 54346 Unclassified

The scope of the discussion is restricted to fixed sample size 2-decision problems, in which, for a preassigned level α or a confidence coefficient $1-\alpha$, the interest is centered on obtaining: (1) a similar region test of the hypothesis H_0 which has some kind of reasonably good property against the whole class of relevant composite alternatives $H(\epsilon\,\Omega)$ or (2) a set of simultaneous confidence bounds on deviations from H_0 with confidence bounds which have some kind of good properties in terms of covering wrong values of the deviations. (ASTIA abstract)

NCU. 04:019

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

UNBIASED ESTIMATION OF FUNCTIONS OF THE BINOMIAL PROPORTION, by S. K. Mitra. Feb. 1, 1955, 17p. (Mimeograph series no. 122; CIT rept. no. 18) ([AF]OSR-TN-55-51) (AF 18(600)83) AD 56935 Unclassified

Explicit characterizations are given for the class of estimable functions (EPF) of the parameter p in the binomial population and the subclass G of EPF's possessing uniformly minimum variance unbiased estimators (UMVUE). The EPF's not possessing UMVUE, the explicit expression for the unbiased estimator with minimum variance at some $p' \epsilon \Omega$(the parameter space) is given. The subclass G* of G of EPF's possessing unreasonable UMVUE has been considered when $\Omega = [0, 1]$. Such estimators are necessarily inadmissible in the Waldian sense, with any loss function which increases with the absolute error. No attempt is made, however, either to prove or disprove the admissibility of reasonable UMVUE (in general) in such a case except for f(p) = p with loss function proportional to squared error, when it is shown that the reasonable UMVUE for p is admissible also. (Contractor's summary)

NCU. 04:020

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

ON MINIMUM VARIANCE ESTIMATION OF LOCATION AND SCALE PARAMETERS, by S. K. Mitra. Feb. 1955, 14p. (Mimeograph series no. 126; CIT rept. no. 17) ([AF]OSR-TN-55-77) (AF 18(600)83) AD 56934 Unclassified

It is shown that uniformly minimum variance unbiased estimators (UMVUE) of location and scale parameters, when they exist, satisfy Pitman's configurational condition (Biometrika, v. 30: 391-421, 1938). As an illustration the case of rectangular population with range depending on location and scale parameters has been considered in some detail.

NCU. 04:021

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

ON INVERTING A CLASS OF PATTERNED MATRICES. PART 1, by S. N. Roy and A. E. Sarhan. Feb. 23, 1955, 23p. (Mimeograph series no. 123; CIT rept. no. 16) ([AF]OSR-TN-55-78) (AF 18(600)83) AD 56936 Unclassified

Also published in Biometrika, v. 43: 227-231, Pts. 1 and 2, June 1956.

Consideration is given to the inversion of a class of patterned matrices that come up in different fields of statistics, including least squares solutions relating to problems like estimation of population parameters by ordered or unordered observations, analysis of variances and covariance, response surfaces, etc. In order to make it available even to those who have little background of matrix theory and other parts of mathematics but who still need to invert such matrices, the treatment is made as simple and elementary as possible, with appropriate illustrative examples from the different fields of application. The actual matrices discussed do not by any means exhaust the list of all patterned matrices that might be useful in the various sectors. They are merely illustrative and other matrices will be discussed in a sequel to this note, to be called Part II, which will be based on the same technique, as is indicated and used here. In this technique, use is made of the facts that: (i) a nonsingular square matrix has a unique inverse and (ii) for the class of patterned matrices considered here it is possible to guess a form for the inverse with a few unknown (and thus flexible) parameters which could then be determined by equating to the identity matrix the product of the original matrix and the inverse that is guessed. At the moment, the guess is just intuitive but it is believed that is a deeper general calculus behind the whole thing, which may come to light in the near future, thus making the inversion of such matrices an entirely trivial problem.

NCU. 04:022

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

A GENERALIZATION OF ANALYSIS OF VARIANCE AND MULTIVARIATE ANALYSIS TO DATA BASED ON FREQUENCIES IN QUALITATIVE CATEGORIES OR CLASS INTERVALS, by S. N. Roy and M. A. Kastenbaum. June 1, 1955, 27p. (Mimeograph series no. 131; CIT rept. no. 19) ([AF]OSR-TN-55-167) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)83 and U. S. Public Health Service under HTS 5065(c)) AD 70214 Unclassified

In the situation indicated by the title a p-variate body of data arranged in a q-way classification will formally look like a body of data arranged in a (p + q)-way table, but the fundamental distinction between a so-called "variate" and a so-called "way of classification" is that along the direction of a "variate," the marginal frequencies are stochastic variates, while along a "way of classification," the marginal frequencies are fixed or prescribed. The hypotheses of "no total correlation," "no multiple correlation," "no partial correlation," "no canonical correlation," "no main effect," "no interaction," etc., are translated into hypotheses on the structure of the probabilities over the different cells or categories, and, with large sample assumptions, these hypotheses are tested by χ^2 with appropriate degrees of freedom. No exact test in terms of the original multinomial distribution is attempted in this paper. (Contractor's summary)

NCU. 04:023

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

PAIRED COMPARISON DESIGNS FOR TESTING CONCORDANCE BETWEEN JUDGES, by R. C. Bose. June 22, 1955, 14p. incl. tables, refs. (Mimeograph series no. 134; CIT rept. no. 20) ([AF]OSR-TN-55-214) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)83 and Division of Research Techniques, London School of Economics and Political Science) AD 75941 Unclassified

Also published in Biometrika, v. 43: 113-121, Pts. 1 and 2, June 1956.

Further consideration is given to the problem suggested by M. G. Kendall (Further Contributions to the Theory of Paired Comparisons, Biometrics, v. 11, 1955) concerning designs which might prove useful for testing concordance between judges. Certain designs, called linked paired comparison designs, are defined to ensure symmetry between objects and judges. Certain inequalities between the parameters are obtained. Two special classes of these designs have been studied, and explicit design for small values of n (the number of objects to be compared) are presented.

NCU. 04:024

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

THE RATIO OF VARIANCES IN A VARIANCE COMPONENTS MODEL, by W. A. Thompson. July 1953, 15p. (Mimeograph series no. 74) (AF 18(600)83) Unclassified

Also published in Ann. Math. Stat., v. 26: 325-329, June 1955.

In section 1 a lemma is proved which may sometimes be used to find the class of all statistics whose distributions are independent of the nuisance parameters. In section 2 this lemma is then applied to the general incomplete block variance components model to find the class of statistics whose distributions depend only on λ, the ratio of the two variances involved. Section 3 then finds a test of the hypothesis $\lambda < \lambda_0$ versus $\lambda > \lambda_1$. (Contractor's summary)

NCU. 04:025

North Carolina U. [Inst. of Statistics, Chapel Hill].

SOME CLASSES OF PARTIALLY BALANCED DESIGNS, by R. C. Bose and W. H. Clathworthy. [1955] [21]p. incl. tables. (AF 18(600)83) Unclassified

Published in Ann. Math. Stat., v. 26: 212-232, June 1955.

The paper deals with PBIB (partially balanced incomplete

NCU. 04:026 - NCU. 04:029

block) designs with two associate classes and $k > r \geq 2$, with $\lambda_1 = 1$ and $\lambda_2 = 0$. It is shown how the parameters for all such designs depend on the three integral parameters k, r, and t, which satisfy the restrictions that (i) $1 \leq t \leq r$, (ii) $rk(r-1)(k-1)/t(k+r-t-1)$ is a positive integer. For the particular case r = 3 it is shown that all designs with t = 2 or 3 necessarily exist, but if t = 1, then the only possible value of $k > r$ is k = 5. The designs with t = 2 are well known lattice designs and those with t = 3 are duals of certain balanced incomplete block designs. The design for k = 5 is constructed, the only construction in the paper. Other results are a less demanding definition of PBIB designs with two associate classes, and a lemma and five corollaries concerning the block structure of PBIB design with two associate classes having $\lambda_1 = 1$ and $\lambda_2 = 0$, with $p_{11}^1 = k - 2$ (but with no special assumption about the relationship between r and k). (Math. Rev. abstract)

NCU. 04:026

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

CONTRIBUTIONS TO THE STATISTICAL ANALYSIS OF CATEGORICAL DATA, by S. K. Mitra. Dec. 1955, 146p. (Mimeograph series no. 142; CIT rept. no. 22) (AFOSR-TN-56-43) (AF 18(600)83) AD 80555 Unclassified

The problems considered in this mathematical study are of 2 types: (1) multivariate analysis in which samples from 1 population are categorized according to several characteristics; and (2) analysis of variance in which samples from several populations are categorized according to 1 and the same characteristic. Hypotheses applicable to each of these situations are posed and tested. Chapter I gives a heuristic justification for the various frequency χ^2-tests. Chapter II discusses 2 theorems in minimum χ^2 and their applications. Chapter III investigates the property of asymptotic independence of test criteria in several cases of simultaneous testing in multivariate analysis. Chapter IV considers factorial multinomial experiments, their analysis, and a multidecision problem involving, in a restricted situation, the choice of the "best" (in some sense) among several populations. The final chapter presents some applications of the asymptotic power functions (in the Pitman sense) for the various types of χ^2-tests treated. (Contractor's abstract, modified)

NCU. 04:027

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

AN INTRODUCTION TO SOME NONPARAMETRIC GENERALIZATIONS OF ANALYSIS OF VARIANCE AND MULTIVARIATE ANALYSIS, by S. N. Roy and S. K. Mitra. Nov. 1955, 35p. refs. (Mimeograph series no. 139, CIT rept. no. 21) (AFOSR-TN-56-44) (AF 18-(600)83) AD 80556 Unclassified

Also published in Biometrika, v. 43: 361-376, Dec. 1956.

The concepts of a previous study (item no. NCU. 04:022) are extended to a systematic exposition which: (1) is based on a clear distinction between a variate and a way of classification which results from differing experimental situations and sampling schemes; (2) sets up different probability models for the different situations: and (3) poses different types of hypotheses dependent on the existence of the situation as a multivariate analysis, analysis of variance, or a mixed type. The discussion is illustrated by the case of 2 analogous null hypotheses under 2 different probability models. These eventually have the same χ^2 with the same distribution under the respective null hypotheses, but their asymptotic powers differ. Examples from multivariate analysis are presented to show χ^2 additivity in a probabilistic and asymptotic sense. The concept of interaction in the analysis of variance is discussed in terms of randomized block experiments in which ranking procedures may change from block to block.

NCU. 04:028

North Carolina U. Inst. of Statistics, Chapel Hill.

ON A DECISION RULE FOR A PROBLEM IN RANKING MEANS, by S. S. Gupta. May 1956, 104p. incl. tables, refs. (Mimeograph series no. 150) ([AF]OSR-TN-56-300) (AF 18(600)83) Unclassified

The author proposes and studies a statistical decision rule for the following situation. An experimenter is to select one or more populations which possess some characteristic, i.e., a large mean, guaranteeing that the probability of including the population with largest mean in the selected group is at least (1 - a), where a is a small pre-assigned number. The decision procedure proposed is one of a class first formulated by K. C. Seal. This paper explains a precise procedure, examines its properties and the statistic on which it is based, and illustrates its application.

NCU. 04:029

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

FURTHER CONTRIBUTIONS TO MULTIVARIATE CONFIDENCE BOUNDS, by S. N. Roy and R. Gnanadesikan. Aug. 1956, 15p. (Mimeograph series no. 155) (AFOSR-TN-56-380) (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)83 and Research Techniques Unit, London School of Economics and Political Science) AD 95816 Unclassified

Also published in Biometrika, v. 44: 399-410, Dec. 1957.

The implications of certain results obtained in earlier

papers on confidence bounds on parametric functions are fully worked out. This leads to a number of confidence bounds, expected to be useful, but hitherto unnoticed, (i) on the characteristic roots of one population dispersion matrix and on roots connected with (ii) 2 population dispersion matrices, (iii) the regression matrix of a p-set on a q-set, and (iv) multivariate linear hypothesis on means, including, in particular, the problem of discriminant analysis. (ASTIA abstract, modified)

NCU. 04:030

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

MOMENTS OF ORDER STATISTICS FROM A NORMAL POPULATION, by R. C. Bose and S. S. Gupta. July 1956, 13p. incl. tables, refs. (Mimeograph series no. 154) (AFOSR-TN-56-501) (AF 18(600)83) AD 110316 Unclassified

The problem of obtaining the moments of $(X)_k$, the k^{th} order statistic for a sample of size n from a normal population N(0, 1), is considered. The t^{th} moment of $X_{(k)}$, $\mu_t'(n, k)$, can be expressed in terms of lower moments of order $t - 2t$, [$t = 1, 2, \ldots, t/2$ or $(t-1)/2$], and the integral $\int_{-\infty}^{+\infty} P_{t+1}(x)e^{-(t+1)x^2/2}dx$ where $P_{t+1}(x)$ for $t > 0$ is defined by $P_{t+1}(x)$ $= k\binom{n}{k} \frac{d^t}{d\Phi^t}\left[\Phi^{k-1}(1-\Phi)^{n-k}\right]$; Φ is replaced by $\Phi(x)$ after differentiation. $P_t(x)$ is a polynomial of degree $(n - t)$ in $\Phi(x)$ if $n \leq t$, and is zero if $n > t$. Exact values of all odd order moments can be derived when $n \leq 5$, and all even order moments when $n \leq 6$. Tables of exact moments $\mu_t'(n, k)$ for $t = 3$ and 4 are worked out. In general the integral is numerically evaluated by the Gauss-Jacobi method of mechanical quadrature (Szego, Gabor, Orthogonal Polynomials, New York City, American Mathematical Society Colloquium Publications, v. 23, 1939) based on the zeros and the weight factors of the Hermite polynomials.

NCU. 04:031

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

CONTRIBUTIONS TO MULTIVARIATE ANALYSIS INCLUDING UNIVARIATE AND MULTIVARIATE VARIANCE COMPONENTS ANALYSIS AND FACTOR ANALYSIS, by R. Gnanadesikan. June 1956, 177p. refs. (Mimeograph series no. 158) (AFOSR-TN-56-558) (AF 18(600)83) AD 110378 Unclassified

The development of confidence bounds, simultaneous and/or individual, on parameters or parametric functions are formed as natural measures of departure from certain usual null hypotheses. The distributions of the sampled parent populations are assumed univariate or multivariate normal as a basis for the development of general results and a discussion of solutions of various problems in the sectors of variance components (both univariate and multivariate) and factor analysis.

NCU. 04:032

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

MULTIPLE RANGE TESTS FOR CORRELATED AND HETEROSCEDASTIC MEANS, by D. B. Duncan. Dec. 1956, 17p. incl. diagr. refs. (Mimeograph series no. 161) (AFOSR-TN-56-597) (In cooperation with Florida U.) (Sponsored jointly by Florida Agricultural Experiment Station, U. S. Public Health Service, and Air Force Office of Scientific Research under AF 18(600)83) AD 115024 Unclassified

A complete method for the extension of the multiple range tests is presented. The closeness is indicated between the properties of these complete tests of heteroscedastic and correlated means and the properties of the corresponding tests of homoscedastic and uncorrelated means. A short-cut skipping principle is also presented which is useful in applying multiple range tests to a large number of treatment means or totals. The basic rule for complete tests is stated as follows: (1) any subset of p means is homogeneous if the largest adjusted difference in the sub-set fails to exceed the critical value R_p'; (2) any 2 means not both contained in the same homogeneous subset are significantly different; and (3) any 2 means both contained in the same homogeneous subset are not significantly different. Numerical examples are given for the test of unequally replicated means and for the test of treatment of the properties is made in discussing the 2-mean significance levels and the higher-order significance levels and power.

NCU. 05:001

North Carolina U. Inst. of Statistics, Chapel Hill.

BOUNDS FOR THE DISTRIBUTION FUNCTION OF SUM OF INDEPENDENT, IDENTICALLY DISTRIBUTED RANDOM VARIABLES, by W. Hoeffding and S. S. Shrikhande. Oct. 1953, 31p. (Mimeograph series no. 84) (AF 18(600)458) AD 25736 Unclassified

Also published in Ann. Math. Stat., v. 26: 439-449, Sept. 1955.

The problem under study was that of obtaining bounds for the cumulative distribution function of the sum of n independent, identically distributed random variables with k prescribed moments and given range. For $n = 2$ the best bounds are attained or arbitrarily closely approached with discrete random variables which take on at most $2k + 2$ values. Explicit bounds are obtained for the case of nonnegative random variables with a given

NCU. 05:002 - NCU. 05:005

mean for n = 2; for arbitrary values of n, bounds are obtained which are asymptotically best in the tail of the distribution. Some of the results are considered to contribute to the more general problem of obtaining bounds for the expected value of a given function of independent, identically distributed random variables when the expected values of certain functions of the individual variables are given.

NCU. 05:002

North Carolina U. Inst. of Statistics, Chapel Hill.

THE EXTREMA OF THE EXPECTED VALUE OF A FUNCTION OF INDEPENDENT RANDOM VARIABLES, by W. Hoeffding. Oct. 1953, 16p. (Mimeograph series no. 83) (AF 18(600)458) AD 19999 Unclassified

Also published in Ann. Math. Stat., v. 26: 268-275, Jan. 1955.

The problem is considered of determining the least upper (or greatest lower) bound for the expected value $EK(X_1, \ldots, X_n)$ of a given function K of n random variables $X_1, \ldots, X_n$ under the assumption that $X_1, \ldots, X_n$ are independent and each X_j has given range and satisfies k conditions of the form $Eg_i^{(j)}(X_j) = c_{ij}$, $i = 1, \ldots, k$. It is shown that under general conditions, it is necessary to consider only discrete random variables X_j which take on at most $k + 1$ values.

NCU. 05:003

North Carolina U. Inst. of Statistics, Chapel Hill.

ON THE RELATION BETWEEN ESTIMATING EFFICIENCY AND THE POWER OF TESTS, by R. M. Sundrum. Jan. 1954, 6p. (Mimeograph series no. 90; CIT repl. no. 4) [AFOSR-TN-54-28] (AF 18(600)458) AD 35248 Unclassified

Also published in Biometrika, v. 41, Pts. 3 and 4: 542-544, Dec. 1954.

A condition is derived for the case of normal distributions for the validity of the assumption that a statistic which has a high efficiency in estimating an unknown parameter also gives a powerful test of hypotheses about that parameter. An example from genetics by Fisher (Statistical Methods for Research Workers, 11th ed., Oliver and Boyd, Edinburgh, 1950) is given of a failure of this assumption. A presumption in favor of using the more efficient estimator is established by showing that the derived condition fails only in situations where the power of the resulting test is less than one half.

NCU. 05:004

North Carolina U. Inst. of Statistics, Chapel Hill.

A FURTHER APPROXIMATION TO THE DISTRIBUTION OF WILCOXON'S STATISTIC IN THE GENERAL CASE, by R. M. Sundrum. Jan. 1954, 13p. incl. table. (Mimeograph series no. 89; CIT repl. no. 3) [AFOSR-TN-54-29] (AF 18(600)458) AD 35147 Unclassified

Also published in Jour. Roy. Stat. Soc., Series B, v. 16: 255-260, 1954.

General expressions are derived for the third and fourth moments of Wilcoxon's (Biometrics, v. 1: 80, 1945) 2-sample test statistic. This is a distribution-free test of the hypothesis that 2 samples $(X_1, X_2, \ldots, X_m)$ and $(Y_1, Y_2, \ldots, Y_n)$ are independent random samples from the same population. The test is based on the statistic

$$U = \sum_{i=1}^{m} \sum_{k=1}^{n} d_{ik} \text{ where } d_{ik} = 1 \text{ if } X_i < Y_k = 0 \text{ otherwise.}$$

The third and fourth moments depend on relatively few parameters. The general expressions contain the third and fourth moments for the null case as derived by Mann and Whitney (Ann. Math. Stat., v. 18: 50, 1947) and Haldane and Smith (Ann. Eugenics, v. 14: 117, 1948) as special cases. A short table is given of the values of these parameters under normal alternatives.

NCU. 05:005

North Carolina U. Inst. of Statistics, Chapel Hill.

ON SOME SIGN TESTS OF RANDOMNESS UNDER HYPOTHESES OF LINEAR TREND, by R. M. Sundrum. Mar. 1954, 13p. incl. table. (Mimeograph series no. 96; CIT repl. no. 5) ([AF]OSR-TN-54-70) (AF 18-(600)458) AD 35148 Unclassified

General expressions are obtained for the third and fourth moments of a sign test of randomness proposed by Moore and Wallis (Jour. Amer. Stat. Assoc., v. 38. 153-164, 1943). Two additional results are obtained: (1) the general expressions are applicable to the moments of a bivariate difference-sign test proposed by Stuart (Jour. Amer. Stat. Assoc., v. 47: 416-424, 1952) when his parameters are suitably redefined; and (2) the parameters which occur in these expressions are also involved in the formula for the variance of another test of randomness based on the number of turning points proposed by Moore and Wallis (A Significance Test for Time Series, National Bureau of Economic Research, 1941). This test is based on the statistic $T = \sum_{i=1}^{n-2} T_i$, where $T_i = 1$ if $(X_i - X_{i+1})(X_{i+1} - X_{i+2}) < 0 = 0$ otherwise. The results of Moore and Wallis for the null case, $E(T) = \frac{2(n-2)}{3}$ and $\sigma^2(T) = 16n - 29)/90$, were generalized to certain non-null cases by Levene (Ann. Math. Stat., v. 23: 34-56, 1952) in an asymptotic form. These results are obtained exactly. The values of the parameters occurring in these formulas are computed for some special cases. (ASTIA abstract)

NCU. 05:006

North Carolina U. Inst. of Statistics, Chapel Hill.

THE EFFICIENCY OF TESTS, by W. Hoeffding. Apr. 1954, 21p. (Mimeograph series no. 99; CIT rept. no. 6) ([AF]OSR-TN-54-103) (AF 18(600)458) AD 35145 Unclassified

Also published in Ann. Math. Stat., v. 26: 52-63, Mar. 1955.

The efficiency of a family of tests is defined. Methods for evaluating the efficiency are discussed. The asymptotic efficiency is obtained for certain families of tests under assumptions which imply that the sample size is large. (Contractor's summary)

NCU. 05:007

North Carolina U. Inst. of Statistics, Chapel Hill.

FURTHER CONTRIBUTIONS TO THE THEORY OF PAIRED COMPARISONS, by M. G. Kendall. [June 1954] 30p. incl. diagrs. tables. (Mimeograph series no. 108; CIT rept. no. 7) ([AF]OSR-TN-54-146) (AF 18(600)458) AD 37805 Unclassified

Also published in Biometrics, v. 11: 43-62, Mar. 1955.

A theory of paried comparisions is discussed in which n objects are presented to each of m observers, two at a time, and the observer states which of the two he prefers. The problem is to select $k < n$ objects which are most preferred in some sense. Several solutions are considered which correspond to different interpretations of the phrase most preferred. The theory is illustrated by problems such as scoring a chess tournament in which the scores are regarded as a matrix. Various means of reallocating scores are presented which are equivalent to taking successive powers of the matrix. A proof is presented that the process of repeated powering converges to a limiting ranking.

NCU. 05:008

North Carolina U. Inst. of Statistics, Chapel Hill.

SOME RECENT DEVELOPMENTS IN RANKING METHODS, by M. G. Kendall. July 1954, 30p. refs. (Mimeograph series no. 112; CIT rept. no. 9) ([AF]OSR-TN-54-235) (AF 18(600)458) AD 44788 Unclassified

A brief account is presented of the development of ranking methods, and of the use of the theory of continuous or discontinuous observable variates. The rank correlation coefficient, τ, is discussed. The present treatment is concerned with the following subjects: (1) rank correlation coefficients; (2) sampling from ranked populations; (3) ranks and variate values; (4) multivariate ranking theory; (5) relationship with order statistics; and (6) paired comparisons.

NCU. 05:009

North Carolina U. [Inst. of Statistics] Chapel Hill.

DISTRIBUTION OF LINEAR CONTRASTS OF ORDER STATISTICS, by J. St. Pierre. [1954] [2]p. [CIT rept. no. 14] [AFOSR-TN-54-267] [AF 18(600)458] Unclassified

Presented at meeting of the Institute of Math. Statistics, Montreal (Canada), Sept. 10-13, 1954.

Abstract published in Ann. Math. Stat., v. 26: 806-807, Dec. 1954.

Consider $n + 1$ independent normal population with unknown means, $m_0, m_1, \ldots, m_n$, respectively, and with a common known variance $\sigma^2 = 1$. Suppose a sample of size N is available from each population; and let $x_{(0)} > x_{(1)} > \ldots > x_{(n)}$ be the ordered sample means. Consider the linear contrasts $z = x_{(0)} - c_1 x_{(1)} - \ldots - c_n x_{(n)}$, where $\sum_1^n {}_1 c_i = 1$, $c_i \geq 0$, $(i = 1, 2, \ldots, n)$. The probability density function of the contrasts z is derived under the null hypothesis $H_0: m_0 = m_1 = \ldots = m_n$. The density of the contrasts z is also obtained in the case of three populations, under the hypothesis $-\infty < m_2 \leq m_1 \leq m_0 < +\infty$. Particular hypotheses are considered and tables are given. Finally, the particular contrast $y = x_{(0)} - x_{(1)}$ is considered in the general case. (Contractor's abstract)

NCU. 05:010

North Carolina U. Inst. of Statistics, Chapel Hill.

MOST ECONOMICAL MULTIPLE-DECISION RULES, by W. J. Hall. Aug. 1954, 160p. incl. diagrs. tables, refs. (Mimeograph series no. 115; CIT rept. no. 10) ([AF]OSR-TN-54-268) (AF 18(600)458) AD 44786 Unclassified

Also published in Ann. Math. Stat., v. 29: 1079-1094, Dec. 1958.

Multiple-decision theory is extended to the following cases: (1) decision rules for deciding among m alternatives which minimize the sample size subject to bounds on the m probabilities of choosing the preferred alternative or of choosing, in a sense, the correct alternative under the prevailing one of m possible situations; and (2) decision rules which minimize the sample size subject to bounds on each of the probabilities, less than $1 - m$ in number, of making incorrect decisions. Solutions to the first problem are likelihood-ratio decision rules, and solutions to the second problem are unlikelihood-ratio decision rules. Problems of both simple and composite discrimination are considered, and characterization and existence theorems are given. A number of examples are treated which are generalizations of some of the common statistical tests. The theory is applicable to multivariate as well as univariate problems. This generality enables some k-population problems, such as deciding which of several populations has the largest mean, to be covered by a consideration

NCU. 05:011 - NCU. 05:014

of a set of k observations (one from each univariate population) as one observation from a k-variate population. A generalization to a most economical theory of decision functions is considered in which the maximum expected cost is minimized, subject to bounds on the expected loss function. Some particular examples of 2- and 3-decision rules are treated in an appendix. A nomograph is given for explicitly obtaining such rules, and brief tables of most economical sample sizes are computed from it.

NCU. 05:011

North Carolina U. Inst. of Statistics, Chapel Hill.

AN OPTIMUM PROPERTY OF BECHHOFER'S SINGLE-DECISION PROCEDURE FOR RANKING MEANS AND SOME EXTENSIONS, by W. J. Hall. Sept. 1954, 13p. (Mimeograph series no. 118; CIT repl. no. 11) ([AF]OSR-TN-54-279) (AF 18(600)458) AD 44787 Unclassified

The procedures of Bechhofer (Ann. Math. Stat., v. 25: 16-39, 1954) of grouping populations according to ranks are justified for the case when the population variances and the sample sizes are specified as equal among the populations. The analysis shows that if the bounds on the distances are to be satisfied, the procedure of Bechhofer is the most economical multiple-decision rule as defined in Hall's Most Economical Multiple-Decision Rules (item no. NCU. 05:010). Similar results, with some limitations are obtained for problems of ranking other population parameters and for a distribution-free ranking problem. Difficulties in computing the most economical sample size for these nonnormal problems arediscussed.

NCU. 05:012

North Carolina U. Inst. of Statistics, Chapel Hill.

SOME PROPERTIES OF A BAYES TWO-STAGE TEST FOR THE MEAN, by M. Skibinsky. June 1954, 123p. incl. diagrs. tables, refs. (Mimeograph series no. 107) [AF 18(600)458] Unclassified

The author examines a special case of the general Bayes solution to Wald's two-stage decision problem. He considers general properties of the second sample size function, for a normal frequency function, and both the asymptotic and non-asymptotic properties of the Bayes two-stage test. These include, in the asymptotic case, the expansion of the second sample size function, the expected value of the second sample size, error probabilities, and a comparison with the one-stage test. These topics are treated in detail, and at some length.

NCU. 05:013

North Carolina U. Inst. of Statistics, Chapel Hill.

ON THE DISTRIBUTION OF THE NUMBER OF SUCCESSES IN INDEPENDENT TRIALS, by W. Hoeffding. Apr. 1955, 13p. (Mimeograph series no. 128; CIT rept. no. 13) ([AF]OSR-TN-55-96) (AF 18(600)458) AD 61149 Unclassified

Also published in Ann. Math. Stat., v. 27: 713-721, Sept. 1956.

Let S be the number of successes in n independent trials and let p_j denote the probability of success in the j-th trial, j = 1, 1, ..., n (Poisson trials). The problem of finding the maximum and the minimum of Eg(S), the expected value of a given real-valued function of S, is considered when ES = np is fixed. It is well known that the maximum of the variance of S is attained when $p_1 = p_2 = \ldots = p_n = p$. This can be interpreted as showing that the variability in the number of successes is highest when the successes are equally probable (Bernoulli trials). This interpretation is further supported by the following 2 theorems which are proved. If b and c are 2 integers, $0 \leq b \leq np \leq c \leq n$, the probability $P(b \leq S \leq c)$ attains its minimum if, and only if $p_1 = p_2 = \ldots = p_n = p$ unless b = 0 and c = n (Theorem 5). If g is a strictly convex function, Eg(S) attains its maximum if and only if $p_1 = p_2 = \ldots = p_n = p$ (Theorem 3). These results are obtained with the help of 2 theorems concerning the extrema of the expected value of an arbitrary function g(S) under the condition ES = np. Theorem 1 gives necessary conditions for the maximum and the minimum of Eg(S). Theorem 2 gives a partial characterization of the set of points at which an extremum is attained. Corollary 2.1 states that the maximum and the minimum are attained when $p_1, p_2, \ldots, p_n$ take on at most 3 different values, only 1 of which is distinct from 0 and 1. Applications of Theorems 3 and 5 to problems of estimation and testing are given. (Contractor's abstract)

NCU. 05:014

North Carolina U. Inst. of Statistics, Chapel Hill.

ON A CERTAIN CLASS OF STOCHASTIC APPROXIMATION PROCESSES, by D. L. Burkholder. May 1955, 79p. incl. refs. (Mimeograph series no. 129; CIT rept. no. 14) ([AF]OSR TN-55-168) (AF 18(600)458) AD 70213 Unclassified

Also published in Ann. Math. Stat., v. 27: 1044-1059. Dec. 1956.

Methods are investigated which in certain cases will give information about: (1) the solutions of the equation $M(x) - \alpha = 0$, if any exist; and (2) the location of the maximum of M, if it exists. M is a function from the real numbers into the real numbers. The function is not assumed to be known, but for each real number x there is a probability distribution function H such that $\int_{-\infty}^{\infty} y\,dH(y/x) = M(x)$. The literature is surveyed for information relevant to the first problem for the case when the root exists uniquely. Results on convergence with probability 1 are given for the case where the assumption of a unique root is not satisfied. Blum's

result (Ann. Math. Stat., v. 25: 382-386, 1954) that the stochastic approximation process $\{x_n\}$ of type A_2 converges to θ with probability 1 is obtained with several of his conditions relaxed. Results on asymptotic normality are also given in connection with problem 2. Stochastic approximation processes of type A_3 are shown to give information about the location of points of inflection of M under certain conditions. Results on convergence with probability 1 and on asymptotic normality are given for the problem of locating the maximum of a probability density function.

NCU. 05:015

North Carolina U. Inst. of Statistics, Chapel Hill.

THE ROLE OF ASSUMPTIONS IN STATISTICAL DECISIONS, by W. Hoeffding. July 1955, 17p. incl. refs. (Mimeograph series no. 136; CIT rept. no. 16) ([AF]OSR-TN-55-263) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)-458 and [Office of Ordnance Research under DA-04-200-ORD-355]) AD 75910 Unclassified

Also published in Proc. Third Berkeley Symposium on Mathematical Statistics and Probability, California U., Dec. 1954, and June and July 1955, p. 105-114.

The first part of this paper is concerned with the problem of investigating how the performance of a decision rule is affected when the assumptions under which it was derived are violated, with emphasis on assumptions concerning the class of distributions. Consequences of assuming that the distribution is continuous or normal are discussed. The second part deals with distinguishable sets of distributions, a concept related to the problem of the existence of unbiased or consistent tests. Criteria for the distinguishability of 2 sets by means of a test based on finitely many observations and by a sequential test are considered, and their uses are illustrated. An example of 2 sets which are distinguishable only by a randomized test is given. (Contractor's abstract)

NCU. 05:016

North Carolina U. Inst. of Statistics, Chapel Hill.

ON A CLASS OF NON-PARAMETRIC TESTS, by J. R. Rosenblatt. Aug. 1955, 106p. incl. tables, refs. (Mimeograph series no. 138; CIT rept. no. 15) ([AF]OSR-TN-55-319) (AF 18(600)458) AD 75602 Unclassified

A class of nonparametric statistical decision problems is characterized by partition of a set of possible probability distributions into sets defined by the value of a functional. Particular attention is given to a class of functionals of the form $E_\varphi(X;F)$, where X is a vector random variable with distribution $F(x)$, and especially to the subclass in which the function $\varphi(x)$ takes only the values zero and 1. Certain families of decision procedures are considered, which are based on functions of the observed values of X which depend on these values only through the function $\varphi(x)$. Two principal types of results have been obtained. (1) Methods are developed for determining the asymptotic relative efficiency of 2 families of decision procedures under assumptions such that the methods are applicable in the situation described above. These methods are applied in particular to comparison of a family of 2-sample tests based on the Wilcoxon-Mann-Whitney statistic with a family of tests based on a related statistic which has binomial distribution. (2) Certain 2-sample decision problems, for which $E\varphi(X)$ is the probability of an event, are investigated. Some properties of the related families of decision procedures are obtained for small and large finite sample sizes, under assumptions which imply that the (nonparametric) sets of alternatives are very large. (Contractor's abstract)

NCU. 05:017

North Carolina U. Inst. of Statistics, Chapel Hill.

A NOTE ON TRUNCATION AND SUFFICIENT STATISTICS, by W. L. Smith. Nov. 1955, 10p. (Mimeograph series no. 140; CIT rept. no. 17) (AFOSR-TN-56-36) (AF 18(600)458) AD 80547 Unclassified

Also published in Ann. Math. Stat., v. 28: 247-252, Mar. 1957.

Generalizing earlier observations by Fisher and Hotelling, Tukey (Ann. Math. Stat., v. 20: 309-311, 1949) showed that if a family of distributions admits a set of sufficient statistics, then the family obtained by truncation to a fixed set, or by a fixed selection, also admits the same set of sufficient statistics (this wording is Tukey's; a precise mathematical statement is given later). Tukey's proof assumed the relevant family of probability measures to be dominated by a fixed measure function, and made use of the factorization theorem concerning sufficient statistics in this case. In the present short note, Tukey's result is first reproved without assuming domination (and, hence, without appealing to the factorization theorem). Then it is shown that, under general conditions, if a sufficient statistic has one or more of the properties of completeness, bounded completeness, or minimality, before truncation, it preserves such after truncation. The treatment is on the lines of the abstract discussion of sufficient statistics given by Halmos and Savage (Ann. Math. Stat., v. 20: 225-241, 1949). Familiarity with the results given in this latter paper is assumed. For definitions of completeness, bounded completeness, and minimality, and for a discussion of the significance of these concepts reference is made to Lehmann and Scheffé (Shankhya, v. 10: 305-340, 1950). (Contractor's abstract, modified)

NCU. 05:018

North Carolina U. Inst. of Statistics, Chapel Hill.

ON SUFFICIENT STATISTICS WHEN THE RANGE

NCU. 05:019 - NOR. 01:001

DEPENDS UPON THE PARAMETER, by W. L. Smith. Nov. 1955, 21p. (Mimeograph series no 141; CIT repl. no. 18) (AFOSR-TN-56-37) (AF 18(600)458) AD 80548 Unclassified

This mathematical study strengthens a theorem concerning the factorability of the probability density function presented by R. C. Davies (Ann. Math. Stat., v. 22: 43-57, 1941). Let $\{\mu_\theta\}$ be a family of probability measures defined on a measurable space (X, F_x), where θ, the parameter, is a point in the abstract parameter space Ω. It is assumed that $\{\mu_\theta\}$ is dominated by some fixed σ-finite measure λ, and that $f_\theta = d\mu_\theta/d\lambda$ represents some fixed version of the probability densities. $(\mu_\theta^n, X^n, F_x^n)$ is written for the n-product probability measure space derived in the usual way; evidently $\prod_1^n f_\theta(x_i)$ is measurable F_x^n. Furthermore, it is clear that μ_θ^n is dominated by λ^n, and $f_\theta^n = d\mu_\theta^n/d\lambda^n$ is written for some version of the probability densities on X^n. If $\underset{\sim}{x}_n = (x_1, x_2, \ldots, x_n)$ is a point of X^n, then $\{\underset{\sim}{x}_n\}$ is written for the finite subset of X which consists of the n points $x_1, x_2, \ldots, x_n$. When $\underset{\sim}{x}_n$ and $\underset{\sim}{x}_{n+1}$ appear in the same context, it is understood that the first n coordinates of $\underset{\sim}{x}_{n+1}$ are the coordinates of $\underset{\sim}{x}_n$ (repeated sampling). Then $\underset{\sim}{x}_n \in X^n$ a θ-set $t_n(\underset{\sim}{x}_n) = \left\{\theta : \prod_1^n f_\theta(x_i) > 0\right\}$. This set-valued function may be considered to be a statistic defined on X^n, and this study is concerned with necessary and sufficient conditions for t_n to be a sufficient statistic for $\{\mu_\theta^n; \theta \in \Omega\}$.

NCU. 05:019

North Carolina [U.]. Inst. of Statistics, Chapel Hill.

ANALYSIS OF PAIRED COMPARISON DESIGN WITH INCOMPLETE REPETITIONS, by J. W. Wilkinson. Apr. 1956, 81p. incl. tables, refs. (Mimeograph series no. 147) (AFOSR-TN-56-189) (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)458 and National Research Council of Canada) Unclassified

Published in Biometrika, v. 44: 98-113, Pts. 1 and 2, June 1957.

A method of paired comparison of treatments is frequently used when quantitative measurement of treatment effects is not possible or practicable. The problem of analysis of the paired comparison designs developed by Bose and Kendall was studied. Other designs were obtained by constructing the complementary designs corresponding to the designs given by Bose. The designs have a high degree of symmetry as they are balanced by numbers of comparisons, objects compared, and numbers of observers on given comparisons. Some test procedures for examining the relative rating of the number of objects to be compared, and some large-sample properties of the tests and examples to clarify the test procedures are given.

NCU. 05:020

North Carolina U. Inst. of Statistics, Chapel Hill.

ON RENEWAL THEORY, COUNTER PROBLEMS AND QUASI-POISSON PROCESSES, by W. L. Smith. Jan. 1956, 31p. refs. (Mimeograph series no. 144) (AFOSR-TN-56-191) (AF 18(600)458) AD 87064 Unclassified

Also published in Proc. Cambridge Philos. Soc. (England), v. 53: 175-193, 1957.

The standard machinery of renewal theory, with certain minor additions, is used to derive without recourse to unnatural boundary conditions the asymptotic results given by Hammersley (Proc. Cambridge Philos. Soc. (England), v. 49: 623-637, 1953). Two methods of censoring a renewal process are given. The first process is designated the guarantee-censor process. Such a process occurs if the renewals carry a maker's guarantee to replace without charge the renewal if it needs replacement in less than a certain number of time units from its moment of installation. The second process is called the paralysis-censor process because it corresponds to the effect of an automatic self-paralysis mechanism in a counter of a type described by Hammersley. A formula for the variance of the number of recorded points given by Hammersley for the guarantee-censor case is shown to be erroneous. Correct formulas for the case of the paralysis-censor are derived.

NCU. 05:021

North Carolina U. Inst. of Statistics, Chapel Hill.

ON THE EFFICIENCY OF CERTAIN TESTS FOR 2 X 2 TABLES, by J. H. MacKay. Apr. 1956, 124p. refs. (Mimeograph series no. 148) (AFOSR-TN-56-192) (AF 18(600)458) AD 87065 Unclassified

The following topics are discussed: (1) choosing between two binomial populations when the sample sizes are equal and the loss function is symmetrical; (2) asymptotic solutions as the distance between the alternatives tends to zero; (3) asymptotic efficiency of Fisher-Tocher tests and the approximate Chi square test; and (4) asymptotic solutions as the error probabilities tend to zero.

NOR. 01:001

Northwestern U., Evanston, Ill.

PROCEEDINGS OF THE GAS DYNAMICS SYMPOSIUM ON AEROTHERMOCHEMISTRY, AUG. 22, 23, 24, 1955,

ed. by D. K. Fleming. 1956, 284p. incl. illus. diagrs. tables, refs. (In cooperation with American Rocket Soc.) (AF 18(600)1536) Unclassified

Twenty-five papers delivered at the Symposium are presented on the following aspects of aerothermochemistry: combustion of condensed phases, nonsteady combustion, laminar flames, turbulent combustion, flame stabilization, as well as detonation and thermodynamics.

NOR. 02:001

Northwestern U. Dept. of Mathematics, Evanston, Ill.

SOME RATIONALITY QUESTIONS ON ALGEBRAIC GROUPS, by M. A. Rosenlicht. July 1956, 43p. refs. (AFOSR-TN-56-318) (AF 18(600)1571) AD 94854 Unclassified

Also published in Ann. Math. Pura Appl., v. 43: 25-50, 1957.

The connected linear algebraic group over the field of complex numbers G is defined over a field k and the perfect arbitrary field k(G) is k – isomorphic to a subfield of a transcendental extension of k. Rationality questions dealing with solvable algebraic groups are expressed as results. The propositions formulated therefrom evidence that much information on the structure of the group can be obtained by the study of the type of field extension obtained by adjoining the characteristic roots of a generic element of an algebraic group of matrices to the field of the generic element. Fields of definition of generalized Jacobian varieties of curves are considered and an example is given of a connected algebraic group whose maximal connected linear algebraic subgroup is not defined over the same field.

NOR. 02:002

Northwestern U. Dept. of Mathematics, Evanston, Ill.

SOME BASIC THEOREMS ON ALGEBRAIC GROUPS, by M. [A.] Rosenlicht. [1956] [43]p. (AF 18(600)-1571) Unclassified

Published in Amer. Jour. Math., v. 78: 401-443, Apr. 1956.

The purpose of this paper is to give a systematic development of some basic results in the theory of algebraic groups. The main results proved are structure theorems dealing with the existence in an algebraic group G of a normal algebraic subgroup H such that H and G/H are of specified types. The most important of these results, announced by Chevalley in 1953 and first proved in print by Barsotti (Ann. Mat. Pura Appl., v. 38: 77-119, 1955; Atti Accad. Naz. Lincei. Rend. Cl. Sci. Fis. Mat. Nat., v. 18: 43-50, 1955), asserts that if G is connected then there exists a linear H such that G/H is an Abelian variety. The first two parts of the paper develop the necessary concept of factor group, in its natural setting of transformation spaces and orbit varieties. The general methods stem from Nakano (Mem. Coll. Sci. Univ. Kyoto. Ser. A. Math., v. 27: 55-66, 1952) and Weil (Amer. Jour. Math., v. 77: 355-391; 493-512, 1955), but here are generalized to permit reducible varieties. The third part deals with the homomorphism theorems. The natural group isomorphism $G/H \supseteq (G/N)/(H/N)$ is shown to be birational, buth the natural isomorphism $H/(H \cap N) \supseteq HN/N$ is not always so; it is, however, rational and purely inseparable. Reformulating Weil's notion of "isogeny" of Abelian varieties in a way appropriate to arbitrary algebraic groups, the author obtains a result somewhat more precise than the fact that $H/(H \cap N) \supseteq HN/N$ is a purely inseparable isogeny. This permits him similarly to recapture for algebraic groups the Jordan-Hölder-Schreier theorem via Zassenhaus' lemma. The fourth part treats connected algebraic groups which are solvable (in the strong sense that the factor groups of some normal chain are all birationally isomorphic to either the additive or multiplicative group of the universal field. The main result here is that if V is a transformation space for such a group G and if $\tau: V \to W$ denotes the canonical generically surjective rational mapping of V onto the orbit variety W, then there exists a "cross-section," i.e., a rational mapping $\sigma: W \to V$ such that $\tau\sigma = 1$. The final part of the paper develops the structure theorems as mentioned above. (Math. Rev. abstract)

NOR. 03:001

Northwestern U. Dept. of Metallurgy, Evanston, Ill.

TRANSFORMATIONS IN DISORDERED GOLD-COPPER ALLOYS, by G. C. Kuczynski, M. Doyama, and M. E. Fine. Mar. 1, 1956 [19]p. incl. diagrs. refs. (AFOSR-TN-56-66) (In cooperation with Notre Dame U., Ind.) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1468 and Office of of Naval Research under [N7onr-43908]) AD 81058 Unclassified

Also published in Jour. Appl. Phys., v. 27: 651-655, June 1956.

In this study, measurements were made of the specific heat, temperature coefficient of expansion, Young's modulus, and yield point in Cu_3Au alloys. It has been established that this alloy undergoes a phase transition between 550° and 600°C, and possible another one near 850°C. The temperature of the 550°-600°C transition decreases sharply as the composition of the alloy deviates from Cu_3Au. (Contractor's abstract, modified)

NOR. 03:002

Northwestern U. Dept. of Metallurgy, Evanston, Ill.

ACOUSTIC RELAXATION EFFECT IN Mn_3O_4, by M. E. Fine and C. Chiou. Aug. 14, 1956 [9]p. incl. diagrs. (AFOSR-TN-56-312) (AF 18(600)1468) AD 94847 Unclassified

NOR. 03:003 - NOT. 01:003

Also published in Phys. Rev., v. 105: 121-122, Jan. 1, 1957.

Internal friction and Young's modulus for specimens of polycrystalline Mn_3O_4 rods were determined as functions of temperature by the resonant longitudinal vibration method using piezoelectric excitation and detection of vibrations. Specimen 1 was sintered in air at 1100° and 1200°C. Internal friction peaks occur near 75°C at 60 kc/sec, and near 105°C at 180 kc/sec. Specimen 2A was sintered in He at 1100°C. An internal friction peak occurs near -10°C at 50 kc/sec. Specimen B was sintered additionally in air at 1200°C and showed a second peak near 75°C at 75 kc/sec. Compared with internal friction peaks in Fe_3O_4 and Ni-Fe ferrites, those in Mn_3O_4 are quite broad. Young's modulus, plotted as a function of temperature for specimen 1, showed a rapid decrease on heating in the region of the internal friction peak. By analogy with magnetite and Ni-Fe ferrites, the internal friction peaks in Mn_3O_4 are attributed to a stress-induced change in the distribution of Mn^{++} and Mn^{++++}.

NOR. 03:003

Northwestern U. [Dept. of Metallurgy] Evanston, Ill.

THE STRENGTH OF AN ALLOY CONTAINING ZONES, by A. Kelly and M. E. Fine. Dec. 27, 1956, 7p. refs. (AFOSR-TN-56-581) (AF 18(600)1468) AD 115005 Unclassified

Also published in Acta Metallurgica, v. 5: 365-367, July 1957.

Rough estimates are made of the stress necessary to force a dislocation through a Guinier-Preston zone in an Al alloy containing 2 atomic % Cu and in an Al alloy containing 13 atomic % Ag. The values found are significantly less than those calculated using a model for the strength of a precipitation hardened alloy proposed by Orowan. It is suggested that the process of shearing the zones determines the initial flow stress in these age-hardening alloys. (Contractor's abstract)

Northwestern U. Technological Inst., Evanston, Ill.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:127-PRI. 11:130.

NOT. 01:001

Notre Dame U. [Dept. of Mathematics] South Bend, Ind.

[A SURFACE OF SECTION IN THE PROBLEM OF STÖRMER. Surface de section dans le problème de Störmer, by R. De Vogelaere. [1954] [10] p. [AF 18(600)776] Unclassified

Published in Bull. Acad. Roy. de Belgique, Cl. Sci., Series 5, v. 40: 705-714, July 1954.

The author sharpens several statements of Graef (Bol. Soc. Mat. Mexicana, v. 1: 1-31, 1944) and gives a direct proof of a statement called P^2. By means of the latter he then deduces the existence of a surface of section in the sense of Poincaré in a problem of Störmer (motion of an electric particle in the field of a magnetic dipole). (Math. Rev. abstract)

NOT. 01:002

Notre Dame U. Dept. of Mathematics, South Bend, Ind.

SOLUTIONS OF TRANSCENDENTAL EQUATIONS BY ITERATIONS, by R. De Vogelaere. Nov. 1954, 22p. incl. diagrs. tables, refs. (Technical repl. no. 1) (AF 18(600)776) Unclassified

The solution of a nonalgebraic equation $f(x) = 0$ is a very common problem in numerical analysis. If a first approximation of the solution is known, a very popular class of methods used is iteration methods. Although none of the principles given in this study are new, it was felt interesting to assemble and to compare the different method commonly used, and their criteria of convergence. In addition, a combination of those methods well suited for electronic digital computers is given which will solve, in general, any problem of this kind. The usefulness of the point of view here taken is made clear when a comparison of methods is made. First, definitions on iterations are attempted, and general convergence theorems are given.

NOT 01:003

Notre Dame U. Dept. of Mathematics, South Bend, Ind.

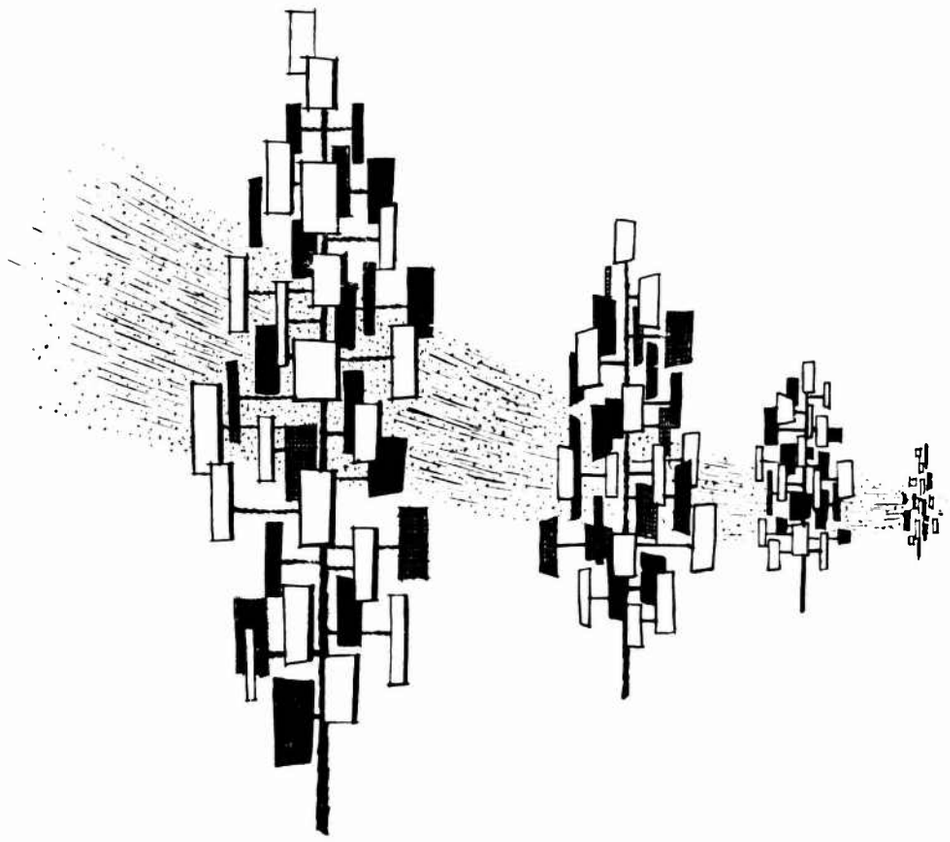
ON THE STRUCTURE OF SYMMETRIC PERIODIC SOLUTIONS OF CONSERVATIVE SYSTEMS, WITH APPLICATIONS, by R. De Vogelaere. Dec. 1954, iv. incl. diagrs. tables, refs. (Technical repl. no. 2) (AF 18(600)776) Unclassified

In studying a given algebraic curve, it is necessary to investigate the properties of such a curve near an ordinary point; however, this does not furnish any information on the behavior of the curve in the large. The knowledge of the singular points will furnish one of the tools for such a study in the large and the classification of these points into double points, triple points, cusps, etc., will be of utmost importance. A similar situation arises in the study of differential equations. Consider those of the type

$$\frac{d^2x}{dt^2} = \frac{\partial}{\partial x}U(x,y),\quad \frac{d^2y}{dt^2} = \frac{\partial}{\partial y}U(x,y);$$

$$\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 = 2U(x,y).$$

Here again the properties of existence and uniqueness of a solution, or of the behavior near a solution do not give any information on the manifold of solutions in the large. Moreover, the complete knowledge of one solution for an infinite time gives rise to a new difficulty except for periodic solutions. These may be taken as analogous to the singular point of an algebraic curve, and their knowledge and classification may furnish a good tool to advance in the study of such equations. Such classification is considered here, and is made dependent on a correspondence of solutions of the differential equation with points on a 2-dimensional manifold. Such a manifold can easily be constructed, in general, if there exists a surface which is crossed by all the trajectories. This surface is called surface of section by Poincaré, and to successive intersections of the surface of section by the trajectories correspond successive points A and B on the manifold. The correspondence of B to A defines a transformation T of the manifold into itself, and the problem of finding periodic solutions of the differential equations is equivalent to the determination of the fixed points of transformation T. It is not, unfortunately, generally easy to obtain a simple surface of section. Therefore, it makes sense to consider the similar transformation that can be deduced from the successive intersection of part of a surface satisfying less stringent conditions. This transformation furnishes those periodic solutions which cross this surface, and this gives at least a partial answer to the problem. In a certain number of applications, e.g., the billiard ball problem and the restricted 3 bodies problem, the transformation T is the product of 2 involutions M_1M_0. This paper will restrict itself to such a transformation.



ODI. 01:001 - OSU. 02:002

ODI. 01:001

Odin Associates, Pasadena, Calif.

AN AERO-THERMODYNAMIC PROPULSION METHOD, by S. Lal and I. Michelson. Sept. 1956, 81p. incl. diagrs. tables, refs. (Rept. no. 100-1) (AFOSR-TN-56-523) (AF 18(600)1501) AD 110341 Unclassified

A first-phase study is summarized in which the basic aerodynamic and propulsion properties are investigated for a propulsive system in which friction heating of the boundary layer is utilized for the vaporization and superheating of an internally circulated coolant-fuel. For supersonic flow within the earth's atmosphere, there is a double benefit from such an arrangement: reduction to within tolerable limits of peak skin temperatures, as well as improvement of propellant performance as compared with fuels at ordinary temperatures. The aerodynamic investigation consists of an examination of heat transfer properties of boundary layers on three-dimensional configurations at moderate and high Mach numbers, in relation to skin friction of the same layers. Computations are carried out for the specific impulse of sample coolant-fuels. In the absence of reliable data on heat transfer in high temperature hypersonic flows, as well as more complete analysis of coolant-fuels and flight plan optimizations, a full systems evaluation analysis is not attempted in the present report, but is planned for further study in the immediate future. (Contractor's abstract)

ODI. 02:001

Odin Associates [Pasadena, Calif.]

ON COANDA EFFECT, by I. Michelson. Mar. 30, 1956, 41p. incl. refs. (AF 18(600)1568) Unclassified

A detailed statement of the essential features of the "Coanda Effect" is presented in a definition based on a study of the literature, independent analysis, and discussions with experts, including M. Henri Coanda. The development of the "Effect" is traced historically through the work of Coanda and other researchers. Examination of the physics of the relevant processes leads to the conclusion that turbulent mixing is the essential element. It is stated that much of the early work in the field did not consider the effects of turbulent mixing. The basic mechanisms of the "Effect" are described and discussed. (Contractor's abstract, modified)

See also Pioneer Industries, Inc., item no. PIO. 01:001.

OSU. 01:001

Ohio State U. Research Foundation, Columbus.

STUDY OF CLASS FIELD THEORY, by H. B. Mann. Final rept. July 1-Sept. 30, 1953. 77p. ([AF]OSR-TR-54-1) (AF 18(600)595) Unclassified

This report presents a detailed study of the construction and properties of the class fields over an algebraic number field.

OSU. 01:002

Ohio State U. Research Foundation, Columbus.

ON AN EXCEPTIONAL PHENOMENON IN CERTAIN QUADRATIC EXTENSIONS, by H. B. Mann. [1954] [3]p. [AF 18(600)595] Unclassified

Published in Canad. Jour. Math., v. 6: 474-476, 1954.

Let Σ be an algebraic number field and Ω/Σ be a cyclic extension of a prime degree l. Then Ω would contain a unit ξ such that $\xi^{l^\beta} \in \Sigma$, $\xi^{l^{\beta-1}} \notin \Sigma$, $\beta > 1$. This is possible only for $l = 2$ and the author determines all possible cases. (Math. Rev. abstract)

OSU. 02:001

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

OXIDATION REACTIONS AS RELATED TO HYDROCARBON STRUCTURE AND ENGINE KNOCK, by C. E. Boord, K. W. Greenlee, and J. M. Derfer. [Apr. 1951] 25p. incl. tables, refs. (AF 33(038)22959) Unclassified

Presented at Symposium on Combustion Chemistry at the 119th meeting of the Amer. Chem. Soc., Cleveland, Ohio, Apr. 1951.

The free-radical chain-reaction mechanism for the oxidation of hydrocarbons is outlined in detail. The point of attack is through the H atoms of the hydrocarbon. The initiation is assumed to involve all types of H (primary, secondary, and tertiary) in the order of their numbers and relative reactivities. The propagation phase involves a complex sequence of step-wise reactions. The termination phase functions in the same manner as in other chain reactions. The 3 factors which unite to determine the velocity of the combustion and hence the critical compression ratio are the initiation rate, the very high free-radical formation in the propagation phase, and the peroxidation of tertiary free-radicals. On the basis of the reaction mechanism described, the following points are explained: (1) high critical compression ratios for paraffin gases, (2) low critical compression ratios for the higher normal paraffins, (3) the high values for highly branched paraffins, (4) the fall of critical compression ratio with increase in intake manifold temperature, (5) the basis for dual-fuel ignition in the gas-diesel engine, (6) the basis for rich-mixture performance, (7) high critical compression ratios for aromatic hydrocarbons, and (8) the high blending octane numbers of mono-olefins.

OSU. 02:002

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

ISOLATION OF ALKYL HYDROPEROXIDES FROM

COMBUSTION REACTIONS OF HYDROCARBONS (Abstract), by E. W. Malmberg, D. L. Fishel and others. [1953] [2]p. [AF 33(038)22959] Unclassified

Presented at meeting of the Amer. Chem. Soc., Los Angeles, Calif., Mar. 15-19, 1953.

Published in 123rd meeting of the Amer. Chem. Soc. Abstracts of Papers, 1953, p. 52-M-53-M.

Alkyl hydroperoxides play an important role in the generally accepted mechanism of noncatalytic oxidation of hydrocarbons; to date no proof of the presence of these intermediates has been reported. In the present investigation, chromatographic and other chemical studies have been made on known organic peroxy compounds which may occur in combustion products of hydrocarbons; these classes include alkyl hydroperoxides, carbonylhydrogen peroxide addition products, and percarboxylic acids. These methods were applied to the study of intermediates isolated from the reactions which occur in a hydrocarbon-air mixture when subjected to the compression stroke of a motored engine, in a turbulent flame, and in a heated tube. When iso-octane was used as a fuel in the engine experiments, four major chromatographic zones were obtained from the condensate; their chromatographic properties and other chemical data gave a preliminary identification as alkyl hydroperoxides. This conclusion was confirmed by comparing the polarographic properties of known peroxides and these zones. Carbonylperoxide addition compounds and percarboxylic acids were eliminated as possibilities; the peroxides from iso-octane all showed the half-wave reduction potential which is uniquely characteristic of alkyl hydroperoxides. Characteristic alkyl hydroperoxide zones were also obtained from other engine samples, the turbulent flame, and the heated tube reaction. (Contractor's abstract)

OSU. 02:003

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

A CHROMATOGRAPHIC STUDY OF CARBONYL COMPOUNDS PRESENT IN A HYDROCARBON-AIR FLAME, by E. W. Malmberg. June 30, 1953 [4]p. incl. tables, refs. [Technical rept. no. 7] (AF 33(038)22959) Unclassified

Presented at meeting of the Organic Div. of the Amer. Chem. Soc., Atlantic City, N. J., Sept. 1952.

Published in Jour. Amer. Chem. Soc., v. 76: 980-983, Feb. 20, 1954.

A study has been made of the carbonyl compounds which are present in a hydrocarbon-air flame. The experimental methods included formation and chromatographic separation of the 2,4-dinitrophenylhydrazone derivatives. In addition to the carbonyl compounds which are to be expected in the light of presently accepted mechanisms, a number of synthesis products were obtained, compounds in which the length of the carbon chain was increased. These results are interpreted in terms of the free radicals which must have been present, including the formyl radical. Three products, glyoxal, methylglyoxal, and formaldehyde, were found to be common to 18 hydrocarbon fuels. Quantitative analysis for these products showed no correlation with the type of fuel. This fact seems to indicate that the differences in the burning characteristics of hydrocarbons lie in the earlier stages of the combusion. (Contractor's abstract)

OSU. 02:004

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

KINETICS OF OXYGEN UPTAKE BY CYCLOHEXENE IN THE LIQUID PHASE, by A. T. Touma and F. H. Verhoek. [1954] 5p. incl. diagrs. tables. [AFOSR-TN-54-73] (AF 33(038)22959) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 741-745.

The oxidation rate of cyclohexene, both as a pure liquid and in benzene, in contact with oxygen-enriched air is studied. Since Pyrex surfaces affected the oxidation rate, the experiments were conducted in Teflon-lined containers over a temperature range of 15°-40°C. The data show that the oxidation of liquid cyclohexene is accounted for satisfactorily by the mechanism of Bolland and Gee (Trans. Faraday Soc., v. 42: 236, 1936), with second-order hydroperoxide decomposition as the initiating step.

OSU. 02:005

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

STUDY OF THE OXIDATION OF HYDROCARBONS, by J. M. Derfer, K. W. Greenlee, and C. E. Boord. Final rept. Apr 12, 1951-Sept. 15, 1953. Nov. 12, 1954. 31p. incl. tables, refs. [AFOSR-TR-54-34] (AF 33(038)22959; continued by AF 18(600)787) AD 50173 Unclassified

The following investigations which were conducted under this research task are described briefly: synthesis of hydrocarbons, hydroperoxides, and intermediates; study of microdistillation apparatus and techniques; kinetics of oxygen uptake by cyclohexene in the liquid phase; oxidation of pentane; the cool-flame oxidation of normal hexane; initial studies of precombustion reactions; development of experimental procedures for sampling intermediate combustion products and a comparison of the intermediate-combustion products formed in an engine with and without ignition; spectroscopy; development of certain analytical methods and the application of the methods to the study of the oxidation of hydrocarbons; the investigation of carbonyl compounds: turbulent flame

OSU. 03:001 - OSU. 03:003

combustion (Jour. Amer. Chem. Soc., v. 76:980, 1954); the investigation of carbonyl compounds: preflame reactions in a test engine; development of methods for studying alkyl hydroperoxides and application to the study of oxidation; development of methods of analysis for alcohols; development of methods of analysis for higher olefins; liquid phase oxidation of ethylcyclohexane; polarographic studies of hydrocarbon oxidation products; and thermodynamic functions for some molecules occurring in flames.

OSU. 03:001

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

INVESTIGATION OF CARBONYL INTERMEDIATES IN THE PREFLAME REACTIONS IN AN ENGINE (Abstract), by E. W. Malmberg, J. A. Bobbitt and others. [1953] [1]p. [AF 18(600)787; continuation of AF 33(038)22959] Unclassified

Presented at meeting of the Amer. Chem. Soc., Chicago, Ill., Sept. 6-11, 1953.

Published in 124th meeting of the Amer. Chem. Soc. Abstracts of Papers, 1953, p. 39-O.

The carbonyl compounds which form in the well-known preflame reactions, reactions which occur in a hydrocarbon-air mixture upon adiabatic compression in an engine cylinder, have been studied with n-heptane, n-pentane, propane, and propene. The compounds were isolated as dinitrophenylhydrazones and these products were studied qualitatively and quantitatively by application of chromatographic methods. Samples were collected from the exhaust and from the cylinder at various times during the compression by means of a Cox valve. Studies were made both with the engine driven by an electric motor and with spark ignition. Qualitatively, the carbonyl products which are formed are in accord with the reaction mechanism based upon formation and decomposition of alkyl hydroperoxides. Quantitative analyses were made for known components which accounted for 80 to 85% of the total yield of hydrazones. The quantitative results are valuable because they indicate the relative importance of several alternate paths of reaction, and because they have justified certain procedures in the use of the engine. One of these results is a very good indication that the results from a motored engine without autoignition are closely comparable to the results when spark ignition is used. (Contractor's abstract)

OSU. 03:002

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

LIQUID PHASE OXIDATION OF ETHYLCYCLOHEXANE BY MOLECULAR OXYGEN (Abstract), by J. Hoffman and C. E. Boord. [1953] [1]p. [AF 18(600)787) Unclassified

Presented at meeting of the Amer. Chem. Soc., Chicago, Ill., Sept. 6-11, 1953.

Published in 124th meeting of the Amer. Chem. Soc. Abstracts of Papers, 1953, p. 34-O.

The oxidation of ethylcyclohexane by molecular oxygen at 120°C and atmospheric pressure has been studied. Runs were made for periods of 24, 48, and 100 hours by slowly bubbling oxygen into the hydrocarbon. A yield of 4 to 6% of hydroperoxides at 48 hours was obtained. This appeared to be a mixture of secondary and tertiary hydroperoxides as evidenced by decomposition products. At the end of 24 hours, ketones were already present in appreciable amount as well as small amounts of fatty acids. At the end of about 30 hours carbon dioxide and acetaldehyde were noted in the effluent gases. A hydroperoxide concentrate of better than 98% purity was obtained through distillation and sodium salt formation. This appeared to be mostly a mixture of secondary hydroperoxides. Upon distillation of a 24-hour sample evidence was found for the presence of cyclohexanone, methylcyclohexyl ketone, and ethylcyclohexanone(s). A 100-hour sample was heated at 120°C in the absence of oxygen until all the hydroperoxide had decomposed. A good yield (based on hydroperoxide) of methylcyclohexyl ketone and ethylcyclohexanone(s) was obtained. The hydroperoxides from a 24 hour sample were decomposed with 70% sulfuric acid. Cyclohexanone, methylcyclohexyl ketone, and ethylcyclohexanone(s) were found among the decomposition products. Water extraction of a 24-hour sample afforded a keto acid which appeared to be mostly α-ketocyclohexyl acetic acid. Further extraction with aqueous sodium carbonate gave a small amount of a mixture of several fatty acids of variable and unknown composition. (Contractor's abstract)

OSU. 03:003

Ohio State U. [Research Foundation] Dept. of Chemistry, Columbus.

HOW DO MOTOR-FUELS BURN? by C. E. Boord. Oct. 27, 1953, 19p. incl. diagrs. refs. [AF 18(600)787)] Unclassified

Published in O. S. U. Engineering Experiment Station News, v. 25: 9-16, 1953.

The theories of hydrocarbon oxidation are reviewed, and supporting evidence is presented to show why various hydrocarbons behave differently when used as fuels in internal combustion engines. The oxidation, although initially involving peroxidation, actually proceeds by different steps in each case. The reactions proceed each at its own characteristic rate and produce different intermediate products. Combustion velocities are dependent upon the structure of the hydrocarbon and the engine conditions. Studies involving every phase of the problem from room temperature oxidation to the most severe engine conditions gave strong support to the peroxidation theory. Oxidation products were identified by chromatographic, polarographic, and infrared spectrometric techniques. The characteristic differences of typical hydrocarbon structures have not been determined.

OSU. 03:004

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

COMPARISON OF INTERMEDIATE-COMBUSTION PRODUCTS FORMED IN ENGINE WITH AND WITHOUT IGNITION, by W. C. Davis, M. L. Smith and others. Jan. 14, 1954 [10]p. incl diagrs. [AFOSR-TN-54-20] [AF 18(600)787] Unclassified

Presented at annual meeting of the Soc. of Automotive Engineers, Detroit, Mich., Jan. 11-15, 1954.

Published in SAE Trans., v. 63: 387-395, 1955.

Engine combustion tests were conducted on a modified Coordinating Fuel Research (CFR) Engine, type F4, of the single-cylinder, variable compression ratio design. Precombustion reactions in the motored, nonfiring engine produced the same carbonyl compounds as the firing engine. The carbonyls from gas samples withdrawn at various crank angles were absorbed in 2,4-dinitrophenylhydrazine-HCL, and identified by chromatography. The yield of total carbonyl /° of crank angle was constant to -20°, then increased sharply across the top center to a maximum at +10°. With pentane fuel, the carbonyls sampled were formaldehyde and acetaldehyde, 60 - 70%; propionaldehyde, acrolein, and crotonaldehyde, 10 - 20%, the balance being unidentified. Heptane gave formaldehyde and acetaldehyde, each in yields of 20 - 30%, the balance being unidentified. Isooctane gave formaldehyde 30 - 40%, isobutryaldehyde 15%, actaldehyde and acetone, each in yields of 5 - 10%, the balance being unidentified. It was noted in the discussion that a motored engine should operate at higher rpm than a fired engine for comparable data, and that there is no correlation between carbonyl yield and knock.

OSU. 03:005

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

POLAROGRAPHIC STUDY OF COOL-FLAME OXIDATION PRODUCTS OF HYDROCARBONS, by W. M. MacNevin, P. F. Urone, and others. [1954] 4p. incl. diagrs. tables. [AFOSR-TN-54-72] [AF 18(600)787] Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 402-405.

The use of polarography is considered in this combustion study of oxidation products of n-hexane, 2-methylpentane, 3-methylpentane, and 2,2-dimethylbutane obtained from cool-flame oxidation experiments. From experimental analyses conducted, it was concluded that the polarographic method described provides a relatively rapid procedure for the measurement of some of the oxidation products of the cool-flame combustion of these hydrocarbons. It allows the measurement of 10^{-5} to 10^{-6} mole of reducible substance to be made; however, it is reliable only in that the identification of the constituents in totally unknown samples should be further verified with chromatographic, infrared, or other procedures of chemical identification.

OSU. 03:006

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

A STUDY OF COOL FLAMES AND ASSOCIATED REACTIONS IN AN ENGINE, by E. W. Malmberg, M. L. Smith and others. [1954] 8p. incl. diagrs. tables, refs. [AFOSR-TN-54-75] [AF 18(600)787] Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 385-392.

It has been found that the cool flame does not form in one section of the engine cylinder and move relatively slowly across the combustion chamber as does the normal hot flame. n-C_7H_{16}, n-C_5H_{12}, and isooctane were studied, and it was observed that with each of these compounds, the cool flame persists for about 30°-40° of crank angle. For the n-paraffins, the cool flame results at the same point in the cycle for both stoichiometric and lean mixtures. With rich mixtures, each event shifts to a point later in the cycle. With isooctane as the fuel, the appearance is at the same time, regardless of the mixture strength, the peak intensity is greater with rich mixtures, and the point of peak intensity occurs earlier in the cycle; however, for the n-paraffins, the peak intensity appears with approximately stoichiometric mixtures. The peak intensities of the n-paraffins are about 5-10 times those of isooctane. Evidently the point in the cycle at which the cool flame appears is influenced more by the temperature and pressure in the cylinder than by the structure of the fuel molecule. The rise in carbonyl compounds in the cool-flame reaction parallels the integrated amount of light produced. The chemical study of preflame-reaction product is in agreement with peroxide mechanism of oxidation, with, however, attack occuring primarily at the secondary H atoms. The presence of acrolein and crotonal as primary cool flame products may be explained by means of an intramolecular free radical reaction. This explanation focusses attention on the possible importance of intramolecular attack in oxidation.

OSU. 03:007

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

COMPARISON OF CARBONYL PRODUCTS FROM COOL-FLAME REACTIONS IN A TUBE AND IN AN ENGINE, by E. W. Malmberg. [1955] [6]p. incl. tables [AFOSR-TN-55-22] [AF 18(600)787] Unclassified

OSU. 03:008 - OSU. 03:010

Published in Amer. Chem. Soc., Div. Petrol. Chem., General Papers, no. 33: 241-246, Apr. 1955.

The carbonyl yields in the products from cool-flame reactions in flowing systems at atmospheric pressure and in "adiabatically" compressed hydrocarbon-air mixtures in a motored or fired engine were determined qualitatively and quantitatively for the following fuels: diethyl ether; pentane; hexane; heptane; 2-methylpentane; 3-methylpentane; 2, 2-dimethylbutane; and cyclohexane. The carbonyl compounds produced in the stabilized cool flame and the cool-flame reaction in an engine are the same, but are produced in different ratios. The relative importance of the various reactions is probably in agreement with the changes to be predicted from a consideration of the pressure change and the molecularity.

OSU. 03:008

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

SEPARATION OF HYDROGEN PEROXIDE FROM ORGANIC HYDROPEROXIDES. APPLICATION TO POLAROGRAPHIC ANALYSIS OF MIXTURES, by W. M. MacNevin and P. F. Urone. Feb. 2, 1953 [2]p. incl. diagrs. table. [AFOSR-TN-55-23] [AF 18(600)787] Unclassified

Presented at meeting of the Analytical Div. of the Amer. Chem. Soc., Spring, 1955.

Published in Anal. Chem., v. 25: 1760-1761, Nov. 1955.

The polarographic wave for H_2O_2 can be eliminated by complexing it with Ti(IV) ion, added as TiO_2 dissolved in N HCl, followed by precipitation of the complex with NH_4OH. The decrease in wave height before and after complexing allows H_2O_2 and hydroperoxide to be determined. Mixtures of H_2O_2 and 3-pentyl, tert-butyl, 3-cyclohexenyl, cyclohexyl, and 2, 5, 5-trimethyl-2-hexyl hydroperoxide have been analyzed with success. Concentrations studied were of the order of 10^{-4} M in the solutions measured polarographically.

OSU. 03:009

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

PREPARATION OF SOME SUBSTITUTED ALLYL HYDROPEROXIDES FROM BROMIDES, by J. Hoffman. [1955] [2]p. incl. tables. (AFOSR-TN-55-24) (AF 18(600)787) Unclassified

Presented at meeting of the Organic Div. of the Amer. Chem. Soc., Spring 1955.

Also published in Jour. Org. Chem., v. 22: 1747-1748, Dec. 1957.

Substituted allyl hydroperoxides may be prepared from substituted allyl bromides, which can be obtained by reaction of the appropriate olefin with N-bromosuccinimide and treatment of these bromides with potassium hydroxide-hydrogen peroxide in an aqueous methanol medium at room temperature. Alpha- and β-diisobutylene hydroperoxides were prepared by this procedure: 2-neopentylallyl hydroperoxide from 2, 4, 4-trimethyl-1-pentene and 2, 4, 4, -trimethyl-2-pentenyl hydroperoxide from 2, 4, 4-trimethyl-2-pentene; 2-t-butylallyl hydroperoxide was likewise prepared from 2, 3, 3-trimethyl-1-butene. Evidence was obtained in the bromination of 2, 4, 4-trimethyl-2-pentene for a 85-90% double-bond shift to the α-position with attachment of the bromine to the neopentyl carbon atom as indicated by comparison of infrared spectrograms of the bromide and the α- and β-diisobutylene. During the reaction of this bromide with alkaline hydrogen peroxide, a shift of the double bond back to the β position yielded mainly β-diisobutylene hydroperoxide. The infrared spectrogram of the bromination product of 2, 4, 4-trimethyl-1-pentene indicated little if any double-bond rearrangement. This bromide on reaction with alkaline hydrogen peroxide gave α-diisobutylene hydroperoxide. Further evidence for the position of the double bonds in these two hydroperoxides is given.

OSU. 03:010

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

THE COOL-FLAME COMBUSTION OF THE ISOMERIC HEXANES, by P. E. Oberdorfer and C. E. Boord. [1955] [3]p. incl. tables. [AFOSR-TN-55-263] [AF 18(600)787] Unclassified

Presented at meeting of the Petroleum Div. of the Amer. Chem. Soc., Minneapolis, Minn., Sept. 11-16, 1955.

Published in Amer. Chem. Soc., Div. Petrol. Chem., General Papers, no. 34. 183-185, Sept. 1955.

The differences in the cool-flame combustion of the isomeric hexanes are particularly significant in view of the known differences of their engine behavior. Cool-flame combustion occurs in the upper range of low temperature oxidation. It is pointed out that alkylhydroperoxides, aldehydes, and olefins are almost certainly precursors of gum formation. When cool-flame combustion of hexane is permitted to operate for a few hr without cessation, a sticky, brownish gummy substance is deposited which becomes a varnish-like resin after a few hr. This substance is very similar to the uncharred residues found on the inner walls of the intake manifold, piston, and entry port of an engine. Tests were conducted using hexane, 2-methylpentane, 3-methylpentane, and 2, 2-dimethylbutane. Data are presented showing initial tube temperatures, maximum temperatures, and ΔT (maximum temperature - tube temperature). Also included are the carbon balances between the intermediate combustion products and hexane.

OSU. 03:011

Ohio State U. [Research Foundation]. Dept. of Chemistry, Columbus.

SYNTHESIS OF HYDROPEROXIDES FROM AROMATIC ALCOHOLS AND FROM PHENYLOLEFINS (Abstract), by A. D. Boggs and C. E. Boord. Aug. 26, 1955 [1]p. [AFOSR-TN-55-284] (AF 18(600)787) Unclassified

Presented at 128th meeting of the Organic Div. of the Amer. Chem. Soc., Minneapolis, Minn., Sept. 11-16, 1955.

Hydroperoxides were prepared by reacting a C_6H_6 solution of a primary, secondary, or tertiary aromatic alcohol or a conjugated arylolefin with an aqueous solution of H_2O_2 and H_2SO_4. The hydroperoxide concentrate obtained was purified by a combination of salt formation and distillation. Some of the hydroperoxides prepared and purities obtained were α-methylbenzyl (99.9%), 1, 2, 3, 4-tetrahydro-1-naphthyl (100%), p-methoxybenzyl (69%), α, α-dimethylbenzyl (97%), 1, 1-diphenylmethyl (100%), p-methylbenzyl (94%), α-ethyl-p-methylbenzyl (90%), 1, 2-diphenylethyl (97%), and benzyl (87%).

OSU. 03:012

Ohio State U. [Research Foundation]. Dept. of Chemistry, Columbus.

STUDIES OF THE FORMATION AND PROPERTIES OF THE 2, 4-DINITROBENZENESULFENYL CHLORIDE ADDUCTS OF OLEFINS, by E. W. Malmberg and F. G. H. Lee. Aug. 26, 1955. 10p. incl. tables. [AFOSR-TN-55-285] (AF 18(600)787) Unclassified

Presented at 128th meeting of the Organic Div. of the Amer. Chem. Soc., Minneapolis, Minn., Sept. 11-16, 1955.

Test results pertaining to the formation and properties of the 2, 4-dinitrobenzenesulfenyl chloride adducts of olefins are described in the following topics: (1) study of the reaction of the formation of the adducts, (2) the chromatographic properties, (3) absorption spectra, (4) methods for detecting trace amounts of the olefins, and (5) a study of oxidation products.

OSU. 03:013

Ohio State U. [Research Foundation]. [Dept. of Chemistry] Columbus.

A NEW SYNTHESIS OF NEOPENTYL ALCOHOL, by J. Hoffman and C. E. Boord. [1955] [2]p. incl. refs. [AF 18(600)787] Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 3139-3140, June 5, 1955.

H_2O_2 (30%) (160 g) treated with vigorous stirring below 25° with 350 g cold 95% H_2SO_4, the mixture treated during 1 hr with 112.2 g diisobutylene at 6-8°, stirred 2 hrs (the temperature has to be kept below 25° to avoid an uncontrollable reaction), and filtered with suction through a sintered-glass funnel, the lower acid layer poured onto 100 g crushed ice and 350 cc H_2O, the organic layer (70 g) separated, the aqueous layer diluted with an equal volume of saturated aqueous $(NH_4)_2SO_4$ and extracted with Et_2O, the combined oily layer and Et_2O extract washed with aqueous Na_2CO_3, dried, and evaporated, the residual crude Me_3CCH_2OH (I) fractionated, and the distillate (37. 0 g), boiling at 110-111° redistilled and a heart-cut twice sublimed at 0. 5 mm gave pure I, melting at 54. 5-55. 5°; the organic layer (10. 5 g) remaining from the original mixture and containing mostly diisobutylene washed with aqueous Na_2CO_3, dried, and distilled to remove the olefin, and the residue treated with 2, 4-$(C_2N)_2C_6H_3$-$NHNH_2$ gave the derivative of Me_3CCH_2AC, melting at 100. 5-101. 5°. The crystalline Me_2CO peroxide (27. 2 g) filtered from the mixture was washed with H_2O, a small amount of EtOH, and C_6H_6, and then sublimed in vacuo at room temperature gave pure crystalline material, melting at 132-133°. (C. A., 1956:24131)

OSU. 03:014

Ohio State U. [Research Foundation]. Dept. of Chemistry, Columbus.

PREFLAME REACTIONS OF BLENDS OF HYDROCARBONS IN A MOTORED ENGINE, by E. W. Malmberg, M. L. Smith and others. [1956] [7]p. [Technical rept. no. 12] [AFOSR-TN-56-29] [AF 18(600)787] Unclassified

Presented at meeting of the Petroleum Div. of the Amer. Chem. Soc., Spring, 1956.

Published in Amer. Chem. Soc., Div. Petrol. Chem., General Papers, v. 1: 135-141, 1956.

MLCR (motored limited compression ratio) was found to be linearly related to PN (performance no.) up to 100 PN. MLCR is inversely related to the carbonyl yield for pure hydrocarbons. Blends of heptane with isooctane, cyclohexane, and diisobutylene, and blends of pentane with 2-methylpentane, cyclohexane, and isopropyl benzene were tested. (C. A., 1958:8527h)

OSU. 03:015

Ohio State U. [Research Foundation]. [Dept. of Chemistry] Columbus.

COOL FLAMES AND THE ORGANIC REACTION MECHANISMS INVOLVED IN THEIR FORMATION (Abstract), by C. E. Boord. [1956] [2]p. [AFOSR-TN-56-63] [AF 18(600)787] AD 81055 Unclassified

Presented at meeting of the Amer. Chem. Soc., Dallas, Texas, Apr. 8-13, 1956.

OSU. 03:016 - OSU. 03:018

Published in 129th meeting of the Amer. Chem. Soc. Abstracts of Papers, 1956, p. 1-G-2-G.

In the oxidation of hydrocarbons the substitution product is an alkyl hydroperoxide. The mechanism is rendered more complex by virtue of the fact that oxygen is divalent. When the alkyl hydroperoxide has been fully formed, only one half of the oxidizing power of the oxygen has been utilized. Alkyl hydroperoxides are therefore unstable, the stability being dependent upon the structure. Tertiary hydroperoxides are the most and primary hydroperoxides the least stable. The degradation reaction, which is essentially a second stage in the oxidation, may be either intra or intermolecular. By the same token the degradation may be either mono- or bimolecular. The rate of degradation is a function of the temperature and is readily subject to catalysis. Free radicals move in the direction of greater stability. Frequently this results in a dismutation reaction which stabilizes a portion of the molecule and produces a smaller free radical. The "stabilized cool flame" tube of Barusch and Payne, as modified by Oberdorfer, and the motored engine provide effective techniques for separating the primary combustion products. Chromatography, polarography, and spectroscopy provide excellent techniques for the analysis of such products. These techniques, when they have been perfected, offer strong promise of making it possible to follow the course of the combustion, step by step, from the hydrocarbon to carbon dioxide and water. (Contractor's abstract, modified)

OSU. 03:016

Ohio State U. [Research Foundation]. Dept. of Chemistry, Columbus.

RELATIONSHIP OF COOL-FLAMES AND ENGINE PERFORMANCE OF HYDROCARBONS, by C. E. Boord. [1956] 21p. incl. diagrs. tables, refs. (AFOSR-TN-56-187) (AF 18(600)787) AD 87060 Unclassified

Cool-flame studies were made of the isomeric hexanes. Each hydrocarbon was characterized by a minimum tube temperature at which a cool-flame formed, and by a maximum or peak flame temperature characteristic of each hydrocarbon at its minimum tube temperature. The difference between these 2 temperatures was designated as the temperature differential Δt. These temperature intervals stand in an inverse relationship to the knock resistance of the hydrocarbons. Both the temperature interval (Δt) and the performance numbers vary inversely as the number of methylene groups. Cool-flame engine studies showed that precombustion products from a motored engine operating without ignition were identical in kind with those obtained from the same engine with spark ignition, but with approximately 10° lag in crank angle. Test results indicated that synergistic mixtures gave low carbonyl yields, and antagonistic ones produced high carbonyl yields. A theoretical discussion of the mechanism by which hydrocarbons burn, and the oxidation of n-hexane by the intermolecular path are given.

OSU. 03:017

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

THE AUTOXIDATION OF ETHYLCYCLOHEXANE, by J. Hoffman and C. E. Boord. May 3, 1956 [2]p. [AFOSR-TN-56-196] (AF 18(600)787) AD 87069 Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 4973-4974, Oct. 5, 1956.

A study of the liquid phase oxidation of ethylcyclohexane by molecular oxygen at 120°C was made to determine whether all ring hydrogens are reactive and to what degree. Oxidative attack was discovered to be general for all ring hydrogens, as well as the side-chain secondaries. Most reactive of all was the tertiary hydrogen. The secondary ring hydrogens appeared to be somewhat less reactive than the secondary side-chain hydrogens. The least reactive (most inert) were those ring hydrogens farthest from the ethyl group.

OSU. 03:018

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

STUDIES ON THE GAS PHASE OXIDATION OF CYCLOHEXENE, by G. H. Hembree and F. H. Verhoek. May 1956, 8p. incl. diagrs. tables. (Technical note no. 1) (AFOSR-TN-56-298) (AF 18(600)787) AD 90010 Unclassified

The gas phase reaction of cyclohexene and oxygen was studied in a static system to determine the rate-reaction effect of the following: (1) changes in oxygen pressure at constant cyclohexene pressure, cyclohexene pressure at constant oxygen pressure, the ratio of reactant pressures at constant total pressure, and temperature, and (2) added inert gas. In all reactions of cyclohexene with an equal amount (pressure) or an excess of oxygen, the pressure decreased slowly to a minimum then rose rapidly at an accelerating rate, passed through a maximum rate, and then increased slowly to a steady value. The reaction of a 7:1 oxygen: hydrocarbon mixture at 250°C in a 100 cc flask caused the pressure to rise rapidly after passing through the minimum; the total change in pressure was more than twice as great as that in the slower reaction; this was indicated as a "cool flame" reaction. The addition of N to a cyclohexene-oxygen reaction mixture did not affect the induction period; the total pressure change and maximum rate increased only slightly above that for a similar reaction without N. When varying reactant pressure ratios at a total pressure of 200 mm and 250°C, the maximum rate, the reciprocal of the induction period, and the total change in pressure showed a maxima in the vicinity of the 3:1 oxygen: cyclohexene mixture.

OSU. 03:019

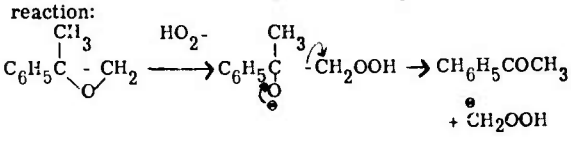
Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

OXIDATIVE STUDIES ON α-METHYLSTYRENE (Abstract), by J. Hoffman. [1956] [1]p. [AF 18(600)787] Unclassified

Presented at meeting of the Amer. Chem. Soc., Atlantic City, N. J., Sept. 16-21, 1956.

Published in 130th meeting of the Amer. Chem. Soc. Abstracts of Papers, 1956, p. 16-O.

In the liquid phase oxidation of α-methylstyrene by molecular oxygen at 100° a large amount of acetophenone was obtained, along with a smaller amount of α-methylstyrene oxide. Chromatographic and polarographic evidence was found for even smaller amounts of α-methylstyrene hydroperoxide in the oxidate. When a sample of pure α-methylstyrene oxide was oxidized by molecular oxygen for 20 hours at 80°, an almost quantitative yield of acetophenone was obtained. A small quantity of a hydroperoxide was isolated from this oxidate by silicic acid chromatography. This material, upon further heating, yielded acetophenone. This indicates that a hydroperoxide derived from α-methylstyrene oxide is an intermediate in the oxidative degradation of the epoxide to acetophenone. Carbon to carbon double bond scission by molecular oxygen (at least in the case of α-methylstyrene) appears therefore to proceed through an epoxide and an epoxide-hydroperoxide; the latter being unstable decomposes to the final product (acetophenone). Evidence for a similar type of unstable intermediate hydroperoxide has been found in the reaction of α-methylstyrene oxide with alkaline hydrogen peroxide in 90% methanol at room temperature. An almost quantitative yield of acetophenone is obtained. This product is most readily explained by the following reaction:



Similarly, α-methylstyrene oxide is cleaved to acetophenone in good yield when refluxed for 48 hours with lithium chloride in acetone.

OSU. 04:001

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

THE CRYSTAL STRUCTURE OF ONE FORM OF TRINITROTOLUENE, by P. G. Taylor and P. M. Harris. July 20, 1954, 14p. incl. illus. tables. (Technical note no. 2) ([AF]OSR-TN-54-30) (AF 33(616)19) AD 43724 Unclassified

The space group symmetry P_{ba} and rough structure of one form of trinitrotoluene have been determined almost entirely from a three-dimensional "Patterson", or vector, map. The unit cell contains eight molecules of $CH_3C_6H_2(NO_2)_3$ in two sets of four each. The two sets are not symmetry connected. Fourier projections on (001), (010), and (100) have been computed. (Contractor's abstract)

OSU. 04:002

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

THE DERIVATION OF THE CRYSTAL STRUCTURE OF TRINITROTOLUENE FROM THE THREE-DIMENSIONAL PATTERSON (Abstract), by P. G. Taylor. [1954] [1]p. [AFOSR-TN-54-60] [AF 33(616)19] Unclassified

Published in Acta Crystallographica, v. 7: 650, Oct. 10, 1954.

Published in Third Congress of the International Union of Crystallography, Paris (France), July 21-28, 1954, p. 37.

Samples of 2:4:6 trinitrotoluene were found to crystallize from chloroform at room temperature in an orthorhombic cell of dimensions 14.85 Å, 19.78 Å, 5.96 Å, containing 8 molecules. The space group was indicated as either D_{2h}^{11} or C_{2v}^{5}. The Patterson synthesis was computed in 3 dimensions using Cu Kα diffraction data. From an examination of the Harker-type vectors, it could be deduced that noncentric space-group C_{2v}^{5} (Pba) was present. Certain features of the Patterson enabled the orientation and relative position of the 2 independent molecules to be deduced. The position of the carbon rings in the cell, and the positions of the remaining atoms were then arrived at by use of Patterson evidence assisted by trial and error work. Agreement of calculated and observed structure factors indicates that the structure is correct, but it cannot be determined with high accuracy until 3-dimensional refinement work is undertaken. Some interesting modifications in the bond lengths, notably those of the carbon ring, appear to be present. (Contractor's abstract)

OSU. 04:003

Ohio State U. Research Foundation. [Dept. of Chemistry] Columbus.

STRUCTURE DETERMINATION OF PICRYL CHLORIDE, by R. E. Gluyas and P. M. Harris. July 20, 1954 [11]p. incl. diagrs. table (Technical note no. 1) [AFOSR-TN-54-219] (AF 33(616)19) AD 43723 Unclassified

Picryl chloride has been found to have a monoclinic unit containing four molecules with space group symmetry of $P2_1/a$. Three dimensional "Patterson", or vector, maps have been calculated, leading to the orientation of a typical molecule. Parameters (x, z) have been determined, and the (010) projection has been

OSU. 04:004 - OSU. 05:003

prepared. Resolution is fairly good and the structure is being refined. (Contractor's abstract)

OSU. 04:004

Ohio State U. Research Foundation. Dept. of Chemistry, Columbus.

INVESTIGATION OF STRUCTURE OF CRYSTALS OF NITRO ORGANIC COMPOUNDS, by R. E. Gluyas and P. M. Harris. Final rept. Mar. 1955, 2p. [AFOSR-TR-55-8] (AF 33(616)19) AD 57441
Unclassified

A brief summary is given of the work conducted under contract AF 33(616)19 on the structures of crystalline aromatic vitro compounds. The structures of 2, 4, 6-trinitrotoluene (TNT), and of picryl chloride (TNBC1) have been studied, and an investigation of 1, 3, 5-trinitrobenzene (TNB) has been initiated. Results have been presented on the orthorhombic crystalline modification of TNT having the symmetry Pca and 8 stoichiometric mol/cell. Complete intensity data have been collected on orthorhombic trinitrobenzene, and coefficients for a 3-dimensional Patterson synthesis have been prepared. It is pointed out that TNB contains 16 mol/cell with the symmetry of Pbca. Structural data have also been presented for TNBCl. This crystal possesses a 4-mol monoclinic cell having a symmetry of P^21/a.

OSU. 05:001

Ohio State U. [Research Foundation]. [Dept. of Chemistry] Columbus.

THE LAUE-BRAGG SCATTERING AND CHARGE DISTRIBUTION IN LITHIUM METAL (Abstract), by P. L. Splitstone and P. M. Harris. [1955] [2]p. [AF 18(600)769] Unclassified

Presented at the 13th annual Pittsburgh Diffraction Conference, Nov. 3-4, 1955.

Using a Geiger-Müller x-ray spectrometer, measurements of the relative crystal structure factors have been made on small single crystals of metallic lithium at 300° and 100°K. These measurements were spread over some seven different crystals at each temperature. From the results the temperature coefficient of the scattering has been evaluated. Comparison of the form of the scattering factor of lithium as a function of $\frac{\sin\psi}{\lambda}$ with theoretical values from Löwdin's analytic wave function for the lithium ion and of McWeeny for the lithium ion and of McWeeny for the lithium atom is made. Löwdin's results have been used to put the "relative" experimental data on an absolute basis. As a further test direct comparison was made of two (different) lithium crystals with two (different) small spheres ground from rock salt (NaCl). The results are compared with measurements of James and Firth, Renniger, and Brill et al. Calculations of the charge density along the [100], [110], and [111] for the lattice at rest show no significant excess charge concentration between nearest neighbors at (000), (1/2 1/2 1/2) as is suggested by some theoretical models; rather, the best model appears to be one in which lithium ions are immersed in a continuous, uniform charge distribution provided by the valence electrons. The reproducibility of the single crystal measurements is shown by tabulated results. (Contractor's abstract)

OSU. 05:002

Ohio State U. [Research Foundation] [Dept. of Chemistry] Columbus.

THE TRANSFORMATION IN SILVER MERCURIC IODIDE AND THE STRUCTURE OF ONE LOW TEMPERATURE FORM (Abstract), by C. E. Olsen and P. M. Harris. [1955] [2]p. [AF 18(600)769]
Unclassified

Presented at the 13th annual Pittsburgh Diffraction Conference, Nov. 3-4, 1955.

Single crystals of Ag_2HgI_4 have been grown from solution and have been investigated using Weissenberg and precession x-ray diffraction photographs supplemented by spectrometer measurements. This work indicates that the crystal phase (B) grown from solution has a 2-molecule, body-centered tetragonal cell of symmetry $I\bar{4}$ (almost $I\bar{4}$ 2m). This cell has a_o - 6.32 A and c_o = 12.64 A. This cell differs in both symmetry and value of c_o from that reported by Ketelaar. Patterson sections disclose, in addition to Hg at 000; Ag at 1/2, 1/2, 0 and 1/2, 0, 1/4; I at 1/4, 1/4, 1/8; 3/4, 3/4, 1/8; 1/4, 3/4, 3/8; and 3/4, 1/4, 3/8 (all + 1/2, 1/2, 1/2), that there are additional vectors corresponding to silver in octahedral sites but displaced from the center of site. It is postulated that iodine vacancies exist due to replacement of HgI_2 by AgI. These provide a mechanism for this disorder. Density, composition and anomalous dielectric polarization of the crystal support this. Further, the phase produced by cooling the disordered high temperature (a) form through the transition temperature is an apparently cubic (B) phase having eight molecules per cell. Single crystals of Cu_2HgI_4 exhibit a one-molecule, tetragonal cell of symmetry P 4/n mc and dimensions: a_o = 4.29 A and c_o = 12.[illegible] A. This is different from the cell proposed by Ketelaar from powder measurements. (Contractor's abstract)

OSU. 05:003

Ohio State U. Research Foundation. Dept. of Chemistry, Columbus.

CHARGE DISTRIBUTION AND CHARACTERISTIC TEMPERATURE OF METALLIC LITHIUM FROM X-RAY SCATTERING AT 300° AND 100°K, by P. L. Splitstone and P. M. Harris. Apr. 1956, 25p. incl. illus. diagrs. tables, refs. (Technical rept. no. 1) (AFOSR-TN-56-235) (Sponsored jointly by Office of Naval Research under N6onr-22517 and Air Force Office of Scientific Research under AF 18(600)769) AD 88355
Unclassified

The Laue-Bragg scattering of single crystals of metallic Li has been measured at 100° and 300°K. These results were placed on an absolute basis by comparison with theoretical atomic form factors for the Li ion and also were compared experimentally with rock-salt. From these results, a characteristic temperature, Θ = 325°K, was derived. Electron density computations suggest no appreciable charge concentration between nearest neighbor atoms. According to the accuracy of the measurements, Li metal may be well represented by the simple model of Li ions immersed in a uniform charge distribution of the valence electrons. These results and the implications of the method of treatment are discussed. (Contractor s abstract)

OSU. 06:001

Ohio State U. Research Foundation. Dept. of Electrical Engineering, Columbus.

THE ANALYSIS AND DESIGN OF DENSE ELECTRON BEAMS, by R. P. Anand. Apr. 1955, 23p. incl. diagrs. refs. (Technical note no. 1) ([AF] OSR-TN-55-156) (AF 18(600)980) AD 68367 Unclassified

Problems associated with the design of high density and high perveance electron guns are discussed, and a number of important techniques for the analysis of such guns are briefly reviewed. Among analog methods, the modified electrolytic trough of Musson-Genon, the elastic membrane technique, and the resistor network are described. In the Musson-Genon method, the bottom of the trough is shaped in a special way to take care of space-charge distribution. Calculation of the shape of a 3-dimensional bottom requires extensive computations which have to be repeated a number of times to produce successively better results. The elastic membrane method is limited to 2-dimensional problems. The resistor-network method has been applied successively to solve partial differential equations like Laplace's and Poisson's, and the wave equations. Numerical methods such as relaxation and iteration procedures are discussed. (Contractor's abstract)

OSU. 06:002

Ohio State U. Research Foundation. Dept of Electrical Engineering, Columbus.

AN APPLICATION OF THE RELAXATION METHOD OF ANALYSIS TO THE HEIL ELECTRON GUN, by R. P. Anand. June 1955, 33p. incl. diagrs. tables, refs. (Technical note no. 2) ([AF]OSR-TN-55-250) (AF 18(600)980) AD 74186 Unclassified

The relaxation method was used to obtain an approximate solution of Poisson's equation in a 1/5-size Heil electron gun. A resistance-network analog performed most of the relaxation calculation automatically. The solution was carried to a second approximation. The current flow is not laminar, and the current density is very nonuniform near the nozzle. The first and second approximations agreed fairly well, except in the region near the anode. The trajectories had the same general features. The ones from the cathode edge were so convergent that they appeared to cross the axis; the results indicated the impossibility of determining the precise position of the trajectories, and the current-density distribution in the nozzle. To obtain a better approximation, a network is needed with a finer mesh. The use of a rectangular mesh in the nozzle region and a large number of net points across the beam (not so large as to become excessive) are suggested. The resistance network is capable of giving an accurate numerical solution of the problem in the area near the cathode. The main work involved in this method is that of obtaining the electron trajectories between successive field solutions. This is also the largest source of error. An investigation into the possibility of some kind of automatic trajectory plotter that could be used in conjunction with the network, is suggested.

OSU. 06:003

Ohio State U. Research Foundation. Dept. of Electrical Engineering, Columbus.

AN APPLICATION OF THE METHOD OF MUSSON-GENON TO THE HEIL ELECTRON GUN, by T. Kuwabara. Aug. 1955, 49p. incl. illus. diagrs. table, refs. (Technical note no. 3) ([AF]OSR-TN-55-419) (AF 18(600)980) AD 81377 Unclassified

The potential distribution and corresponding electron trajectories in the presence of space charge in the Heil electron gun were studied with the use of the method of Musson-Genon (Ann. Telecommunications, v. 2:298-320, Oct. 1947, and L'Onde Electrique, no. 255:236-242, June 1948). The method involves shaping the electrolytic field plotting tank in such a way as to account for the modification of Laplace's equation by the space charge. The potential distribution with space charge of the gun obtained by M. O. Thurston was used to calculate the depth of the bottom in order to eliminate several approximations. The total cathode emission and the transmission efficiency checked quite closely with experimentally determined values. There is no experimental verification available for the current distribution on paths of electrons.

OSU. 06:004

Ohio State U. Research Foundation. Dept. of Electrical Engineering, Columbus.

PINHOLE CAMERA GUN TESTER FOR INVESTIGATION OF ELECTRON BEAMS, by R. M. Campbell. Jan. 1956. 34p. incl. illus. diagrs. (Technical note no. 4) (AFOSR-TN-56-222) (AF 18(600)980) AD 88029 Unclassified

The object of this research was to find a means of making measurements on electron beams to determine whether or not the associated electron gun was performing as expected. From these measurements, it should be possible to determine what must be done in the electron gun to improve or modify the resulting electron

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beam. The method chosen to make these measurements resulted in the design and construction of a pinhole-camera type of gun tester. This type of gun tester is a beam sampling device in which small apertures are moved through the electron beam to determine the current-density distribution of electrons in the beam, and the transverse-velocity distribution of electrons at various points in the beam. Measurements made on a Heil electron gun demonstrated the usefulness of this type of gun tester. It was shown that measurements could be made on an electron gun for which no mathematical analysis was available, and that these measurements could be made relatively rapidly. (Contractor's abstract)

OSU. 07:001

Ohio State U. Research Foundation. Dept. of Electrical Engineering, Columbus.

A MAGNETICALLY FOCUSED RETARDING-FIELD OSCILLATOR OF THE BARKHAUSEN-KURZ TYPE, by M. Uenohara. Sept. 1954, 54p. incl. illus. diagrs. refs. (Technical rept. no. 1) ([AF]OSR-TN-54-330) (AF 18(600)982) AD 50172 Unclassified

An oscillator employing a magnetically focussed electron stream traveling in an electric field resulting from a parabolic potential distribution can be operated as a Barkhausen-Kurz type of oscillator. Electrons perform simple harmonic oscillations across the gap of a cavity resonator. Insofar as an accurate parabolic potential distribution is achieved, the oscillation frequency of the electrons is independent of their amplitudes and they therefore remain in proper phase with the electric field of the resonator and continue to give up energy to that field at successive transits. A preliminary theory of the electronic energy interchange of this oscillator is provided, and the background theory of the oscillator design is discussed. Expressions for electronic admittance, conversion efficiency, starting current, and frequency dependence on accelerating potential have been derived and are in substantial agreement with experimental results. A maximum output power of 1.8 watts has been obtained at 8320 mc with 5.5% efficiency. A maximum efficiency of 13.5% has been obtained at 8400 mc with an output power of 170 milliwatts. Beam starting currents as low as 0.1 ma have been observed at 9800 mc. Tuning over the range 8300 mc to 10,400 mc has been accomplished by varying the position of a movable short in the waveguide. The oscillation frequency of the oscillator can also be adjusted by varying the resonator voltage, and the frequency so controlled is proportional to the square root of the resonator voltage. (Contractor's abstract)

OSU. 07:002

Ohio State U. Research Foundation. [Dept. of Electrical Engineering] Columbus.

A CENTIMETER-WAVELENGTH OSCILLATOR OF THE BARKHAUSEN TYPE, by D. T. Davis. June 1955, 41p. incl. diagrs. refs. (Technical note no. 2) ([AF]OSR-TN-55-251) (AF 18(600)982) AD 69847 Unclassified

A tube employing simple harmonic electron motion across the interaction gap of a resonant cavity can be operated as a Barkhausen-Kurz oscillator. The d-c potential distribution in which the electrons move is parabolic, and a magnetic field is used to focus the electron beam. A tube utilizing this oscillation mechanism and having symmetry with respect to the axis of the electron beam has been tested. Severe ion bombardment of the cathode occurred, but the effects were minimized by use of a nickel matrix cathode. A maximum efficiency of 7% at 180 mw and a maximum output power of 400 mw at 1.13% efficiency were obtained at 3 cm. Starting currents of less than 0.2 ma have been observed. These results indicate the possibility of developing a highpower, high-efficiency tube if the proper electrode geometry and circuit can be obtained. (Contractor's abstract)

OSU. 07:003

Ohio State U. Research Foundation. [Dept. of Electrical Engineering] Columbus.

THEORETICAL AND EXPERIMENTAL STUDY ON THE MILLIMETER-WAVE CAVITY BARKHAUSEN-KURZ OSCILLATOR, by M. Uenohara. Aug. 1956, 214p. incl. diagrs. tables, refs. (Technical rept. no. 3) (AFOSR-TN-56-530) (AF 18(600)982) AD 110349 Unclassified

A higher efficiency, a wider electronic tuning range, and a low starting current are the important characteristics of the magnetically-focused Barkhausen-Kurz oscillator. A theoretical and experimental study on the magnetically focused, Barkhausen-Kurz oscillator has been conducted for the purpose of determining its potentialities as a millimeter-wave generator. A section of the report contains a theoretical discussion of the operation of this device ranging from a simple small-signal theory to a large-signal theory under the general high-frequency field distribution in the interaction space. A planar type 3-cm oscillator, 1-cm oscillator, 6-mm oscillator, and an axially symmetrical 3-cm oscillator were constructed. A maximum oscillation frequency of 48,387 mc was obtained. The experimental results are also discussed in detail. The theoretical results are in substantial agreement with experimental results. (Contractor's abstract, modified)

OSU. 08:001

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

ZEEMAN SPLITTING OF NUCLEAR QUADRUPOLE RESONANCE LINES, by Y. Ting, E. Manring, and D. Williams. [Oct. 21, 1953] 2p. [AF 18(600)772] Unclassified

Also published in Phys. Rev., v. 92: 1581, Dec. 15, 1953.

The Zeeman splitting of Cl^{35} nuclear quadrupole resonance lines in a crystal of sodium chlorate has been observed in external magnetic fields in the range from 0 to 8000 gauss. Theory predicts that at one orientation, in which the 111 plane is normal to the magnetic field there should be 2 symmetrical Zeeman components whose frequency separation from the parent line is strictly proportional to the applied field's strength. In this study, the separation between Zeeman components is approximately 20% of the frequency of the zero-field line at the highest fields employed (8000 gauss). The experimental results show that the splitting is indeed directly proportional to the applied field.

OSU. 08:002

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

INTENSITIES OF THE ZEEMAN COMPONENTS OF QUADRUPOLE TRANSITIONS IN SODIUM CHLORATE, by Y. Ting and D. Williams. [1954] [1]p. [AFOSR-TN-54-33] (AF 18(600)772) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29, 1954.

Also published in Bull. Amer. Phys. Soc., v. 29: 19, Apr. 20, 1954.

Also published in Phys. Rev., v. 95: 607, July 15, 1954.

The Zeeman pattern of the Cl^{35} nuclear quadrupole transition in a single crystal of sodium chlorate has been studied in a field of 6000 gauss. The shifts of the observed lines from the zero-field frequency for various orientations of the crystal in the external field were in close agreement with theoretical predictions. At orientations in which the angle between I direction and the direction of H field approached 90°, rapid changes in the intensities of the observed components were noted. Two of the 4 Zeeman components diminished in intensity, disappearing at 90°. The other Zeeman components increased in intensity, reaching a maximum at 90°. The transformation matrix, which diagonalizes the total Hamiltonian at this orientation (with zero electric field asymmetry factor), can be obtained in closed form. The calculated probability of magnetic dipole transitions shows that the disappearance of the components in question is to be expected.

OSU. 08:003

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

ZEEMAN EFFECTS IN THE CHLORINE NUCLEAR QUADRUPOLE RESONANCE IN SODIUM CHLORATE, by Y. Ting, E. R. Manring, and D. Williams. Apr. 1954, 25p. incl. diagrs. tables, refs. (Technical rept. no. 1) [AFOSR-TN-54-125] (AF 18(600)772) AD 31476 Unclassified

Also published in Phys. Rev., v. 96: 408-414, Oct. 15, 1954.

The Zeeman splitting of Cl^{35} nuclear quadrupole resonance lines in a single crystal of sodium chlorate has been studied in a magnetic field sufficiently large to permit detailed investigation of individual Zeeman components for various orientations of the crystal in the applied magnetic field. The observed patterns are in agreement with theoretical predictions based on a Hamiltonian involving an interaction of the nuclear electric quadrupole moment with a crystalline field having axial symmetry, and the interaction of the nuclear magnetic moment with the applied magnetic field. The quadrupole interaction term e^2Qq was found to be 58.806 ±0.002 mc/sec and the effective nuclear magnetic moment was found to be 0.8215 ±0.0001 nuclear magnetons. An upper limit for the electric asymmetry parameter η was found to be 0.0012. The intensity variations of individual Zeeman components for different orientations of the crystal relative to the magnetic field were studied. The line width of individual Zeeman components was of the order of 900 cps. (Contractor's abstract)

OSU. 08:004

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

PARAMAGNETIC RESONANCE ABSORPTION IN CHROMIC CHLORIDE, by Y. Ting, L. D. Farringer, and D. Williams. [1954] 2p. incl. diagr. ([AF]OSR-TN-54-246) [AF 18(600)772] Unclassified

Also published in Phys. Rev., v. 97: 1037-1038, Feb. 1955.

The paramagnetic resonance absorption of powdered anhydrous chromic chloride has been examined at a frequency 9308 mc/sec. The line width between points of maximum slope was found to be 79 gauss; the line width at half height was 148 gauss; and the measured root-mean-square width was 103 gauss. The line width at half-height is considerably smaller than the width calculated for dipole-dipole broadening on the assumption of a Gaussian line shape. The effective g value was found to be 1.997 ± 0.003. (Contractor's abstract)

OSU. 08:005

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

THE MICROWAVE SPECTRUM OF OZONE (Abstract), by P. N. Wolfe and D. Williams. [1954] [1]p. [AF 18(600)772] Unclassified

Presented at meeting of the Amer. Phys. Soc., Poughkeepsie, N. Y., Oct. 16-17, 1953.

Published in Phys. Rev., v. 93: 360, Jan. 15, 1954.

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The absorption spectrum of O_3^{16} has been investigated in the microwave region between 20 and 30.3 kmc/sec. Accurate determinations of line frequencies were made between 20 and 26 kmc/sec and approximate measurements were made with a calibrated resonant cavity at frequencies above 26 kmc/sec. The lines observed in this region are in excellent agreement with those observed by Hughes but some improvements in frequency determinations seem to have been achieved. The observed spectrum is readily interpreted in terms of the obtuse-angled isosceles triangular model proposed by Hughes. Splitting of the ground vibrational state due to intramolecular inversions in such a triangular model are found to be negligible within the limits of the frequency discrepancies between observed and predicted lines. If such inversion occurs, its frequency is extremely low.

OSU. 08:006

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

NUCLEAR QUADRUPOLE TRANSITION IN A SINGLE CRYSTAL OF SODIUM CHLORATE (Abstract), by E. Manring, Y. Ting, and D. Williams. [1954] [1]p. [AF 18(600)772] Unclassified

Presented at meeting of the Amer. Phys. Soc., Poughkeepsie, N. Y., Oct. 16-17, 1953.

Published in Phys. Rev., v. 93: 360, Jan. 15, 1954.

Powdered samples of sodium chlorate have been found to exhibit an extremely narrow absorption line near 30 mc/sec due to nuclear quadrupole transitions involving Cl^{35}. The present work has been concerned with a study of single crystals of sodium chlorate. In the experimental work a single crystal was mounted in the coil of an oscillating detector, and an external magnetic field was employed to produce Zeeman splitting. The observed Zeeman pattern is dependent upon the orientation of the crystal in the external magnetic field. The patterns to be expected can be calculated. The patterns for five orientations will be compared in detail with theoretical predictions. From the observed patterns it is possible to calculate the nuclear magnetic moment of Cl^{35}. The preliminary value of 0.820 ± 0.001 nuclear magnetons compares favorably with the value 0.8210 nuclear magnetons obtained in nuclear magnetic resonance studies of liquid samples and serves as a check on the validity of theory. (Contractor's abstract)

OSU. 08:007

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

PROTON LINE SHAPES IN THE MAGNETIC RESONANCE SPECTRA OF AMMONIUM SALTS (Abstract), by R. Carpenter and D. Williams. [1954] [1]p. [AF 18(600)772] Unclassified

Presented at meeting of the Amer. Phys. Soc., Poughkeepsie, N. Y., Oct. 16-17, 1953.

Published in Phys. Rev., v. 93: 360, Jan. 15, 1954.

Proton magnetic resonance line shapes have been observed in the ammonium halides, ammonium sulfate, and ammonium nitrate at room temperature. Measurements were made with an unquenched radio-frequency oscillating detector in a field of approximately 7800 gauss. Frequency measurements were made with a radio receiver and a 10 kc/sec crystal-controlled multivibrator. The line widths in ammonium halides showed a monotonic decrease with increasing atomic number of the halide. The proton resonance line in ammonium fluoride was the widest observed in this study. Ammonium sulfate and ammonium nitrate both showed comparatively narrow proton absorption lines, the ammonium nitrate line showing the narrowest width of any of the salts studied. The second moments of the proton line for the different salts were computed from the observed line shapes and were found to be smaller than would be expected for a rigid lattice structure. (Contractor's abstract)

OSU. 08:008

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY, by D. Williams. [1954] [4]p. incl. diagrs. [AF 18(600)772] Unclassified

Published in O. S. U. Engineering Experiment Station News, v. 26: 16-19, Feb. 1954.

There are a number of external nuclear properties that can be studied by much less drastic methods than are required in external examination of the nucleus. These include (1) nuclear charge Σe; (2) nuclear mass M; (3) nuclear spin I; (4) nuclear electric quadrupole moment eQ; and (5) nuclear magnetic moment μ. A study is presented of nuclear magnetic resonance phenomena and data are provided on the fundamental properties of a number of nuclear species.

OSU. 08:009

Ohio State U. [Research Foundation]. [Dept. of Physics and Astronomy] Columbus.

[STRETCHING DUE TO CENTRIFUGAL FORCE IN COMPONENT LEVELS SEPARATED BY Λ-TYPE DOUBLING] Élargissement dû à la force centrifuge dans des niveaux composants séparés par un dédoublement du type Λ, by H. H. Nielsen. [1954] [3]p. [AF 18(600)772] Unclassified

Published in Jour. de Physique et Radium, v. 15: 601-603, July-Aug.-Sept. 1954.

The Hamiltonian for a polyatomic molecule is subjected to contact transformation so that the first-order transformed Hamiltonian vanishes to the fourth order. The resulting matrix elements are used for calculations on HCN and DCN. The l-type doubling coefficients so obtained are in good agreement with those obtained from microwave spectra. (C. A., 1955:5106e)

OSU. 08:010

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

MAGNETIC RESONANCE SPECTRA OF BERYL CRYSTALS, by L. C. Brown and D. Williams. [June 1954] 2p. [AF 18(600)772] Unclassified

Published in Phys. Rev., v. 95: 1110, Aug 15, 1954.

The magnetic resonance absorption patterns of Be^9 and Al^{27} have been observed in single crystals of beryl, $Be_3Al_2Si_6O_{18}$. The Be^9 pattern consists of a strong centr' line with 2 weaker satellites as expected for a nucleus with I = 3/2, and with a nonzero nuclear quadrupole coupling factor. The Al^{27} pattern consists of a strong central line with 2 pairs of satellites as expected for a nucleus with I = 5/2 and with a nonzero quadrupole coupling factor.

OSU. 08:011

Ohio State U. [Research Foundation]. [Dept. of Physics and Astronomy] Columbus.

QUADRUPOLAR SPLITTING OF THE Al^{27} AND Be^9 MAGNETIC RESONANCES IN BERYL CRYSTALS, by L. C. Brown and D. Williams. June 3, 1955 [17]p. incl. diagrs. [Part 1 of Technical rept. no. 2] (AFOSR-TN-55-345, Pt. 1) (AF 18(600)772) AD 100978 Unclassified

Also published in Jour. Chem. Phys., v. 24: 751-756, Apr. 1956.

The quadrupolar hyperfine structure of the Al^{27} and Be^9 nuclear magnetic resonance peaks in beryl crystal at 300°K have been examined. From the observed spectra, the following values were obtained for the nuclear spins I, the effective nuclear magnetic moments μ, the nuclear quadrupole coupling constants eQ $\cdot$ zz and the electric field asymmetry parameters η:

Al^{27}: I = 5/2, $|\mu|$ = 3.6385 ± 0.0003 n. m., $eQ \cdot zz$ = 3.093 ± 0.015 mc/sec, η = 0.000 ± 0.005.
Be^9: I = 3/2, μ = 1.174 ± 0.0002 n. m., $eQ \cdot zz$ = 0.504 ± 0.004 mc/sec, η = 0.090 ± 0.005.
(Contractor's abstract)

OSU. 08:012

Ohio State U. [Research Foundation] [Dept. of Physics and Astronomy] Columbus.

NUCLEAR MAGNETIC DIPOLE AND ELECTRIC QUADRUPOLE ENERGY RELATIONS, by L. C. Brown and P. M. Parker. Aug. 31, 1955 [4]p. incl. refs. [Part 2 of Technical rept. no. 2] (AFOSR-TN-55-345, Pt. 2) (AF 18(600)772) AD 100978(a) Unclassified

Also published in Phys. Rev., v. 100: 1764-1767, Dec. 15, 1955.

Calculations based on existing theory of nuclear magnetic dipole and electric quadrupole transitions provide general expressions in closed form relating I, μH_0, e^2Qq, η, θ, and Φ to experimentally determined frequencies ν_{ij}. The angles θ and Φ determine the orientation of H_0 in the principal axis system of ∇E. Methods of applying the expressions in specific situations are discussed. Application of the procedure to similar systems, such as the asymmetric rotator, is pointed out. (Contractor's abstract)

OSU. 08:013

Ohio State U. [Research Foundation]. [Dept. of Physics and Astronomy] Columbus.

NUCLEAR QUADRUPOLE LEVELS IN SINGLE CRYSTALS, by P. M. Parker. May 1956 [7]p. incl. diagrs. tables, refs. [Part 3 of Technical rept. no. 2] (AFOSR-TN-55-345, Pt. 3) (AF 18(600)772) AD 100978(b) Unclassified

Also published in Jour. Chem. Phys., v. 24: 1096-1102, May 1956.

Numerical methods are used to study the behavior of the energy levels of a nucleus, having nonzero quadrupole moment and spin I = 1 or 3/2, under the influence of a constant uniform external magnetic field and an electric crystalline field of axial symmetry. These numerical results are of use when experimental conditions are such that perturbation theory cannot be applied in data analysis. (Contractor's abstract)

OSU. 08:014

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

PROTON POSITIONS IN BRUCITE CRYSTALS, by D. E. Elleman and D. Williams. Nov. 7, 1955 [3]p. incl. diagrs. tables, refs. [Part 1 of Technical rept. no. 4] [AFOSR-TN-55-399] [AF 18(600)772] AD 115057 Unclassified

Also published in Jour. Chem. Phys., v. 25: 742-744, Oct. 1956.

The proton positions in brucite ($Mg(OH)_2$) have been determined by comparison of nuclear magnetic resonance spectra with existing x-ray data. The protons are located in parallel planes in each of which the protons are arranged in a pattern having hexagonal symmetry. The distance between adjacent protons in a given plane is 3.12 ± 0.01 Å, while the distance between a given proton and its nearest neighbors in the next plane is

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1.93 ±0.02 Å. The distance between adjacent proton planes is 0.69 ±0.02 Å. The internuclear distance in the OH bond is found to be 0.98 ±0.02 Å. (Contractor's abstract)

OSU. 08:015

Ohio State U. Research Foundation. Dept. of Physics and Astronomy, Columbus.

MICROWAVE SPECTRUM OF CHLOROFORM, by P. N. Wolfe. Nov. 15, 1955 [6]p. incl. diagrs. tables, refs. [Part 2 of Technical rept. no. 4] [AFOSR-TN-55-416] [AF 18(600)772] AD 115057(a) Unclassified

Also published in Jour. Chem. Phys., v. 25: 976-981, Nov. 1956.

A theoretical and experimental examination of the J=2 ⟶ 3 transition in $CHCl_3^{35}$ permits the evaluation of the quadrupole coupling constant of the molecule as eQV_{zz}=28.70 ±.08 mc, and provides an improved value of the rotational constant, B=3302.41 ±.03 mc. Two centrifugal distortion coefficients are also obtained: Dj=4.12 ±.43 kc and Djk = 55 ± 7 kc. The J=2 ⟶ 3 transitions in $CHCl_2^{35}Cl^{37}$ yield the following, revised structural parameters for chloroform: C — H = 1.073 Å, C — Cl = 1.762 Å, and Cl — C — Cl = 110°55'. With the assumption of axial charge symmetry about the C — Cl bond direction, a, the revised bond angle gives eQV_{aa} = -80.39 ±.22 mc for the quadrupole coupling constant of $CHCl_3^{35}$. (Contractor's abstract)

OSU. 08:016

Ohio State U. [Research Foundation]. [Dept. of Physics and Astronomy] Columbus.

NUCLEAR MAGNETIC MOMENT OF POTASSIUM (Abstract), by L. C. Brown and D. Williams. [1955] [1]p. [AF 18(600)772] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Phys. Rev., v. 98: 1537, June 1, 1955.

The nuclear magnetic resonance peak due to K^{39} in a saturated solution of KF has been observed in a field of approximately 7800 gauss. The K^{39} resonance frequency has been compared with that of N^{14} in a solution of HNO_3. The ratio obtained is $\nu(K^{39})/\nu(N^{14})$ = 0.64588, a value in agreement within the limits of experimental error with the value obtained by Collins, who observed the K^{39} resonance in a solution of KNO_2. A comparison of the experimental errors will be given and a "best value" for the magnetic moment will be proposed.

OSU. 08:017

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

HYPERFINE STRUCTURE IN THE PARAMAGNETIC RESONANCES IN SOLUTIONS OF MANGANOUS SALTS (Abstract), by J. E. Geusic and D. Williams. [1955] [1]p. [AF 18(600)772] Unclassified

Presented at meeting of the Amer. Phys. Soc, Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99:612, July 15, 1955.

Studies of paramagnetic resonance absorption by the Mn^{++} ion in solutions of manganese salts have revealed well resolved hyperfine structure. The observed line pattern is predicted by the expression,

$$H = h\nu/g - Am\frac{A^2g^2}{2h\nu}\{1(1+1) - M^2 + M(2M-1)\},$$

in which the symbols have their usual meaning. The value for the hyperfine splitting parameter A=95.3 ±1.0 gauss is in agreement with the value previously obtained by Tinkham, Weinstein, and Kip but in disagreement with the value reported by Schneider and England. The variation of line width with concentration will be discussed. (Contractor's abstract)

OSU. 08:018

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

PARAMAGNETIC FINE STRUCTURE SPECTRUM OF Cr^{+++} IN A SINGLE RUBY CRYSTAL, by J. E. Geusic. July 26, 1956 [2]p. incl. diagrs. (Technical rept. no. 3) (AFOSR-TN-56-154) (AF 18(600)772) AD 86314 Unclassified

Also published in Phys. Rev., v. 102: 1252-1253, June 1, 1956.

The fine structure spectrum of the Cr^{+++} paramagnetic resonance line in a single ruby crystal has been studied at 300°K. From the measurements, it is found that the zero-field splitting of the spin levels is 2(0.193±0.001) cm^{-1}, and the spectroscopic splitting factors are $g_{||}$=2.003 ±0.006 and $g_{\perp}$=2.00 ±0.02. (Contractor's abstract)

OSU. 08:019

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

ZEEMAN SPLITTING OF NUCLEAR QUADRUPOLE ENERGY LEVELS IN A SINGLE CUPRITE CRYSTAL, by H. L. Cox, Jr. and D. Williams. [Dec. 1956] [1]p. [AFOSR-TN-56-585] [AF 18(600)772] AD 115009 Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 2, 1957.

Also published in Bull. Amer. Phys. Soc., Series II, v. 2: 30, Jan. 30, 1957.

The behavior of absorption lines in a single cuprite crystal subjected to an external magnetic field superimposed on the internal electric field at 28°C is studied

and the parameters in the nuclear quadrupole transition of Cu^{63} and Cu^{65} are recorded.

OSU. 09:001

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

SUSCEPTIBILITY AND ENTROPY OF F-CENTERS (Abstract), by J. Forringa and J. G. Daunt. [1955] [1]p. ([AF]OSR-TN-55-34) [AF 18(600)1003] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Phys. Rev., v. 98: 1550, May 15, 1955.

The entropy S and the paramagnetic susceptibility χ of F-centers in alkali halides have been computed using the model of Kip, Kittel, Levy and Portis. With the hyperfine coupling between the F-center electron and the six equivalent nearest alkali nuclei as the only interaction, the eigenvalues of the energy of the center in a weak magnetic field were calculated up to 2nd order in H. The sum of states then yields an expression for S and χ as a function of a reduced temperature $T^*=kT/E_c$, where E_c is twice the hyperfine coupling constant. The calculations have been limited to nuclei with spin 3/2. The influence of the hfs on χ amounts to 7.5 per cent for $T^*=10$, corresponding to $T\approx 0.01°K$ for Li^6 and up to $T\approx 0.4°K$ for Cs^{133}. In a magnetic cooling experiment starting in a strong magnetic field $T_i=1°K$ at most the electronic entropy R ln 2 can be removed, leading to a final temperature $T_f^*\approx 3$. (Contractor's abstract)

OSU. 09:002

Ohio State U. Research Foundation. Dept. of Physics and Astronomy, Columbus.

ON THE SUSCEPTIBILITY AND ENTROPY OF F-CENTERS IN ALKALI HALIDES BELOW 1°K, by J. Korringa and J. G. Daunt. [Feb. 1955] 4p. incl. diagrs. tables. (Technical note no. 2) (AFOSR-TN-55-52) (AF 18(600)1003) AD 202025 Unclassified

Also published in Phys. Rev., v. 102: 92-95, Apr. 1, 1956.

The entropy and the paramagnetic susceptibility of F-centers in alkali halides below 1°K for alkali nuclei with spin 3/2 have been computed using the model of Kip and others (Phys. Rev., v. 91: 1066, 1953) in which the predominant perturbation of the electron in the F-center is the magnetic interaction with the neighbor alkali nuclei. The lower limits of temperature possible by magnetic cooling of such systems are set forth, and considerations are given as to the practical possibility of such cooling of F-center assemblies. (Contractor's abstract)

OSU. 09:003

Ohio State U. Research Foundation. [Dept. of Physics and Astronomy] Columbus.

MAGNETIC PROPERTIES OF DEFECTS AND IMPURITIES IN SOLIDS, by C. V. Heer and C. J. Rauch. July 1955, 5p. incl. table. (Technical note no. 1) ([AF]OSR-TN-55-187) (AF 18(600)1003) AD 74067 Unclassified

Presented at the International Conference on Low Temperature Physics, Paris (France), Sept. 2-8, 1955.

Study was initiated on the magnetic properties of defects and impurities at liquid He temperatures. The correlation between the number of F-centers in the alkali halides determined by optical and magnetic techniques was selected for the initial phase. KCl and KBr crystals were colored by heating to 600° to 700°C in the presence of K vapor for several hours and quenching to room temperature in an AcOH bath. The quench provides rapid cooling, yielding uniformly colored crystals with pure F-band absorption. Magnetic susceptibility measurements of the colored crystals were made between 1° and 300° K by the Gouy method (Phys. Rev., v. 90: 530, 1953). The susceptibility followed Curie's law down to the lowest temperature, and the saturation of the magnetic movement in strong magnetic fields was consistent with a free electron spin. The number of F-centers was determined from the Curie constant. Optical absorption curves were obtained for a series of positions in the crystal, and the number of F-centers was determined by applying Smakula's equation which relates the number of absorption centers to the absorption constant, α, and the half-width of the absorption line. The ratio of the number of centers measured optically to the number measured magnetically is assumed to be the f-value or oscillator strength. The magnetic properties of synthetic ruby (Al_2O_3) with a small amount of Cr^{3+} was examined between 1° and 300°K. The crystal with the magnetic field oriented at 30° with the hexagonal c axis followed a Curie-Weiss law in the He temperature region, $x=\frac{2.77 \times 10^{-3}}{T+0.05}$ emu/cc.

OSU. 09:004

Ohio State U. Research Foundation. Dept. of Physics and Astronomy, Columbus.

SOME F-BAND OPTICAL OSCILLATOR STRENGTHS IN ADDITIVELY COLORED ALKALI HALIDES, by C. J. Rauch and C. V. Heer. July 26, 1956 [7]p. incl. diagrs. tables, refs. (Technical note no. 3) (AFOSR-TN-56-352) (AF 18(600)1003) Unclassified

Also published in Phys. Rev., v. 105: 914-920, Feb. 1, 1957.

OKA. 01:001 - OKA. 02:002

The number of magnetic centers in alkali halides additively colored in the alkali vapor were determined by measuring the static magnetic susceptibility. Curie's law was followed, and the measurements were extended to liquid He temps. to increase the sensitivity. The number of centers was compared with the optical absorption of the F band. Under the assumptions that the F-center electron wave function depends parametrically upon the coordinates of the surrounding nuclei, the electric dipole matrix element is independent of the nuclear coordinates, and the electric field at the electron is the Lorentz local field, the optical oscillator strengths for a Lorentz, Gaussian, and observed line shape were determined. The average for a series of experiments yielded $f_L = 0.66$ for KCl, $f_L = 0.71$ for KBr, and $f_L = 0.46$ for KI. Values for CsBr and NaCl are discussed. (Contractor's abstract)

OKA. 01:001

Oklahoma A. and M. Coll., Stillwater.

OPTICAL ABSORPTION, PHOSPHORESCENCE, AND BIREFRINGENCE IN SEMI-CONDUCTING DIAMOND (Abstract), by W. J. Leivo and H. J. Stein. [1956] 1p. [AFOSR-TN-56-461] (AF 18(603)40) AD 97079 Unclassified

Presented at Color Center Symposium, Argonne National Lab., Lamont, Ill., Oct. 31-Nov. 2, 1956.

A type IIb diamond was studied in which the opposite ends show different properties. One half of the crystal has a slight bluish color and has an electrical conductivity considerably greater than the other half. The clear portion, however, would still be classified Type IIb from a conductivity standpoint. A double set of intersecting birefringent lines can be observed at the blue end, whereas the clear side shows only a single set. Both sides show phosphorescence, but the phosphorescent color, lifetime and excitation wavelength are different. There are also changes in the optical absorption in the 2 sides. In particular, the major absorption peaks at 2.43 and 3.56 in the blue end are not observed in the clear end. The absorption at 3.56 (0.35 ev) corresponds to the activation energy for a Group III impurity using the simple hydrogen atom model. A value of about 0.35 ev has also been previously obtained for the slope of the curve k ln R vs 1/T in the low temperature region. The absorption peaks characteristic of the blue side are temperature dependent, increasing with decreasing temperature. Changes in the ultraviolet cut-off region with temperature are are also observed. The investigations on this diamond give some support to Custers' (Physica, v. 20: 183-184, Mar. 1954) proposal that the conductivity may be the result of lattice imperfections other than impurities. (Contractor's abstract)

OKA. 01:002

Oklahoma A. and M. Coll., Stillwater.

PHOTOCONDUCTIVITY IN TYPE IIb DIAMOND (Abstract), by M. D. Bell and W. J. Leivo. [1956] [1]p. [AFOSR-TN-56-504] [AF 18(603)40] AD 110319 Unclassified

Presented at meeting of the Amer. Phys. Soc., Monterey, Calif., Dec. 1956.

The photoconductivity of two specimens of semiconducting diamond has been studied. The diamonds are photoconducting in the visible and near infrared with a major peak occurring at 660 mμ and a slight peak at 890 mμ. The photoconductivity is obtained without previous irradiation with ultraviolet light. Maxims of photoconductivity in the ultraviolet occur at 223 mμ and 228 mμ. The peak at 223 mμ was not observed in all parts of the diamonds. Also, the portion of one specimen which had the highest dark conductivity had no detectable photoconductivity in the ultraviolet above 190 mμ, the lower limit measured, but it did show the visible and near infrared photoconductivity. The photoconductivity was also dependent upon the direction of current flow through the crystal. (Contractor's abstract)

OKA. 02:001

Oklahoma A. and M. Coll. Dept. of Chemistry, Stillwater.

ACTIVITIES OF ELECTROLYTES IN THREE-COMPONENT SYSTEMS, by T. E. Moore. [Aug. 25, 1955] 3p. ([AF]OSR-TN-55-288) (AF 18(600)478) Unclassified

Equations are derived from the Gibbs-Duhem equation for 3 components which are particularly useful in determining the effect of a second electrolyte (at varying concentrations) upon the activity of a given electrolyte at some arbitrary concentration (as might be the case in studying extraction-promoting electrolytes in the liquid-liquid extraction of salts). The results are usually most useful if all activities are referred to the conventional standard states in binary solutions.

OKA. 02:002

Oklahoma A. and M. Coll. Dept. of Chemistry, Stillwater.

ACTIVITY OF HYDROCHLORIC ACID IN MIXTURES WITH COBALT (II) AND NICKEL (II) CHLORIDES, by F. Dyer, E. H. Gilmore, and T. E. Moore. [1955] [2]p. incl. diagr. (AF 18(600)478) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 4223-4224, Aug. 20, 1955.

The activity coefficients of 7 molal HCl in the presence of 0.5 to 2.0 M $CoCl_2$ and $NiCl_2$ were determined from electromotive force measurements in a cell with H and Ag-AgCl electrodes, and from distribution measurements of HCl between benzene and the aqueous mixtures. The results confirm previously reported activities obtained from vapor-pressure measurements. (C.A., 1955:15389b)

OKA. 03:001

Oklahoma A. and M. Coll. Research Foundation, Stillwater.

A NEW POLAROGRAPH FOR USE WITH HIGH RESISTANCE NONAQUEOUS SOLUTIONS, by N. A. Lloyd. May 1955, 75p. incl. illus. tables, refs. ([AF]OSR-TN-54-337) (AF 18(600)477) Unclassified

A detailed description is given of the new polarograph suitable for use with nonaqueous solutions of high resistance. The experimental work is described and applications of the instrument are given.

OKA. 03:002

Oklahoma A. and M. Coll. Research Foundation, Stillwater.

THE CONSTRUCTION AND TESTING OF A POLAROGRAPH FOR USE WITH SOLUTIONS OF HIGH RESISTANCE, by P. Arthur. Final rept. Mar. 20, 1956 [12]p. incl. diagrs. (AFOSR-TR-56-11) (AF 18(600)477) AD 86019 Unclassified

The development is summarized of a polarograph and a cell, described previously in detail, which are suitable for nonaqueous studies of up to 5 megohms cell resistance. Later cell changes found to be essential, are described. Results obtained with the polarograph are discussed. Possible application of the instrument to low-resistance solution is considered.

OKU. 01:001

Oklahoma U. Research Inst., Norman.

ON HODOGRAPH TRANSFORMATIONS OF PARTIAL DIFFERENTIAL EQUATIONS, PART I, by Y. W. Chen. Preliminary technical rept. Aug. 1951, 9p. (AF 33(038)19568) Unclassified

The author generalizes the hodograph transformation method, from a system of 2 partial differential equations with 2 independent and dependent variables, to a system of 3 partial differential equations, with 3 independent and dependent variables. For initial value problems, he shows the latter to be equivalent to a system of 9 (partial differential) equations involving 9 unknown functions. The method is capable of further generalization.

OKU. 01:002

Oklahoma U. Research Inst., Norman.

ON HODOGRAPH TRANSFORMATIONS OF PARTIAL DIFFERENTIAL EQUATIONS (SCHEME OF FINITE DIFFERENCES), by R. B. Deal. Preliminary technical note. Aug. 1951, 3p. (AF 33(038)19568) Unclassified

The author considers a finite difference approach to a solution of the equations obtained by applying the hodograph transformations to the three-dimensional gas dynamic equations of the isentropic, irrotational, steady state flow of an ideal, compressible gas. A basis for computing such solutions is presented.

OKU. 01:003

Oklahoma U. Research Inst., Norman.

TRANSFORMATIONS OF PARTIAL DIFFERENTIAL EQUATIONS, by Y. W. Chen. Sept. 1952, 56p. incl. refs. (AF 33(038)19568) AD 377 Unclassified

A study of degenerate solutions and of hodograph transformations of quasi-linear partial differential equations in n independent variables is presented.

ORL. 01:001

Orlando Research, Inc., Fla.

RESEARCH STUDY OF THE MECHANISM OF ACTION IN THE SYNTHESIS OF CELLULOSE, by G. A. Greathouse, D. E. Barnes, and W. Borysewich. Final technical rept. Mar. 1, 1955 - Feb. 29, 1956, 32p. incl. diagr. tables, refs. (AFOSR-TR-56-16) (AF 18(600)1389) AD 86600 Unclassified

Experimental data are presented on C^{14}-cellulose formation by Acetobacter xylinum or cell-free enzyme systems from D-glucose-1-C^{14}, D-glucose-2-C^{14}, D-glucose-6-C^{14}, and glycerol-1, 3-C^{14}. There are at least 2 mechanisms of cellulose synthesis indicated by these data. One, a prior cleavage of hexoses to trioses and then resynthesis to hexoses, probably hexose phosphates and then polymerization to cellulose; 2nd, a direct polymerization of hexoses, probably through the phosphates, to cellulose. Identification was made of hexose monophosphates, diphosphates, and dihydroxyacetone phosphates as intermediates between glycerol and hexose biosynthesis of cellulose. (Contractor's abstract)

ORL. 01:002

Orlando Research, Inc., Fla.

BIOSYNTHESIS OF C^{14}-LABELED CELLULOSE BY ACETOBACTER XYLINUM. IV. FROM D-GLUCOSE-1-C^{14}, D-GLUCOSE-6-C^{14}, AND GLYCEROL-1, 3-C^{14}, by G. A. Greathouse. Nov. 5, 1956 [3]p. incl. tables, refs. (In cooperation with Florida U. [Engineering and Industrial Experiment Station] Gainesville) [AF 18(600)1389] Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 4503-4507, Aug. 20, 1957.

The distribution of C^{14} in the D-glucose from the bacterial cellulose hydrolyzate produced from D-glucose-1-C^{14}, added 24 hours after inoculation as compared

ORL. 01:003 - OXF. 01:001

with that added initially was 10-12% higher in the original position 1. The hydrolyzate of cellulose-C^{14} produced from D-glucose-6-C^{14} indicated that approximately 82% of the label was in the original position 6 and had 9% in position 1, with smaller quantities in positions 2, 3, 4, and 5. The distribution of C^{14} in the D-glucose units of cellulose produced from glycerol-1, 3-C^{14} was approximately 12% position 1; 4% position 2; 22% position 3; 29% position 4; 3% position 5; and 30% position 6. (Contractor's abstract)

ORL. 01:003

Orlando Research, Inc., Fla.

ISOLATION OF A CELL-FREE ENZYME SYSTEM FROM ACETOBACTER XYLINUM CAPABLE OF CELLULOSE SYNTHESIS, by G. A. Greathouse. Nov. 5, 1956 [2]p. (In cooperation with Florida U. [Engineering and Industrial Experiment Station] Gainesville) [AF 18(600)1389] Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 4503-4504, Aug. 20, 1957.

A cell-free enzyme system was isolated from the cellulose forming bacterium, Acetobacter xylinum. Cellulose-C^{14} was produced by this enzyme system from D-glucose-1-C^{14}. The position of the C^{14}-label was determined in the D-glucose resulting from the hydrolysis of the cellulose formed. It was found that 96% of the label is in position 1 of the cellulose molecule. (Contractor's abstract)

See also Florida U. item no. FLU. 01:001.

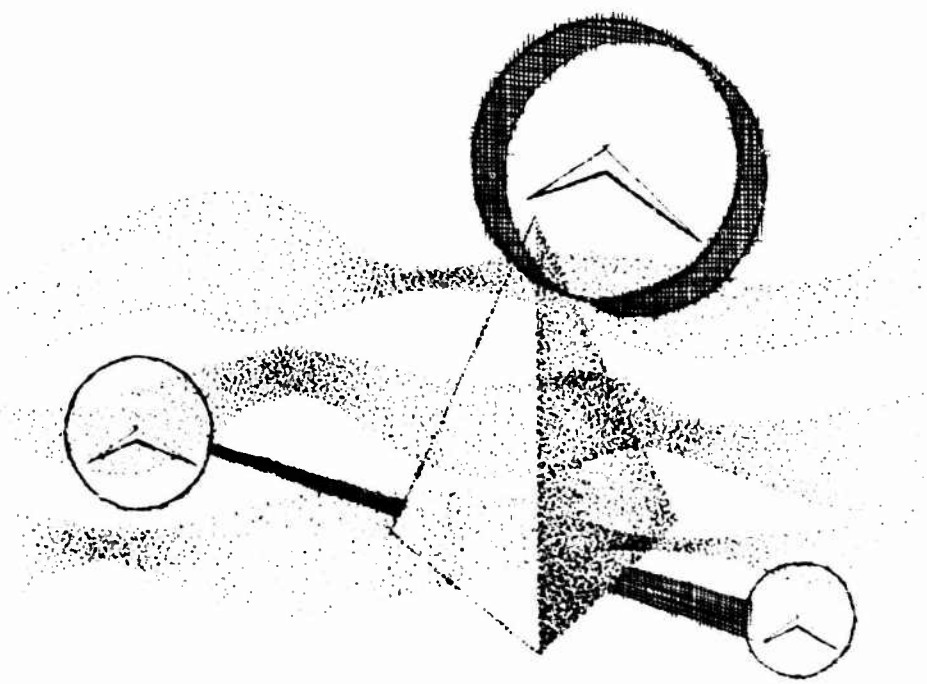
OXF. 01:001

Oxford U. (Great Britian).

CARBON DIOXIDE FIXATION DURING PROTEIN SYNTHESIS FROM AMMONIUM ACETATE, by H. L. Kornberg. [1956] [3]p. incl. diagrs. table. (AF 61(514)1180) Unclassified

Published in Biochem. et Biophys. Acta, v. 22: 208-210, Oct. 1956.

It is shown that in the growth of Pseudomonas KB_1 on acetate as the sole source of C, CO_2-fixation reactions other than those now known must play a major role in the synthesis of proteins, and that most of the C of the amino acids synthesized passes through the stage of CO_2 or compounds in ready equilibrium with CO_2. Both $C^{14}H_3CO_2Na$ and $NaHC^{14}O_2$ were incorporated into the acid-solution and protein fractions of the organism, but this result suggested only minimum value of about 17% incorporation of label from $NaHC^{14}O_2$. By the use of the isotope competition technique, however, it was found that of the order of 70% of the C of amino acids synthesized by the organism growing on acetate as sole source of C could be derived from CO_2.



PSM. 01:001

Pennsylvania Salt Mfg. Co. [Whitemarsh Research Labs.] [Philadelphia].

THE DENSITY OF LIQUID FLUORINE BETWEEN 67° AND 103°K, by R. L. Jarry and H. C. Miller. Nov. 4, 1955, 10p. incl. diagrs. tables. ([AF]OSR-TN-55-286) (AF 18(600)761) AD 77193 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1552-1553, Apr. 20, 1956.

In this study, the density of liquid fluorine has been determined over the temperature range from 66° to 103°K. A description is given of the all-metal system which was used to avoid the danger of contamination resulting from the action of fluorine on glass equipment. The data obtained have been fitted to the equation $d = 1.907 - 2.201 \times 10^{-3}T - 2.948 \times 10^{-5}T^2$, where d is the density in g/cu cm at temperature T. The estimated uncertainty in the density is ± 0.1%. The results are presented in a table, and a comparison is made with fluorine density values collected from other sources.

PSM. 01:002

Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs. [Philadelphia].

THE LIQUID DENSITY, VAPOR PRESSURE, AND CRITICAL TEMPERATURE AND PRESSURE OF NITROGEN TRIFLUORIDE, by R. L. Jarry and H. C. Miller. June 11, 1956, 12p. incl. diagrs. tables, refs. (AFOSR-TN-[56-138]) (AF 18(600)761) AD 86015 Unclassified

Presented at Delaware Valley regional meeting of the Amer. Chem. Soc., Philadelphia, Pa., Feb. 16, 1956.

Also published in Jour. Phys. Chem., v. 60: 1412-1413, Oct. 1956.

The liquid density of NF_3 has been measured from 78° to 170°K. These data have been fitted to the equation, $d(g/cc) = 2.103 - 3.294 \times 10^{-3}T - 4.675 \times 10^{-6}T^2$. The estimated uncertainty in the measured values is ± 0.1%. Vapor pressures measured to the critical point are represented to a precision of ± 0.17 atm by the equation, $\log_{10}P(atm) = 4.27264 - 613.330T^{-1}$. The vapor pressures to 1 atm have been measured to a precision of 0.01° in T and the data have been fitted to the Antoine equation, $\log_{10}P(mm) = 6.77966 - 501.913/T - 15.37$. The normal boiling point calculated from the Antoine equation is 144.10°K. Temperature was known in all cases to ± 0.05°. The critical temperature is 233.90 ± 0.10°K, and the critical pressure is 44.72 ± 0.17 atm. (Contractor's abstract)

PSM. 01:003

Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs. [Philadelphia].

THE LIQUID DENSITY, VAPOR PRESSURE AND CRITICAL TEMPERATURE AND PRESSURE OF PERCHLORYL FLUORIDE, by R. L. Jarry. Aug. 3, 1956, 8p. incl. tables. (AFOSR-TN-56-251) (AF 18(600)761) AD 88971 Unclassified

Also published in Jour. Phys. Chem., v. 61: 498-499, Apr. 1957.

The liquid density of perchloryl fluoride has been measured from 131° to 234°K, and the data have been fitted to the equation, $d(g/cc) = 2.266 - 1.603 \times 10^{-3}T - 4.080 \times 10^{-6}T^2$. The estimated uncertainty in the values of density is ± 0.1%. Vapor pressures have been measured to the critical point. The vapor pressure data to 2 atm are represented by the equation, $\log_{10}P(mm) = 18.90112 - 1443.467T^{-1} - 4.09566 \log_{10}T$. The normal boiling point calculated using this equation is 226.40°K. Vapor pressure data to the critical point are represented to a precision of ± 0.17 atm by the equation, $\log_{10}P\ atm = 4.46862 - 1010.81T^{-1}$. The critical temperature is 368.33 ± 0.10°K and the calculated critical pressure is 53 atm absolute. (Contractor's abstract)

PSM. 01:004

Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs. [Philadelphia].

AN ALL METAL APPARATUS FOR THE DETERMINATION OF THE DENSITIES OF LIQUEFIED GASES, by R. L. Jarry. Dec. 10, 1956, 6p. incl. diagr. (AFOSR-TN-56-497) (AF 18(600)761) AD 110312 Unclassified

Also published in Rev. Scient. Instruments, v. 28: 641-642, Aug. 1957.

An all metal apparatus designed for density measurements on liquefied gases is described. The metal construction enabled its use with corrosive materials, and also allowed measurements to be made to moderate pressures. It consists of a pycnometer, temperature control device and gas handling system. While this apparatus was particularly designed for density work it could be adapted for PVT measurements with slight modifications. The design and construction is detailed and its use with liquid fluorine outlined. (Contractor's abstract)

PSM. 01:005 - PSU. 01:002

PSM. 01:005

Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs. [Philadelphia].

THE VISCOSITY AND SURFACE TENSION OF PERCHLORYL FLUORIDE, by J. Simkin and R. L. Jarry. Technical rept. Dec. 10, 1956, 3p. incl. tables. (AFOSR-TN-56-498) (AF 18(600)761) AD 110313
Unclassified

Also published in Jour. Phys. Chem., v. 61: 503-506, Apr. 1957.

Relative viscosity measurements of perchloryl chloride were made with acetone as the reference material. Surface tension measurements were based on the capillary rise in a Scarpa viscometer. Viscosity values are reported in centipoise at various temperatures (C) as follows:

t, °C	n, centipoise
-76.5	0.572
-75.0	0.563
-65.9	0.500
29.9	0.173
53.8	0.142

Surface tension in dynes /cm is reported as follows:

t, °C	Surface tension
-75.2	24.1
-65.8	22.3
-55.6	21.3

PSM. 01:006

Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs. [Philadelphia].

STUDIES OF THE PROPERTIES OF LIQUID FLUORINE, NITROGEN TRIFLUORIDE AND PERCHLORYL FLUORIDE, by R. L. Jarry. Dec. 10, 1956, 6p. incl. tables. (AFOSR-TR-56-50) (AF 18(600)761) AD 110311
Unclassified

This research project was concerned with the determination of various physical properties of liquid fluorine, nitrogen trifluoride and perchloryl fluoride. The densities of liquid fluorine were measured over the temperature range 67 to 103°K. For nitrogen trifluoride and perchloryl fluoride, determinations were made of the liquid density over the temperature ranges 78 to 170°K and 131 to 234°K respectively. Vapor pressure for these two compounds were measured to the critical region, and their critical temperatures determined. In addition for perchloryl fluoride, data on the viscosity and surface tension were taken over a limited range. During this program apparatus and techniques were adapted or developed for the various measurements. As an example an all metal device was designed and successfully operated for measuring liquid densities of corrosive materials to a precision of ± 0.1%. (Contractor's abstract)

PSU. 01:001

Pennsylvania State U. Dept. of Aeronautical Engineering [University Park].

BOUNDARY LAYER CONTROL BY POROUS SUCTION, by H. G. Lew and R. D. Mathieu. June 1954, 117p. incl. diagrs. table, refs. (Technical rept. no. 3) ([AF]OSR-TN-54-203) (AF 18(600)575) AD 41436
Unclassified

The status of the investigation of the laminar boundary layer with a normal velocity at the wall, especially suction, was surveyed. Certain simple exact solutions of the boundary layer equations with continuous porous suction are given. Among these are the exact asymptotic profile, the circulatory flow about a circular cylinder with constant suction, and the similar profiles in the appropriate coordinate system. The method of Trilling uses (x, u) coordinates and an expansion in terms of the velocity u. Ringleb's solution approximates the velocity profile by an exponential function of a polynomial of the fourth power. The expansion in series method was useful in obtaining an exact solution, but a considerable expenditure of time was required in performing the calculations. Thwaites' new method of unlparametric calculation of the boundary layer with constant suction and an adverse pressure gradient by the use of the momentum equation simplified the calculation by allowing the easy addition of profiles. The approximate momentum method of Schlichting avoided the difficulty by Preston by representing the Blasius profile by a combination of sine curve and an exponential curve. Yuan's method is based essentially on the same profile of Schlichting. The emphasis of theoretical studies of boundary layer control problems by porous means should be placed on 3 dimensional flows and on turbulent flow.

PSU. 01:002

Pennsylvania State U. Dept. of Aeronautical Engineering [University Park].

ON THE LAMINAR COMPRESSIBLE BOUNDARY LAYER OVER A FLAT PLATE WITH SUCTION OR INJECTION, by H. G. Lew and J. B. Fanucci. July 1954, 50p. incl. diagrs. tables, refs. (Technical rept. no. 4) ([AF]OSR-TN-54 255) (AF 18(600)575) AD 44624
Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 589-597, Sept. 1955.

Exact solutions are calculated for the flow of a compressible laminar boundary layer over a flat plate for the cases of homogereous suction and injection. The characteristics of these flows are given in detail. The solutions of the momentum method given by H. G. Lew (Reissner Anniversary Volume, p. 43-60, 1949, J. W. Edwards, Ann Arbor, Michigan, and PIBAL Rept. no. 131 of the Polytechnic Institute of Brooklyn, Sept. 1948) and by H. G. Lew and F. Romano (PIBAL Rept. no. 132, Sept. 1948) compare favorably with the present results. Asymptotic solutions are developed which are valid for

flows which are large distances from the leading edge of the plate or for flows over arbitrary bodies with large suction. The exact solutions for the flow over a flat plate with homogeneous suction approach the asymptotic solution downstream of the leading edge, and for practical purposes, this occurs at a rather short distance from the leading edge. The asymptotic solutions are given in closed form for several cases, and they may be used as first approximations for the above flows. The method of Lighthill (Proc. Roy. Soc. London, A 202, no. 1070:359-377, 1950) for the approximate calculation of heat transfer at the wall is exact for the asymptotic solution.

PSU. 01:003

Pennsylvania State U. Dept. of Aeronautical Engineering, University Park.

AN EXACT SOLUTION OF THE LAMINAR BOUNDARY LAYER WITH ZERO PRESSURE GRADIENT AND HOMOGENEOUS INJECTION, by H. G. Lew and J. B. Fanucci. July 1955 [46]p. incl. diagrs. tables. (Technical rept. no. 6) ([AF]OSR-TN-55-273) (AF 18(600)575) AD 72720 Unclassified

The laminar boundary layer equations with the effects of injection have been transformed to a form such that all equations and boundary conditions are independent of the injection velocity at the wall. The resulting momentum equation, which is independent of the injection velocity, has been integrated along the plate length to almost the vanishing of the wall shear stress. Characteristics of the flow for the incompressible case for homogeneous injection have been evaluated. The velocity profiles have an inflection point, and the wall shear stress rapidly approaches zero. It is determined in the case of injection that results of momentum integral methods (quartic profile) agree favorably for small values of $|v|$ and, may be in considerable error for larger values of $|v|$. For example, for $-0.2 < v < 0$, the error of the wall shear stress is within 10%.

PSU. 01:004

Pennsylvania State U. [Dept. of Aeronautical Engineering] University Park.

THE ASYMPTOTIC BEHAVIOR OF THE BOUNDARY LAYER TO TRANSVERSE CURVATURE, by H. G. Lew. Aug. 25, 1955. 1p. [AF 18(600)575) AD 112889 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 276-277, Mar. 1956.

The asymptotic behavior of a boundary layer far downstream of the nose of a circular cylinder with a small amount of suction at the surface is given herein. A result is that, contrary to the impermeable wall case, the skin friction at the wall is the same as in the flat plate case.

PSU. 01:005

Pennsylvania State U. Dept. of Aeronautical Engineering, University Park.

THE ASYMPTOTIC SUCTION CHARACTERISTICS OF THE BOUNDARY LAYER ON A CIRCULAR CYLINDER, by H. G. Lew. Jan. 1956 [35]p. incl. diagrs. (Technical rept. no. 7) (AFOSR-TN-56-293) (AF 18(600)575) AD 96005 Unclassified

The asymptotic suction characteristics of the boundary layer over a circular cylinder are considered for a rotating and nonrotating cylinder. Both the incompressible and compressible cases are treated. In the nonrotating case, the assumption that the radius may be of the same order as the boundary layer thickness is retained thus, increasing the displacement thickness when suction is present. The effect of suction on the circular cylinder as compared to the flat plate case is minimized by the small radius and is reflected by the parameter $(-v_0 a/\nu)$. For the rotating cylinder, the axial velocity field is coupled to the rotational velocity field and the temperature field by the variable viscosity coefficient. The effect of rotation on the characteristics of the flow is contained in a factor multiplying the Mach number and is small for small rotation. In all cases, the skin friction intensity in the axial direction is independent of the rotation and the transverse curvature. (Contractor's abstract)

PSU. 01:006

Pennsylvania State U. Dept. of Aeronautical Engineering, University Park.

ASYMPTOTIC SUCTION CHARACTERISTICS OF THE BOUNDARY LAYER OVER A CIRCULAR CYLINDER, by H. G. Lew. May 11, 1956, [2]p. [AF 18(600)575] AD 117607 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 895-897, Sept. 1956.

The means of calculating the displacement area and momentum defect area are described. Expressions are given for the displacement thickness and for the ratio of this displacement thickness to that of the two-dimensional asymptotic suction profile. Effects of skin friction are pointed out. These findings are extended to the flow of a compressible heat-conducting boundary layer over a porous circular cylinder with uniform suction. Means for determining the effect of compressibility and velocity profile are given.

PSU. 02:001

Pennsylvania State [U.] Dept. of Chemistry, University Park.

AN ACIDITY FUNCTION IN AQUEOUS HYDRAZINE, by N. C. Deno. [1952] [3]p. incl. tables, refs. (AF 33(038)20391; continued by AF 19(600)448) Unclassified

PSU. 03:001 - PSU. 04:002

Published in Jour. Amer. Chem. Soc., v. 74: 2039-2041, Apr. 20, 1952.

An acidity function (H_-) has been determined from 5-60% (by weight) hydrazine by the use of indicators. This function is identical with pH (measured by the glass electrode) from pH 11 to 12, and reaches the value 15.93 in 60% hydrazine. This H_- function is used to establish a scale of pK values for weak acids. (Contractor's abstract)

PSU. 03:001

Pennsylvania State [U.]. [Dept. of Chemistry, University Park].

THE COMPLEXING OF HYDRAZINE WITH CALCIUM ION AS DETERMINED BY DISTRIBUTION MEASUREMENTS, by R. P. Seward. Technical rept. Aug. 1, 1953, 7p. incl. diagr. tables. (AF 18(600)448; continuation of AF 33(038)20391) AD 15780
Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 4850-4852, Oct. 5, 1954.

Measurements of the distribution of N_2H_4 and NH_3 between benzyl alcohol and aqueous $Ca(NO_3)_2$ solutions were used to determine the extent of complexing of Ca ions with N_2H_4 and NH_3. The experiments indicated that the Ca ion forms complexes with N_2H_4 and NH_3 in very nearly the same degree of stability. A postulation was made that at least three molecules of N_2H_4 can combine with one Ca ion, since the solid $CaBr_2.3N_2H_4$ is known to exist.

PSU. 03:002

Pennsylvania State U. [Dept. of Chemistry] University Park.

FREEZING POINT MEASUREMENTS OF HYDRAZINE AND SOLUTION OF SALTS IN HYDRAZINE, by N. C. Deno and R. A. Baker. Technical rept. Feb. 1, 1954, 44p. incl. illus. tables, refs. [AFOSR-TN-54-26] (AF 18(600)448) AD 106446 Unclassified

The freezing point of hydrazine was found to be 1.666 ± .002° C. For solutions of LiCl, NaCl, KCl, KBr, $CaCl_2$, and $BaCl_2$ in hydrazine, mean activity coefficients were measured as a function of concentration. The data fit the Debye-Huckel theory in dilute solutions. (Contractor's abstract)

PSU. 03:003

Pennsylvania State U. [Dept. of Chemistry] University Park.

THE ELECTRICAL CONDUCTANCE OF WEAK ACIDS IN ANHYDROUS HYDRAZINE, by L. J. Vieland and R. P. Seward. [1955] [4]p. incl. diagr. tables, refs. (AF 18(600)448) Unclassified

Published in Jour. Phys. Chem., v. 59: 466-469, May 1955.

The conductance of dilute solutions of phenol and four substituted phenols in hydrazine has been measured at 25°. Dissociation constants varying from 1.8×10^{-4} for p-cresol to 6.4×10^{-3} for p-chlorophenol were obtained. Conductance in the waterhydrazine system over the complete composition range was measured. For dilute aqueous solution a dissociation constant for hydrazine as a base of 9×10^{-7} was calculated. Water in nearly anhydrous hydrazine was found to be an extremely weak electrolyte. (Contractor's abstract)

PSU. 04:001

Pennsylvania State [U.]. Dept. of Chemistry, University Park.

THE VIBRATIONAL SPECTRUM OF TETRACHLORODIBORINE, by M. J. Linevsky, E. R. Shull and others. [1953] [2]p. incl. table. [AF 18(600)311]
Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 3287-3288, July 5, 1953.

The infrared and Raman spectra of B_2Cl_4 suggest that it has the symmetry (V_d) of a nonplanar ethylene model. The frequency to be associated with the b_1 torsional mode cannot yet be established. The b_2 deformation is assigned the value 445 cm^{-1} as deduced from combination bands. The a_1 B-B stretch appears as a polarized doublet in the Raman spectrum as a result of the B^{10}-B^{11}, B^{11}-B^{11} isotopic shift. The observed intensity ratio accords with the natural isotopic distribution of B.

PSU. 04:002

Pennsylvania State U. [Dept. of Chemistry] University Park.

DISCHARGE-INDUCED FORMATION OF BORON POLYMERS, by T. Wartik and R. Rosenberg. Oct. 22, 1956 [1]p. (AFOSR-TN-56-511) (AF 18(600)311) AD 110326
Unclassified

Also published in Jour. Inorganic and Nuclear Chem., v. 3: 388, Jan. 1957.

The characteristics and qualities of a polymeric solid formed from a mixture of a trichloroborane and carbon monoxide are investigated after undergoing the action of an ozonizer-type discharge. The properties are not typical of boron compounds. Preliminary experiments indicate that $SiCl_4$ and CO undergo a similar reaction to produce a nonvolatile viscous liquid; a mixture of trifluoroborane and CO produced a film similar to that obtained with trichloroborane. (Contractor's abstract)

PSU. 05:001

Pennsylvania State U. [Field Emission Lab.] University Park.

WORK FUNCTION OF TUNGSTEN SINGLE CRYSTAL PLANES MEASURED BY THE FIELD EMISSION MICROSCOPE, by E. W. Müller. Sept. 1954. 15p. diagrs. table, refs. ([AF]OSR-TN-54-257) (AF 18(600)672) AD 47613 Unclassified

Also published in Jour. Appl. Phys., v. 26: 732-737, June 1955.

The work functions of the low-emitting crystallographic planes of tungsten, (011) and (112), are not well known. In previous experiments scattered secondaries and some other disturbing effects covered the spurious emission particularly of the (011) plane. A method combining the field emission microscope with a probe collector has been applied. The current density in the (011) plane turned out to be 4 to 5 orders of magnitude smaller than in strongly emitting planes. Applying the Fowler-Nordheim theory, φ_{011} was found between 5.70 and 6.17 ev and φ_{112} between 4.65 and 4.97 ev depending on the temperature at which the tungsten crystal has been annealed previously. This is not a temperature effect of the work function, but the result of freezing in thermal imperfections of the planes. The work function of the ideal (011) plane appears to be as high as 6.17 ev. The existence of such a high value is further suggested by the ionization of aluminum on a hot polycrystalline tungsten wire, indicating that about 10% of the surface has a work function higher than the 5.98 ev ionization potential of aluminum. (Contractor's abstract)

PSU. 05:002

Pennsylvania State U. [Field Emission Lab.] University Park.

WORK FUNCTIONS OF TUNGSTEN SINGLE CRYSTAL PLANES (Abstract), by E. W. Müller. [1954] [1]p. [AF 18(600)672] Unclassified

Presented at meeting of the Amer. Phys. Soc., Ohio U., Athens, Apr. 16-17, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 26, June 28, 1954.

Published in Phys. Rev., v. 96: 837, Nov. 1, 1954.

Electron emission from the 110 plane has been measured as a spurious effect only. The method of a field emission microscope with a probe hole in the screen and behind it a suppressor and a collector has been improved. The current density in the 110 plane was found to be 4 to 5 orders of magnitude smaller than in the strongly emitting planes. Applying the Fowler-Nordheim theory and assuming φ_{111} = 4.38 ev according to M. H. Nicols and G. F. Smith, NRL rept. no. 24433, 1952, one finds φ_{110} between 5.80 and 6.15 ev, depending on the temperature at which the crystal has been annealed previously (2500°K and 1200°K, respectively, vacuum 10^{12} mm). The same effect at the 112 plane yields work functions between 4.80 and 5.05 ev. It is caused by freezing in the thermal imperfections. The data of all strongly emitting planes agree with those obtained by thermionic methods. (Contractor's abstract)

PSU. 05:003

Pennsylvania State U. [Field Emission Lab.] University Park.

FIELD ELECTRON EMISSION. PART I. STUDY OF ADSORPTION OF BORON ON TUNGSTEN, by R. D. Young. PART II. STUDY OF SILICON DEPOSITS ON MOLYBDENUM, by E. C. Cooper. July 1956 [87]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 2) (AFOSR-TN-56-317) (AF 18(600)672) AD 94853 Unclassified

Part I. The adsorption of B on W was studied with the field electron microscope. Boron was strongly bonded to the W substrate as indicated by activation energies of 2.8 ev for surface migration and 6.2 ev for disappearance. The crystallographic planes which are darkened by the presence of a few B layers have either a zero in the plane's index or each plane has 2 identical indices. A monolayer was defined for B adsorption by noting the degree of covering of the last stable layer as the tip temperature increases. Spiral growths were discovered which have a form similar to that of a screw dislocation. A pole figure for the cubic system and a standard tip temperature vs tip loop current calibration curve are included. Part II. In a second study, the effect of Si deposits on a Mo surface was observed using a field emission microscope. The activation energy of pure Mo for surface migration is 3.1 ev and for the Si deposit ranges from 4.0 to 0.8 ev with a straight line average of about 2.5 ev. The activation energy for the Si deposit is about 4.0 ev for evaporation. It is said that small traces of O hinder the migration of the Si deposit and enhance the migration for pure Mo. (Contractor's abstract, modified)

PSU. 05:004

Pennsylvania State U. [Field Emission Lab.] University Park.

SEEING ATOMS IN A MICROSCOPE, by E. W. Müller. [1956] [3]p. incl. illus. diagrs. (AF 18(600)672) Unclassified

Published in Armed Forces Chem. Jour., v. 10: 13, 36, 38, Nov.-Dec. 1956.

A new low temperature field ion microscope has made it possible to photograph single atoms on the surface of a solid (tungsten). Tungsten atoms are approximately 5 one-thousandths of one-millionth of an inch in diameter. This microscope consists of an evacuated glass tube containing a minute quantity of helium. Sealed in the middle and pointing toward a fluorescent screen is an extremely fine tungsten needle. A very high voltage is applied between the point of the needle and the screen.

PSU. 06:001 - PSU. 06:005

The helium gas is ionized very close to the tip, and these ions stream radially from the point to the screen, giving an enlarged projection of the tip surface. The microscope is a useful tool for investigating the influence of surface films such as oxygen, water vapor, and hydrogen on atomic surface migration, creep of metals at high temperatures, corrosion, and the effects of nuclear radiation on the individual atoms in a solid material. It also has proved useful in studying important problems of the production of high temperature alloys, cathode sputtering, effects of temperature and electric field strength on work functions of single crystal planes, optical and field excitation of absorbed atoms and field emission into liquid and solid insulators.

PSU. 06:001

Pennsylvania State U. [Field Emission Lab.] University Park.

STUDY OF FIELD ION EMISSION, by E. W. Müller. [Nov. 30, 1953] 5p. (Report no. 2) [AFOSR-TN-54-265] (AF 18(600)673) AD 22963 Unclassified

Experiments are described for the study of the tearing off effect of adsorbed Ba atoms on W by high field strengths, and the adsorption on the substrate in the presence of the field. A ZnS screen was replaced by U glass to eliminate H contamination from the Ba source by heating. Preparations were made to design an electronic lens system for use in determining the e/m ratio with H for the field ion microscope in order to determine whether H molecule ions are involved as well as protons. A new pumping system was in preparation to aid in the study of field emission with rare gas ions.

PSU. 06:002

Pennsylvania State U. Field Emission Lab., University Park.

FIELD IONIZATION. PART I. FIELD DESORPTION, by E. W. Müller. Sept. 1955 [20]p. incl. illus. diagrs. refs. ([AF]OSR-TN-55-307 (pt. 1)) (AF 18(600)673) AD 75120 Unclassified

Also published in Phys. Rev., v. 102: 618-624, May 1, 1956.

Field desorption of barium, thorium, oxygen and some other adsorbates is studied in a field emission microscope with reversed polarity as a function of field strength, temperature, and degree of coverage. The desorption occurs in the 100, 200 and 500 million v/cm range, for the 3 substances, respectively. At the highest fields, the tungsten substrate itself evaporates at room temperature. The quantitative interpretation of the measurements suggests that field desorption be considered as an evaporation of ions in which the energy hump is reduced by the Schottky effect.

PSU. 06:003

Pennsylvania State U. Field Emission Lab., University Park.

FIELD IONIZATION. PART II. FIELD IONIZATION OF GASES AT A METAL SURFACE AND THE RESOLUTION OF THE FIELD ION MICROSCOPE, by E. W. Müller and K. Bahadur. Sept. 1955 [31]p. incl. illus. diagrs. refs. ([AF]OSR-TN-55-307 (pt. 2)) (AF 18(600)673) AD 75120(a) Unclassified

Also published in Phys. Rev., v. 102: 624-631, May 1, 1956.

The mechanism of field emission of positive ions is considered to depend upon the supply of molecules and their ionization probability in a field up to 500 million v/cm. Experimental current-field characteristics match the theoretical curves. The velocity distribution, measured in a retarding potential tube, shows that the ions originate some 5 to 100 Å above the surface, depending upon the field. A simple mass spectrometer is described which uses the field emitter as a point ion source. The resolution of the field ion microscope is found to depend upon tip radius, polarizability, and ionization potential of the gas, and possibly upon the accommodation coefficient and the temperature. Helium seems to give the best resolution of about 4 Å. The possibility of operating a field desorption microscope with sufficient resolution to show the lattice structure of the surface is discussed. (Contractor's abstract)

PSU. 06:004

Pennsylvania State U. Field Emission Lab., University Park.

THE RESOLUTION OF THE FIELD ION MICROSCOPE, by E. W. Müller. Oct. 1955, 6p. (AF 18(600)673) Unclassified

Presented at meeting of the Electron Microscope Soc., Oct. 28, 1955.

Published in Zeitschr. Naturforsch., v. 11a: 88-94, Jan. 1956.

The results of utilizing positive ions rather than electrons in microscopy are reported. Both hydrogen and helium ions were employed in the apparatus. The author presented ion pictures with resolutions down to 2.7 Å, the distance between two neighboring tungsten atoms.

PSU. 06:005

Pennsylvania State U. Field Emission Lab., University Park.

FIELD ION EMISSION. PART I. EXPERIMENTAL INVESTIGATION OF FIELD ION EMISSION, by K. Bahadur. Mar. 1956 [30]p. incl. diagrs. tables. (Technical rept. no. 2, pt. 1) (AFOSR-TN-56-118) (AF 18(600)673) AD 82514 Unclassified

A gas source and means for measuring amounts of various gases were added to the apparatus used previousiy in the study of field ion emission. The vacuum system employs a Hg cutoff valve to isolate the tube from the vacuum pumps. He, A, Kr, and Xe were used. A Pd tube was the source of H, $KMnO_4$ was the source of O, and NaN_3 was the source of N. ZnS activated with Ag was used as the fluorescent material for the screens. The screens tended to be deactivated under intense bombardment by a 10- to 20-kv ion beam. A partial recovery was achieved by baking the tube at about 480°C for several hours. Preliminary measurements were made of the ion current in a simple 2-electrode emission microscope which consisted of a W emitter sealed in a glass envelope. The inside walls of the tube were coated with SnO and kept at a high voltage to serve the purpose of the accelerating electrode and of preventing any undesirable and uncontrolled charging up of the walls. The ic -current characteristics for the various gases were in good agreement with the theoretical data. The increase in the ion-current value was ascribed to secondary electrons produced at the accelerating electrode and partly to spatial ionization of gas molecules by high-velocity ions. Space ionization occurred to some extent. Measurements were made of the apparent ion current drawn by the accelerating electrode and the collector together. Field-ion mass-spectroscopy experiments were conducted with a symmetrical 3-element electrostatic lens for focusing the ion beam. Measurements showed an equal abundance of H^+ and H_2^+ for various fields at the emitter and for different gas pressures.

PSU. 06:006

Pennsylvania State U. Field Emission Lab., University Park.

FIELD ION EMISSION. PART II. RESOLUTION OF THE ATOMIC STRUCTURE OF A METAL SURFACE BY THE FIELD ION MICROSCOPE, by E. W. Müller. [Mar. 1956] [12]p. incl. illus. diagr. refs. [Technical rept. no. 2, pt. 2] [AFOSR-TN-56-157] (Bound with its AFOSR-TN-56-118; AD 82514) [AF 18(600)673] AD 82514(a) Unclassified

Also published in Jour. Appl. Phys. v. 27. 474-476, May 1956.

Experiments were conducted with a new field emission microscope especially designed for low-temperature work. Cooling the emitter tip with liquid N greatly improved the resolution. Sufficient accommodation of the He atoms apparently was reached at the temperature of solid N. The use of liquid H increased the intensity but did not improve the resolution. Cooling by liquid He gave a slightly more blurred image. The advantage in using the low-temperature ion microscope become apparent when the conventional field electron emission pattern of a W tip is compared with an ion image of a similar single crystal tip. In many parts of the picture, the individual atoms constituting the concentric edges of the 011 net planes are resolved. The individual atoms along many lattice steps are resolved. The atoms are not clearly oriented in a regular network, but rather along a slightly staggered and almost evenly curved line. A study of a cork ball model of a hemispherical single crystal tip showed that the ion images reveal exactly what would be expected under the restriction of visualizing only the protruding atoms along the net plane edges. The model also indicated that 2 adjacent lattice sites along the steps are very rarely occupied in such a manner as to have both atoms protrude equally. The actual observing of the arrangement of the atoms in the surface lattice apparently will give additional information on surface problems in the future.

PSU. 07:001

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

X-RAYS AND THE ABSOLUTE CONFIGURATION OF OPTICALLY ACTIVE MOLECULES, by R. Pepinsky. [1956] [45]p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Office of Naval Research, National Inst. of Health, National Science Foundation, and Air Force Office of Scientific Research under [AF 18(600)-1556]) Unclassified

Presented at Frontiers in Chemistry Lecture, Wayne U., Detroit, Mich., Mar. 5, 1956.

Published in Record Chem. Prog., v. 17: 145-189, 1956.

The author discusses the following: (a) new developments of the x-ray diffraction method of structure analysis, with particular reference to the structures of moderately complex organic molecules and of coordination compounds; (b) the fundamental difficulty of the x-ray method, the phase problem; (c) the utilization of anomalous dispersion is presented as a new approach which not only aids in solving the phase problem for noncentrosymmetric crystals but also establishes the absolute configuration of optically active molecules.

PSU. 07:002

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

FERROELECTRICITY IN THE ALUMS, by R. Pepinsky, F. Jona, and G. Shirane. [1956] [2]p. incl. illus. diagr. (Sponsored jointly by Signal Corps and Air Force Office of Scientific Research under AF 18(600)1556) Unclassified

Published in Phys. Rev., v. 102: 1181-1182, May 15, 1956.

In a reinvestigation of the optical, dielectric and structural properties of a large number of alums, ferroelectric behavior was discovered in a number of these, and antiferroelectricity in others. A striking property of these ferroelectrics is that the coercive field is unusually large and increases rapidly with decreasing temperature. The behavior of methyl-ammonium aluminum sulfate dodecahydrate is reported in detail. Comments are also made concerning urea chromium alum and guanidinium aluminum alum.

PSU. 07:003 - PSU. 07:005

PSU. 07:003

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

CRYSTAL STRUCTURE OF CHOLINE REINECKATE (Abstract), by Y. Takeuchi and R. Pepinsky. [1956] [1]p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1556 and Office of Naval Research under N6onr-26913) Unclassified

Published in Programs and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind., June 1956, Paper C-5.

The structure of choline reineckate has been determined, as a further illustration of the method of "crystal engineering." Excellent crystals were prepared by the method of diffusion of choline chloride and Reinecke's salt, in opposite arms of a U-tube, into a silicic acid gel in the bend of the tube. Optical observations revealed holohedral orthorhombic symmetry. Weissenberg photographs with Cu Kα radiation showed the space group to be Icma, with a = 12.69 ± 0.03 A; b = 22.80 ± 0.03 A; c = 6.75 ± 0.03 A. There are four formula units of $[C_5H_{13}NOH] \cdot [Cr(NCS)_4(NH_3)_2]$ per cell. The calculated specific gravity of 1.48 compares with the measured value of 1.475. Patterson map revealed that Cr atoms lie on centers with point symmetry 2/m, and Cr-S vectors were found from these maps. Cr and S positions sufficed to determine phases for a Fourier syntheses. The Cr-N-S angle is not 180° as in other reineckates studied, but is 150° on the (001) projection. This affords extra space for the choline ion, the nitrogen atom of which is at (0, 1/4, z). The choline group is randomly oriented in four positions. Atoms of the group could be located from packing considerations, and were clearly revealed in (100) and (001) projections. The structure was refined via these projections and a subsequent three-dimensional synthesis. The R-factors are 11.2 for F(hk0) and 11.8 for F(0kl); B = 2.8A^2. The choline configuration is gauche. In ammonium and pyridine reineckates the N ≡ C-S isothiocyanate structure appears, with N-C distances 1.14 and 1.15 A, and C-S distances 1.80 and 1.76 A, respectively; and the N-C-S groups are on Cr-N = 1.94 A, N-C = 1.27 A, C-S = 1.64 A. The isothiocyanate group is predominately -[N = C = S], therefore. A possible explanation of the differences in the isothiocyanate group in these three structures is offered. (Contractor's abstract)

PSU. 07:004

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

SOME EXPERIENCE WITH THE CRYSTAL ENGINEERING TECHNIQUE (Abstract), by R. Pepinsky, Y. Takeuchi and others. [1956] 2p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)1556 and National Inst. of Health) Unclassified

Published in Program and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind., June 1956, Paper no. F-6.

The method of control of crystal symmetry designated as "crystal engineering," for studies of organic ion structures via the preparation of salts with complex ions, has been explored further during the past year. Several hundred complex ion-organic ion salts have been prepared, and many of these examined by single-crystal x-ray diffraction. In all cases where the complex ion locations have been established, these outline the unit cells, and organic ions are in spaces between the complex ions. A number of examples are presented. Where the spaces between the complex ions are so large as to permit disorder in the organic ion arrangement, this disorder can often be eliminated by the use of a complex ion having a polar structure (such as nitroprusside or cobaltpentaminochlor ions). The crystal engineering technique can be extended via the use of large ions such as chlorostannates or silicofluorides. As previously pointed out, use of optically-active complex ions of known hand permits determination of the hand of an optically active organic ion. Temperature-induced crystal transitions have been observed in a number of these compounds. Some interesting features of complex ion structures are reported. (Contractor's abstract)

PSU. 07:005

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

CRYSTAL STRUCTURE AND DISORDER IN $K_3Co(CN)_6$ AND RELATED COMPLEX ION SALTS (Abstract), by Y. Okaya and R. Pepinsky. [1956] 3p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1556 and Office of Naval Research under N6onr-26916) Unclassified

Published in Program and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind., June 1956, Paper no. 1-6.

Crystals of compounds of the type $K_3M(CN)_6$, with M = Cr, Mn, Fe and Co, have been examined as a part of our program for the investigation of complex ion salts of organic ions. $K_3Co(CN)_3$ is orthorhombic, with a = 10.53 A, b = 13.26 A, c = 8.32 A; $\rho_{obs.}$ = 1.906 gr/cc, $\rho_{calc.}$ for Z = 4 is 1.900 gr/cc. Space group extinctions correspond to Pcnb, showing isomorphism with the corresponding Fe, Cr, Mn and Ir salts whose crystallography was reported by Gottfried and Nagelschmidt. No definitive structure analysis of the series of salts has been published, and several other workers have reported other symmetries for the series. Oscillation and Weissenberg patterns, taken with Co Kα radiation, show that all (hkl) reflections with l even have integral indices; but for l odd the reflections are linked by diffuse streaks parallel to b^*, with integral h indices. For some rapidly-grown crystals no sharp reflections appear, and only streaks parallel to b^* are obser[illegible]e. In addition to space group extinctions, (h, k, 2n) [illegible]sent only for k + n even. A c-axis Patterson projection aided in the location of all atoms. Positions were refined by electron density and structure factor iterative calculations on X-RAC and

S-FAC in two and three dimensions. Interatomic distances are Co - C_1 = 2.07 A; C_1 - N_1 = 1.16 A; Co - C_2 = 2.0**A; C_2 - N_2 = 1.16**; about K_1 at 0, 1/4, 1/8: 2N at 2.57 A and 4N at 2.77 A; about K_2 at 1/4, 0, 1/8: 2N at 3.02 A, 2N at 2.87 A, 2N at 3.14 A. R factors are 0.15 for (hk0) and 0.16 for (hk2) reflections. The reflection anomalies for odd-l layer indicate one-dimensional disorder along b. This is due to the fact that layers perpendicular to b are occasionally displaced by $\frac{c}{2}$. The disorder is permitted because of the particular z-coordinates of K ions on planes x = 1/4, which permit random location of Co atoms at either z = 3/8 or 7/8 without configuration changes. Similar disorder is found in the Cr, Fe, and Mn salts. The disorder probably accounts for the incorrect symmetries reported by Barkhatov and Zhdanov. (Contractor's abstract)

PSU. 07:006

Pennsylvania State U. [X-Ray and Crystal Analysis Lab.] University Park.

REMARKS ON THE DESIGNING OF CRYSTALS (Abstract), by R. Pepinsky. [1956] [1]p. (AF 18(600)1556) Unclassified

Presented at Fourteenth Pittsburgh Diffraction Conference, Oct. 31-Nov. 2, 1956, Paper no. 30.

The concept of "crystal engineering" has proved very advantageous not only for the preparation of crystals of symmetries and with atoms in positions advantageous for structure analysis, but also for the development of crystals with desired physical properties as a function of temperature. The theory and application of designing for such purposes is discussed. (Contractor's abstract)

PSU. 07:007

Pennsylvania State U. [X-Ray and Crystal Analysis Lab.] [University Park].

ON THE DESIGNING OF CRYSTAL STRUCTURES (Abstract), by R. Pepinsky. [1956] 2p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1556 and National Insl. of Health) Unclassified

Presented at meeting of the Wilmington Section of the Amer. Chem. Soc., Dec. 12, 1956.

Crystallization of organic ions with complex ions of suitable sizes, charges and solubilities results in structure with cells and symmetries determined chiefly by packing of the complex ions. These cells and symmetries are to a good extent controllable; hence crystals with advantageous properties can be designed or "engineered." X-ray examination of a large number of such structures show the complex ions ideally placed for crystal structure analysis, since structure factor phase determination is facilitated both by direct contribution of the ions to the structure factors and through image-seeking in interatomic vector maps. Locations of the complex ions are readily established from such maps. Use of the optically-active complex ions of known hand permits direct establishment of the absolute configuration of optically-active organic ions included in the lattice, and conversely. Use of complex ion salts also facilitates introduction of anomalous scatterers into non-centrosymmetric crystals, to permit application of a new, direct method for structure determination. This method also reveals the absolute configurations of optically-active components in such a crystal, and hence is of profound stereochemical importance. Examples of structures of a number of complex ion salts with organic ions are presented, to illustrate these concepts. (Contractor's abstract)

PSU. 08:001

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

A NEW FERROELECTRIC CRYSTAL CONTAINING NO OXYGEN, by R. Pepinsky and F. Jona. [Nov. 10, 1956] [7]p. incl. diagrs. refs. (AFOSR-TN-56-571) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233) AD 110393 Unclassified

Also published in Phys. Rev., v. 105: 344-345, Jan. 1, 1957.

A study is made of the dependence of ferroelectricity, or antiferroelectricity in ionic crystals, upon O_2. $(NH_4)_2BeF_4$ has its ferroelectric and other properties compared with $(NH_4)_2SO_4$ and explained. X-ray and neutron diffraction analyses of the low temperature phases of both crystals are in progress in order to better understand the transition mechanisms.

PSU. 08:002

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

X-RAY STUDY OF THE FERROELECTRIC LOW-TEMPERATURE PHASE OF SODIUM NIOBATE, $NaNbO_3$ (Abstract), by G. Shirane, J. Johns and others. 1956, 2p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233) Unclassified

Published in Program and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind., June 1956, Paper no. E-3.

The room-temperature structure of sodium niobate, $NaNbO_3$, was first studied by Vousdan. The unit cell is orthorhombic with lattice parameters a = 5.505 A, b = 5.568 A, c = 15.518 A, and space group $P222_1$. At higher temperatures the crystal is cubic of the perovskite type. The room-temperature structure can be obtained from the perovskite phase through antiparallel shifts of the Nb atoms along the cubic (110) direction, which becomes the orthorhombic b axis. A superstructure is

PSU. 08:003 - PSU. 08:005

developed, the periodicity along the c axis being four times greater than that along the original cubic (001) axis. Dielectric observations and the structural study indicate that this phase is antiferroelectric. Recently Cross and Nicholson have reported another phase change at about -150°C. Dielectric measurements reveal ferroelectric behavior in this phase. In order to understand the mechanism of this lower transition, an x-ray study of the ferroelectric phase of $NaNbO_3$ has been carried out. The analysis was accomplished on single crystals grown by using an excess of sodium carbonate as flux. At -170°C. the symmetry is monoclinic, with lattice parameters a = 7.812 A, b = 5.564 A, c = 5.484 A, $\gamma = 80° 51'$ where c is the unique axis. The ferroelectric axis is along a, which is now only twice as long as the original cube axis. Examination of rotation and Weissenberg pictures indicates that the antiparallel shifts of the Nb atoms disappear in the ferroelectric range. The monoclinic cell is approximately rhombohedral with parameters (T= -170°C): $a_R = 3.906$ A, $\alpha = 89° 11'$. Both optical and x-ray observations of the twinning exclude the possibility of true rhombohedral symmetry. X-rays reveal a large volume increase ($\Delta V = 0.31$ A^3) when the transition point is passed from above. (Contractor's abstract)

PSU. 08:003

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

X-RAY AND NEUTRON DIFFRACTION STUDY OF ANTIFERROELECTRIC LEAD ZIRCONATE, $PbZrO_3$, by F. Jona, G. Shirane and others. [1956] 1v. incl. illus. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35, Signal Corps Engineering Labs. under DA 36-039-sc-63233, Atomic Engergy Commission under AT(30-1)1516, and Office of Naval Research under N6onr-26916)
Unclassified

Published in Program and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind. June 1956, Paper no. E-4.

Published in Phys. Rev., v. 105: 849-856, Feb. 1, 1957.

The room-temperature structure of antiferroelectric lead zirconate, $PbZrO_3$, has been studied by x-ray and neutron diffraction. The symmetry is orthorhombic (pseudo-tetragonal) with lattice parameters a = 5.88 A, b = 11.77 A, c = 8.22 A. The space group is Pba2 and there are 8 formula units in the unit cell. The structure results from slight distortions of the cubic perovskite lattice, which the crystal assumes above 230°C. With respect to the ideal perovskite structure, Pb atoms suffer antiparallel shifts along the former cubic [110] direction; oxygen atoms also suffer antiparallel shifts within the (0, 0, 1) plane and, in addition, unbalanced antiparallel shifts along the c direction. The non-centric symmetry is in accord with the presence of a small piezoelectric effect as reported by Roberts. The oxygen octahedra surrounding the Zr atoms appear to be distorted, and it is possible to explain the strong optical anisotropy within the (0, 0, 1) plane as well as the pseudo-tetragonality (b = 2a). (Contractor's abstract)

PSU. 08:004

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

A NEW, LARGE FAMILY OF FERROELECTRICS (Abstract), by R. Pepinsky, F. Jona and others. [1956] 2p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233)
Unclassified

Published in Program and Abstracts, Amer. Crystallographic Assoc., French Lick, Ind., June 1956, Paper no. E-5.

An investigation of the optical, dielectric, thermal, and structure properties of the alum family has resulted in the discovery of a large number of ferroelectrics in this group. A variety of known and new types alums have been prepared and examined, and some debated points in alum chemistry clarified. The dielectric behavior of these crystals is exemplied by that of methylammonium aluminum alum, $(CH_3NH_3)Al(SO_4)_2 \cdot 12H_2O$. This has Curie point at 176°K, with the dielectric constant following a Curie-Weiss law as a function of temperature for a range of about 25° above the transition point. The Curie constant is about 1000°K; the dielectric constant climbs from about 9 at room temperature to about 60 at the Curie point; the coercive field is about 5KV/cm at 2° below the Curie point, and climbs to 15KV/cm 25° below that point; saturated hysteresis loops can be observed only in the temperature range from Curie point to about 20° below it; and the spontaneous polarization is about 0.6 μ-coulombs/cm^2 at 166°K. It has been possible to prepare guanidinium aluminum sulfate and the corresponding chromium salt as an alum. Normal preparation of these salts lead to the hexahydrates, the ferroelectric activity of which was discovered by Holden et al. The structure of chromium guanidinium sulfate hexahydrate was determined in order to permit comparison with the alum structure. Modifications of published alum structures appear to be required. The high- and low-temperature symmetries of the methylammonium alums are discussed. (Contractor's abstract)

PSU. 08:005

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

FERROELECTRICITY IN THE LANGBEINITE SYSTEM (Abstract), by F. Jona and R. Pepinsky. [Aug. 15, 1956] [1]p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233)
Unclassified

Published in Phys. Rev., v. 103: 1126, Aug. 15, 1956.

Optical examination of $(NH_4)_2Cd_2(SO_4)_3$ over the range from room temperature to 77°K revealed a crystal

transition about 10° above the lowest temperature. The material is cubic above the transition point, and belongs to the langebeinite [$K_2Mg_2(SO_4)_3$] family. An x-ray powder pattern establishes the lattice constant as $a = 10.35_0 \pm 0.005$ A at room temperature. Growth from water solution at 80°C results in predominance of octahedral (111) faces. Dielectric measurements were made on plates cut perpendicular to the cubic [111] direction. The behavior of the low-field dielectric constant ϵ_{111} as a function of temperature is depicted. The room temperature value of ϵ_{111} is about 9.5; the constant begins to climb slightly at -160°C, and reaches a peak of 10.2 at -184°C. Below this point, ferroelectric hysteresis loops are observed. The coercive field at -190°C is approximately 15 KV/cm for an applied field of 25 KV/cm, and the spontaneous polarization above the former [111] cube direction is about 0.3 microcoulombs/cm^2. The hysteresis loops sometimes appear with noncentric symmetry, as in the case of guanidinium aluminum sulfate hexahydrate as reported by Holden et al. Detailed dielectric, optical, thermal and x-ray measurements on this and isomorphous crystals are in progress. (Contractor's abstract)

PSU. 08:006

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

IS THE SYMMETRY OF THE LOW-TEMPERATURE PHASE OF $BaTiO_3$ RHOMBOHEDRAL? by F. Jona and R. Pepinsky. [Oct. 1956] [18]p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233) Unclassified

X-ray Weissenberg patterns of a barium titanate crystal in the low-temperature phase (below -90°C) show that the spacings along the perovskite cubic axes are equal and that the cube faces are sheared through a small angle, i.e., the unit cell has rhombohedral character. Optical examination of these crystals in electric fields, together with dielectric constant measurements, suggest that the cell is only pseudo-rhombohedral. The true symmetry appears to be lower and may possibly be monoclinic (point group 2 or m). The contradictions in the early dielectric measurements are explained by this assumption. (Contractor's abstract)

PSU. 08:007

Pennsylvania State U. [X-Ray and Crystal Analysis Lab.] University Park.

DIELECTRIC AND THERMAL STUDY OF THE FERROELECTRIC TRANSITION IN METHYLAMMONIUM ALUMINUM ALUM (Abstract), by F. Jona, S. Vidulich and R. Pepinsky. [1956] [1]p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 36-039-sc-63233) Unclassified

Presented at the Fourteenth Pittsburgh Diffraction Conference, Oct. 31-Nov. 2, 1956, Paper no. 22.

The dielectric and thermal properties of the alum MASD, $(CH_3NH_3)[Al(H_2O)_6](SO_4)_2 \cdot 8H_2O$, which has recently been found to be ferroelectric, have been examined. A dielectric constant versus temperature study has determined the transition temperature as 177.2°K. The maximum value of ϵ at this temperature is 60. For the chromium isomorph MCrSD, $(CH_3NH_3)[Cr(H_2O)_6](SO_4)_2 \cdot 6H_2O$, the transition temperature is 185°K, at which point ϵ reaches a maximum of about 70. The Curie-Weiss law appears to be followed over a short temperature range (about 6°). The transition temperature is raised by appoximately 1 percent, and the dielectric constant lowered by about 2%, by a dc biasing field. The original cubic [100] direction becomes the polar axis below the transition temperature. P_s drops very sharply at the transition temperature. The heats of transition of MASD and MCrSD are large, and are comparable to the heat of transition in KH_2PO_4. The transition is probably of first order. X-ray and optical observations indicate that the symmetry of the low-temperature phase is probably monoclinic. (Contractor's abstract)

PSU. 08:008

Pennsylvania State U. [X-Ray and Crystal Analysis Lab.] [University Park].

NEW OBSERVATIONS OF CRYSTAL TRANSITIONS (Abstract), by R. Pepinsky and F. Jona. 1958, 1p. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA 38-039-sc-63233) Unclassified

Presented at Fourteenth Pittsburgh Diffraction Conference, Oct. 31-Nov. 2, 1956, Paper no. 23.

Optical, dielectric and other physical measurements have been carried out on a wide variety of crystalline compounds, in a search for and examination of temperature-induced transitions at normal pressure. A report is made of a good number of previously-unreported transitions. Some families of compounds have been discovered in which members showing transitions are very common. Criteria for such families are discussed. (Contractor's abstract)

PSU. 08:009

Pennsylvania State U. X-Ray and Crystal Analysis Lab., University Park.

SYMMETRY OF THE LOW-TEMPERATURE PHASE OF $BaTiO_3$, by F. Jona and R. Pepinsky. [1956] [4]p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(603)35 and Signal Corps Engineering Labs. under DA-36-039-sc-63233) Unclassified

Published in Phys. Rev., v. 105: 861-864, Feb. 1, 1957.

PEN. 01:001 - PEN. 01:004

X-ray Weissenberg patterns of a barium titanate crystal in the low-temperature phase (below -90°C) show that the spacings along the perovskite cubic axes are equal and that the cube faces are sheared through a small angle, i.e., the unit cell has rhombohedral character. Optical examination of these crystals in electric fields, together with dielectric constant measurements, suggest that the cell is only pseudorhombohedral. The true symmetry appears to be lower and may possibly be monoclinic (point group 2 or m). The contradictions in the early dielectric measurements are explained by this assumption. (Contractor's abstract)

PEN. 01:001

Pennsylvania U., Philadelphia.

CORRELATION ENERGIES AND ANGULAR COMPONENTS OF THE WAVE FUNCTIONS OF THE GROUND STATES OF H^-, He I, AND Li II, by L. C. Green, M. N. Lewis and others. [1953] [22]p. incl. tables, refs. [In cooperation with Haverford Coll., Strawbridge Observatory, Pa.] (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)660 and Office of Naval Research) Unclassified

Also published in Phys. Rev., v. 93: 273-279, Jan. 15, 1954.

A 3-parameter variational function involving a symmetrized exponential in the nuclear distances and a linear factor in the interelectron distance has been obtained for He I and Li II to examine the effects of configuration interaction in the ground state of the 3 simple atomic systems, H^-, He I, and Li II. These functions together with the one of the same type already in existence for H^- have been expanded in series of Legendre functions of the cosine of the angle between the 2 radius vectors. The coefficients in these expansions are functions of the nuclear distances of the 2 electrons. The various component functions are presented, together with the coefficients with which they enter the expansions, and their contributions to the total energies. A discussion is given of the method of estimating the magnitude of the total correlation, or configuration interaction, energy and its radial, angular, and mixed parts. A table is given of the values of the correlation energy, and its various parts for H^-, He I, and Li II. (Contractor's abstract)

PEN. 01:002

Pennsylvania U., Philadelphia.

A DISCUSSION OF ANALYTIC AND HARTREE-FOCK WAVE FUNCTIONS FOR $1s^2$ CONFIGURATIONS FROM H^- TO C v, by L. C. Green, M. M. Mulder and others. [Oct. 30, 1953] [19]p. incl. tables, refs. [In cooperation with Haverford Coll., Strawbridge Observatory, Pa.] (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)660 and [Office of Naval Research]) Unclassified

Also published in Phys. Rev., v. 93: 757-761, Feb. 15, 1954.

Two simple analytic expressions are presented, both of which are excellent approximations to a Hartree-Fock 1s wave function in a $1s^2$ configuration. One of these expressions is a 2-parameter function and the other a 3-parameter one. The parameters were chosen variationally, and their values are given for the various members of the isoelectronic sequence from H^- to C v. The energies were also computed, and the energies and the wave functions are compared with the corresponding Hartree-Fock quantities, where the latter are known. Both the 2- and the 3-parameter functions approximate the numerical functions closely, and give energies as low, or almost as low, as the more reliable of the Hartree-Fock energies. The 3-parameter wave function proves to be the better, particularly in the case of H^-. Some comments are made on the existing numerical functions and their energies. (Contractor's abstract)

PEN. 01:003

Pennsylvania U., Philadelphia.

THE DETERMINATION OF ATOMIC WAVE FUNCTIONS, by L. C. Green. [Oct. 1, 1954] [14]p. incl. diagrs. refs. [In cooperation with Haverford Coll., Strawbridge Observatory, Pa. and Yale U., New Haven, Conn.] (Sponsored jointly by [Air Force] Office of Scientific Research under [AF 18(600)660], Office of Naval Research, and Research Corp.) Unclassified

Also published in Proc. National Science Foundation Conference on Stellar Atmospheres, Indiana U., Bloomington, Sept. 30, Oct. 1-2, 1954, p. 72-79.

This is a review of work being carried out, both in this country and in Europe, in an attempt to obtain more accurate atomic wave functions. The work being done at Haverford College is treated at some length. (Contractor's abstract, modified)

PEN. 01:004

Pennsylvania U., Philadelphia.

AN ANALYSIS OF THE THREE-PARAMETER WAVE FUNCTION OF HYLLERAAS FOR THE He I GROUND STATE IN TERMS OF CENTRAL FIELD WAVE FUNCTIONS, by L. C. Green, M. M. Mulder and others. [June 8, 1954] [22]p. incl. diagrs. tables, refs. [In cooperation with Haverford Coll., Strawbridge Observatory, Pa.] [AFOSR-TN-54-366] (Sponsored jointly by [Air Force] Office of Scientific Research under [AF 18 (600)660], Office of Naval Research, and Research Corp.) Unclassified

Also published in Phys. Rev., v. 96: 319-325, Oct. 15, 1954.

A study of configuration interaction in the ground state of He I has been carried through by expanding the various angular components of the 3-parameter wave function of Hylleraas in orthonormal sets of functions. The different sets have been constructed from symmetrized products of hydrogenic wave functions with different values of the parameter Z. The importance of the various configurations for Z = 2 is commented upon at some length. Configurations involving a free electron are shown to make surprisingly large contributions. The changing importance of the various components with changing Z is illustrated. In particular, the minimum with respect to Z of the contribution of configurations containing a free electron is pointed out. The implications of the results of these expansions for attempts to obtain wave functions for both normal and excited states of 2-electron systems by the minimum principle from linear combinations of products of hydrogenic functions of the proper symmetry are discussed. (Contractor's abstract)

PEN. 01:005

Pennsylvania U., Philadelphia.

COMPUTED TRANSITION PROBABILITIES FOR X-RAY CONTINUA OF POTASSIUM, by M. N. Lewis, L. C. Green and others. [Jan. 20, 1955] 32p. incl. tables, refs. [In cooperation with Haverford Coll., Strawbridge Observatory, Pa.] [AFOSR-TN-55-225] (Sponsored jointly by National Science Foundation and [Air Force] Office of Scientific Research under [AF 18(600)660])
AD 85449 Unclassified

Presented at meeting of the Amer. Phys. Soc., Providence, R.I., Apr. 2, 1955.

Also published in Phys. Rev., v. 98: 1020-1028, May 15, 1955.

The rate of change of the oscillator strength at the K-edge of ionized potassium has been computed in a number of ways, and a few computations have been made on the L-edge. The work has been carried through by using both hydrogenic and Hartree wave functions at the level of the single-electron approximation and Hartree and Hartree-Fock wave functions when the single-electron approximation was not used. Calcium wave functions both with and without exchange have also been employed. The moment, momentum, and acceleration matrix elements have been computed. The momentum matrix element gives values most closely in agreement with experiment, and is most stable with respect to changes in the wave functions. It is followed by the acceleration and the moment in that order. The single electron approximation gives good results. If the single-electron approximation is not used, it is essential that exchange effects be included by employing the determinant form of the wave functions, and the Hartree-Fock 1-electron wave functions then give considerably better results than the ordinary Hartree functions. It also proves to be possible to substitute the wave functions of the unexcited ion of next higher atomic number, calcium, for the wave functions of potassium excited in an x-ray level without noticeable deterioration in the results. (Contractor's abstract)

PEN. 02:001

Pennsylvania U., Philadelphia.

THERMOELASTIC DAMPING AT THE BOUNDARY BETWEEN DISSIMILAR SOLIDS, by M. Lessen. [Oct. 19, 1956] [3]p. [AF 18(603)124] Unclassified

Published in Jour. Appl. Phys., v. 28: 364-366, Mar. 1957.

The problem of thermoelastic damping at the boundary between dissimilar solids is investigated for the case of small sinusoidal, longitudinal disturbances of long wavelength, propagating normally through the interface. The relevant equations are derived from thermodynamic considerations, and it is found that the mechanical energy absorption per unit time is proportional to the square root of the disturbance frequency. (Contractor's abstract)

PEN. 03:001

Pennsylvania U. [Dept. of Mathematics] Philadelphia.

CHARACTERIZATION OF ALMOST PERIODIC TRANSFORMATION GROUPS, by W. H. Gottschalk. Dec. 1955, 5p. ([AF]OSR-TN-55-217) (AF 18(600)1116)
AD 85550 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 709-712, Aug. 1956.

Let X be a compact, uniform space and let T be a multiplicative topological group operating as a (right) transformation group on X. The author treats interconnections between almost periodicity, local almost periodicity and equicontinuity of T (for definitions of terms, see Gottschalk and Hedlund, Topological Dynamics, Amer. Math. Soc. Colloq. Publ., v. 36, Providence, R.I., 1955; MR 17, 650). It is proved that T is almost periodic if and only if T is locally almost periodic and T is distal; the transformation group T is said to be distal on X provided that if $x, y \in X$ with $x \neq y$, then there is an index α of X such that $(xt, yt) \notin \alpha$ for all $t \in T$. It is also proved that if T is locally almost periodic on X, then T is not equicontinuous on X if and only if there exists a pair of distinct points of X which is syndetically proximal under T; here the pair (x, y) is said to be syndetically proximal provided that if α is an index of X, then there exists a syndetic subset A of T such that $(xa, ya) \in \alpha$ for all $a \in A$. (Math. Rev. abstract)

PEN. 03:002

Pennsylvania U. [Dept. of Mathematics] Philadelphia.

TOPOLOGICAL DYNAMICS, by W. H. Gottschalk and

PEN. 04:001 - PEN. 04:003

G. A. Hedlund. American Mathematical Soc. Colloquium Publications, v. 36. Amer. Math. Soc., Providence, R. I., 1955, 151p. incl. refs. (AF 18(600)-1116 and AF 18(600)667) Unclassified

A topological transformation group is defined to be a triple consisting of a topological space X, a topological group T and a continuous mapping $(x, t) \longrightarrow xt$ from $X \times T$ into X such that $(xt)s = x(ts)$ and $xe = x$, where e is the identity in T. In part 1, which consists of 11 sections, various concepts and theorems of dynamical systems are generalized to suitably extensive classes of topological transformation groups. Isomorphisms, homomorphisms, orbits, orbit closures, invariant subsets, etc., of topological transformation groups are defined, as are partitions and decompositions of spaces. Theorems are given stating when the orbit closures constitute a partition of X. A subset A of T is called left syndetic in T if $T = AK$ for some compact subset K of T. The period of T at x is defined to be the greatest subset P of T such that $xP = x$. The group T is said to be periodic at x if P is a syndetic subset of T. The group T is said to be recursive at x if for each neighborhood U of x there is an "admissible" subset A of T such that $xA \subset U$. Various generalizations of periodicity such as almost periodicity, regular almost periodicity and recurrence are obtained as special cases of recursion by choosing suitable classes of admissible sets. Thus many theorems can be stated and proved for all these kinds of recursions at once. In sections 4 and 5 numerous theorems on almost periodicity and regular almost periodicity, are proved under conditions on X and T which vary from theorem to theorem. In sections 7 and 8 recurrence and incompressibility are studied under the condition that T is generative, that is, T is Abelian and is generated by some compact neighborhood of the identity. It is shown that the recurrence properties are essentially equivalent to incompressibility properties. The group T is said to be transitive at x if for every open set U of X there exists $t \in T$ such that $xt \in U$. The group is said to be regionally transitive if for every two open sets U and V of X there exists $t \in T$ such that $Ut \cap V \neq \emptyset$. Transitivity is studied in section 9. In section 10 asymptoticity is studied under the condition that X is a compact metric space and T is the cyclic group generated by a homeomorphism ϕ of X onto itself. A point x is said to be (positively) asymptotic to a closed invariant set B if $x \in \mathfrak{B}$ and $\lim \varrho(x\phi^n, B) = 0$. Section 11 deals with function spaces with a view to the properties needed elsewhere. Part I is written in a very precise terse style, and definitions and theorems are given under most general conditions. It contains a fully organized presentation of topological dynamics from a certain point of view. Part II consists of three sections dealing with some specific examples of flows and has a much more classical approach to the subject. Sections 12 and 13 are respectively on symbolic dynamics and geodesic flows, subjects with which one of the authors has been intimately associated. The theorem on the topological transitivity of a geodesic flow on surfaces of constant negative curvature is proved. Section 14 is on cylinder homeomorphisms. (See also item no. IAS. 02:002) (Math. Rev. abstract, modified)

PEN. 04:001

Pennsylvania U. [Dept. of Mathematics] Philadelphia.

A NOTE ON MULTIPLY POSITIVE SEQUENCES AND THE DESCARTES RULE OF SIGNS, by I. J. Schoenberg. [1955] [9]p. (AFOSR-TN-55-434) [AF 18(600)1158] Unclassified

Published in Rend. Circ. Matem. Palermo, Series II, v. 4: 123-131, Jan.-Apr. 1955.

It is demonstrated how multiply positive sequences and their variation-diminishing property furnish a seemingly very natural proof of Obreschkoff's extension of Descartes' rule of signs to include complex zeros in a sector. So far only Obreschkoff's original proof of this extension has been available. It is considered desirable to have at least two avenues of approach to this proposition. A theorem of S. Lipka states the following: Let k be an integer, $0 \leq k \leq n$. If the polynomial $P(x)$ has the property

$$Z\left(|\arg x - \pi| \leq \frac{\pi}{k+2}\right) \geq n-k,$$

$$v(a) \leq k.$$

This theorem is generalized, and this generalization leads easily to the Obreschkoff-Descartes rule.

PEN. 04:002

Pennsylvania U. [Dept. of Mathematics] Philadelphia.

ON THE ZEROS OF THE GENERATING FUNCTIONS OF MULTIPLY POSITIVE SEQUENCES AND FUNCTIONS, by I. J. Schoenberg. July 26, 1954 [25]p. incl. refs. ([AF]OSR-TN-55-435) (AF 18(600)1158) AD 85551 Unclassified

Also published in Ann. Math., v. 62: 447-471, Nov. 1955.

The generating functions of k-times positive sequences are considered for the special case when the generating function is a polynomial. A zero-free strip for this polynomial is given, the width of the strip depending on the value of k. There is an analogous theorem for the Laplace transform of a k-times positive function in case the transform is of exponential type. (Contractor's abstract)

PEN. 04:003

Pennsylvania U. [Dept. of Mathematics] Philadelphia.

ON MULTIPLY MONOTONE FUNCTIONS AND THEIR LAPLACE TRANSFORMS, by R. E. Williamson. June 1955, 2tp. incl. refs. ([AF]OSR-TN-55-436) (AF 18-(600)1158) AD 85546 Unclassified

Also published in Duke Math. Jour., v. 23: 189-207, June 1956.

Ths analog of the Bernstetn-Widder reprssentation of completsly monotone functions on $(0,\infty)$: $f(t) = \int_0^\infty e^{-tu}\, d\beta(u)$, where $\beta(u)$ ts nondecreasing, ts given as the n-times monotons function $f(t) = \int_0^\infty [(1-ut)_+]^{n-1} d\beta(u)$, where $\beta(u)$ ts nondscreasing and bounded below and $(t)_+ = \begin{cases} t, & t \geq 0 \\ 0, & t < 0 \end{cases}$. The Laplacs transforms of these functions are characterized by ths following theorem. Let $\alpha \geq 1$ be a real number. Necessary and sufftctent condttions that the nonnsgativs function $f(s)$, $0 < s < \infty$, be the Laplace transform of a function $\varphi(t)$, such that $\varphi(t)$ tε α-times monotone and summable tn every ftnite tnterval, are that (1) $D^\alpha[s^\alpha f(s)]$ be completsly monotone and summable at the origin, (2) $\lim_{s\to\infty} f(s) = 0$, and (3) $\lim_{s\to 0} sf(s)$ exists. Transforms of 3-times monotone functions are shown to be univalent for $Re(s) > 0$.

PEN. 04:004

Psnnsylvania U. [Dept. of Mathematics] Philadelphia.

ON HAAR'S THEOREM CONCERNING CHEBYCHEV APPROXIMATION PROBLEMS HAVING UNIQUE SOLUTIONS, by J. C. Mairhuber. June 1955, 8p. refs. ([AF]OSR-TN-55-437) (AF 18(600)1158) AD 85545 Unclassifted

Also publtshed in Proc. Amer. Math. Soc., v. 7: 609-615, Aug. 1956.

A principal result is given by the following theorem. A compact subset M of a k-dimensionat Euclidean space containing at least n potnts, $n \geq 2$, may serve as the domain of definition of a set of real conttnuous functions $f_t(x), \ldots, f_n(x)$ with property D, tf and only tf M ts homeomorphic to a closed subset of the circumference of a ctrcle. The proof is obtained by use of the auxiliary theorem that a compact set M in E_n wtth the property that at most n potnts of M lte on any hyperplane of E_n is the homeomorplic tmage of a closed subset of the circumference of a circle. Property D states that the determtnant

$$\begin{vmatrix} f_1(x_1)\ f_2(x_2) \ldots f_n(x_t) \\ f_1(x_n)\ f_2(x_n) \ldots f_n(x_n) \end{vmatrix} \neq 0$$

for every set of n distinct points $x_t, \ldots, x_n$ of M.

PEN. 04:005

Pennsylvania U. [Dept. of Mathematics. Philadelphia.

APPROXIMATIONS: THEORY AND PRACTICE, by I. J. Schoenberg. 1955, 169p. incl. diagrs. ([AF]OSR-TN-55-474A) (AF 18(600)158) AD 85549 Unclassified

Notes, taken by L. H. Lange of Valparatso U., Indtana, on a sertes of lectures by Professor I. J. Schoenberg of the Universtty of Pennsylvania at the Summer Institute for Teachers of Collegiate Mathematics sponsored at Stanford U., California, by the National Sctencs Foundation, June 27-Aug. 19, 1955 are presented. The subjects treated tnclude:

Part I: Theory and Tools

Chapter 1. Interpolatton
Chapter 2. Approximatton of defintte integrals
Chapter 3. Least squares
Chapter 4. Least deviatton

Part II: Practtce and Applicattons

Chapter 1. The solution of equations
Chapter 2. The solutton of systems of linear equattons
Chapter 3. The solutton of differential equations.

PEN. 05:001

Psnnsylvania U. [Dept. of Physics] Philadelphia.

PHOTOPROTONS FROM BISMUTH (Abstract), by M. E. Tonis and W. E. Stephens. [1952] [1]p. (Sponsored jotntly by [Air Force Offtce of Sctentiftc Research under AF 33(038)20381], Atomtc Energy Commtssion, and Office of Naval Research) Unclasstfied

Presented at meeting of the Amer. Phys. Soc., Chtcago, Ill., Oct. 24-27, 1951.

Published in Phys. Rev., v. 85: 728, Feb. 15, 1952.

The high energy photoprotons from some medtum weight elements have seemed to show an angular vartation whtch suggests that they were produced by a direct photoprocess. To check tf this mechanism were present tn heavy nuclei, for which the coulomb barrter would suppress lower energy evaporated photoprotons, we have looked for photoprotons from a one-mil foil of bismuth irradiated wtth x-rays from a 24-mev betatron and recorded in nuclear emulstons. The photoproton yield observed is about 3×10^4 protons/mole/r, whtch ts smaller than the anisotropic protons observed tn Rh, Ag, and Cu. This yield is of the order of magnitude of or somewhat smaller than the yield calculated with reasonable assumptions on the Weisskopf-Ewing model. The photoproton energy distributton has a peak near 11 mev, somewhat higher than that calculated on thts model. The angular distribution seems isotropic, within the rather poor statistical uncertainties of 20 percent. Thus no evidence was found for any direct photoeffect for protons from bismuth in this energy range. (Contractor's abstract)

PEN. 05:002 - PEN. 05:006

PEN. 05:002

Pennsylvania U. [Dept. of Physics] Philadelphia.

ANGULAR DISTRIBUTION OF PHOTOPROTONS, by A. K. Mann, J. Halpern, and M. Rothman. [1952] [4]p. incl. diagrs. table. (Sponsored jointly by [Air Force Office of Scientific Research under AF 33-(038)20381], Office of Naval Research, and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 31, Feb. 1-2, 1952.

Abstract published in Phys. Rev., v. 86: 629, May 15, 1952.

Published in Phys. Rev., v. 87: 146-149, July 1, 1952.

The angular distributions of photoprotons from Cu, Ni, and Co targets irradiated with bremsstrahlung of 23-mev maximum energy have been measured. Protons from Cu and Co show a large asymmetric component which is described by the expression $(\sin\theta + 0.5 \sin\theta \cos\theta)^2$. Absorption experiments on the protons are consistent with the assignment of the asymmetric component to transitions involving discrete levels in the vicinity of the ground state of the residual nucleus. The angular distributions observed are interpreted as resulting from interference between electric dipole and quadrupole absorption of the initial photons with the relative quadrupole intensity equal to 5 percent. (Contractor's abstract)

PEN. 05:003

Pennsylvania U. [Dept. of Physics] Philadelphia.

ANGULAR DISTRIBUTION OF PHOTOPROTONS FROM CARBON, by J. Halpern, A. K. Mann, and M. Rothman. [1952] [1]p. (Sponsored jointly by [Air Force Office of Scientific Research under AF 33(038)20381], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 87: 164-165, July 1, 1952.

The photoproton angular distribution of C^{12} bombarded by bremsstrahlung of 23 mev maximum energy contains a large asymmetric component peaked in the forward direction. The curve fits the formula $(\sin^{\square} + 0.25 \sin^{\square} \cos^{\square})^2$. (C. A., 1952:8987a)

PEN. 05:004

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTO PROTONS FROM HEAVY ELEMENTS (Abstract), by W. E. Stephens and M. E. Toms. [1952.] [1]p. (Sponsored jointly by [Air Force Office of Scientific Research under AF 33(038)20381.], Office of Naval Research, and Atomic Energy Commission.) Unclassified

Presented at meeting of the Amer. Phys. Soc., Denver, Colo., June 30-July 3, 1952.

Published in Phys. Rev., v. 88: 160, Oct. 1, 1952.

The photoprotons ejected from bismuth, cerium, and barium by the 24-mev bremsstrahlung from the University of Pennsylvania betatron have been measured in nuclear emulsions. Preliminary results give yields of approximately 16×10^4 and 23×10^4 protons per mole per roentgen unit for Ce and Ba, respectively. A second run with better statistics than our previous data gives 4×10^4 p/m/r from bismuth. The yields calculated from an evaporation process are roughly 0.4×10^4, 0.07×10^4, and 0.09×10^4 p/m/r for Bi, Ce, and Ba, respectively. The angular distribution of the bismuth photoprotons is markedly asymmetric with three times as many protons at 30° and 50° as at 130° and 150°. If these asymmetric protons are ascribed to a direct photoelectric effect, then at least half of the bismuth yield is due to such an effect. It would seem reasonable then to associate the high yields from Ce and Ba also with a direct effect. The angular distribution of the photoprotons from Ce and Ba will be measured to examine this further.

PEN. 05. 005

Pennsylvania U. Dept. of Physics, Philadelphia.

ENERGY DISTRIBUTIONS OF PHOTOPROTONS FROM HEAVY ELEMENTS (Abstract), by W. E. Stephens, M. E. Toms and others. Nov. 28, 1952. [1]p. (Sponsored jointly by [Air Force Office of Scientific Research] under AF 33(038)20381, Office of Naval Research, and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., St. Louis, Mo., Nov. 28-29, 1952.

Published in Phys. Rev., v. 89: 893, Feb. 15, 1953.

The energy distributions of the photoprotons ejected from indium, cerium, and bismuth by 24-mev betatron x-rays were measured and compared with calculated distributions based on Courant's direct photoeffect and Weisskopf's evaporation process. The direct photoprotons could in these cases be partially distinguished from the evaporated protons on the basis of energy distribution. The results indicate the importance of the direct photoeffect for the (γ, p) process in heavy nuclei. (Contractor's abstract, modified)

PEN. 05:006

Pennsylvania U. Dept. of Physics, Philadelphia.

PULSE HEIGHT ANALYZER, by J. W. Thomas, V. Verbinski, and W. E. Stephens. Technical rept. Mar. 31, 1953 [13]p. incl. diagrs. [Suppl. no. 1.] [Sponsored jointly by Air Force Office of Scientific Research

under AF 33(038)20381, Office of Naval Research, and Atomic Energy Commisston] AD 13708 Unclassified

Also published in Rev. Sctent. Instruments, v. 24: 1017-1020, Nov. 1953.

A descrtption ts given of a multichannel pulse height analyzer which converts incomtng electrtcal pulses of vartous amplttudes to time gates whose durations are proportional to the tncoming putse heights. The time gate controls a 100-kc osctllator whose osctllations are counted by a scaler. The scaler total ls recorded on a paper tape tn the form of a coded sertes of black dots. The analyzer can be exposed to pulse rates of several thousand/se' and records on tape up to 50 pulses/sec. Three decades of 1, 2, 4, and 8 are normally used, and 50-v pulses give a dtgital output readtng of about 250. The tapes can later be read at 500 to 1000/hr/person. The readtng operation is the main practical ltmitation. (ASTIA abstract)

PEN. 05:007

Pennsylvania U. Dept. of Physics, Phtladelphta.

A DILATOMETRIC STUDY OF THE ORDER-DISORDER TRANSFORMATION IN Cu-Au ALLOYS (Abstract), by W. W. Sanvitle, F. C. Nix, and F. E. Jaumot, Jr. Mar. 27, 1953 [2]p. [AF 33(308)20381] Unclasstfied

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 220-22t, July 1, t953.

The order-disorder transformation in Cu-Au alloys tn the composttion range from 10 to 32.2 atomtc % Au was studied by dilatometrtc means. An interferometrtc dtlatometer was used. All samples containing greater than 17.5 atomtc % Au exhibited an anomalous peak in the curve of the coefftcient of thermal expansion as a function of temperature. A plot of the critical ordering temperature, T_C, as a function of composttion deftnes an ordered region about 25 atomtc % Au which is in agreement with that defined by resistivity. The coefficient of thermal expansion was rigorously constant above the ordering temperature (to 500°C). The data indicate that the volume expansion is sensttive to small changes in the degree of long-range order, since in all cases the region of anomalous expansion begins at temperatures from 200 to 250°C. (Contractor's abstract)

PEN. 05:008

Pennsylvania U. [Dept. of Physics] Philadelphia.

[THE PULSE HEIGHT ANALYZER tN THE OBSERVATION OF CERTAIN NUCLEAR TRANSMUTATIONS: AND THE USE OF MONOCHROMATIC TRANSMUTATTONS GAMMA RAYS FOR PHOTO DISINTEGRATION STUDIES]. July 1, 1953 [6]p. incl. diagrs. (Suppl. no. 3) [Sponsored jointly by Air Force Office of Scientific Research under AF 33(038)20381, Office of Naval Research, and Atomic Energy Commission] AD 17274 Unclassified

A discussion ts presented on the use of the pulse hetght analyzer in the observation of certain nuclear transmutations, and the use of monochromatic transmutation gamma rays for photo dtsintegrating studies. Initial work was devoted to (1) testing a scintillation detector for the measurement of neutrons, and (2) a preliminary check of the intensity of the photo neutrons from Bt produced by the Li(p,γ) gamma ray.

PEN. 05:009

Pennsylvania U. Dept. of Phystcs, Philadelphia.

SHORT-RANGE-ORDER tN A Cu-Au ALLOY (Abstract), by C. H. Sutcliffe and F. E. Jaumot, Jr. Mar. 27, 1953 [1]p. [AF 33(038)20381] Unclasstfied

Presented at meeting of the Amer. Phys. Soc., Durham and Chapel Hill, N. C., Mar. 26-28, 1953.

Published in Phys. Rev., v. 91: 221, July 1, 1953.

Short-range-order parameters have been measured ustng x-ray diffraction techniques, at three tempera tures above the crttical temperature of ordertng, for a Cu-Au alloy containing 23 atomtc % gold. The expertmental technique used was similar to that employed by J. M Cowley (Jour. Appl. Phys., v. 21:24, t950). The diffuse scattered tntensity was measures at approximately 900 potnts wtthin 1/32 of a unit cell, and corrected for the tntenstty due to factors other than short-range order. A three-dtmensionat Fourier analysts was made on the short-range order intensities. The Fourier coefficients are tnen interpreted as short-range order parameters. The data tndtcate that an alloy contatning less than 25 atomtc % Au exhibtts a greater tendency to short-range order than does an alloy at the stotchiometrtc composttion. The tendency to what Cowley has referred to in a "liquid-like distribution about an origin atom in a Cu_3Au alloy, although present, is considerably less in the 23 percent Au sample. (Contractor' s absiract)

PEN. 05:010

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTO PROTONS FtROM tn, Ce AND Bi, by M. E. Toms, E. E. Carroll, Jr. and others. Technical rept. [Mar. 31, 1953] [20]p. incl. diagrs. tables, refs. [Suppl. no. 2. (Bound with its Suppl. no. 1; AD 13708) (Sponsored jotntly by [Air Force Office of Scientific Research under AF 33(038)20381., Offtce of Naval Research, and Alomtc Energy Commisston) AD t3709 Unclassified

PEN. 05:011 - PEN. 06:002

Also published in Phys. Rev., v. 92: 362-366, Oct. 15, 1953.

The charged particles ejected from In, Ce, and Bi foils by 24-mev-betatron x-rays were observed in nuclear emulsions. The yields of photo protons, photo deuterons, and photo α particles were determined, and the energy and angular distributions of the photo protons were measured and compared with theoretical calculations based on the evaporation process and on the direct photo effect. The energy distributions observed indicate a large fraction of direct photo effect. A marked forward asymmetry was observed in the angular distributions from In and Bi.

PEN. 05:011

Pennsylvania U. Dept. of Physics, Philadelphia.

[INTERACTION OF HIGH ENERGY RADIATION] by W. E. Stephens, A. K. Mann, and D. H. Wilkinson. Final rept. Nov. 30, 1954, 16p. incl. diagrs. refs. ([AF]OSR-TR-54-37) (AF 33(038)20381) AD 51765 Unclassified

A summary is presented of the nuclear research conducted under this task. Some of the highlights of the work are listed. These include: (1) the construction of a thin lens spectrometer; (2) the investigation of electron-electron scattering using a cloud chamber; (3) the measurement of the angular distribution of photoprotons; (4) the fabrication and testing of a pulse height analyzer; (5) the testing of an anthracene crystal, coupled with a scintillation counter, for detecting protons; and (6) production of photoneutrons in Bi using Li γ rays from a stalliron.

PEN. 05. 0t2

Pennsylvania U. [Dept. of Physics] Philadelphia.

ENERGY SPECTRUM OF PHOTOPROTONS FROM CARBON, by W. E. Stephens and A. K. Mann. [Nov. 30, 1954] 3p. incl. diagrs. [AFOSR-TR-54-37(A)] (AF 33(038)20381) (Also bound with its AFOSR-TR-54-37; final rept.; AD 51765 as Appendix A) AD 51765(a) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 26-27, 1954.

Abstract published in Bull. Amer. Phys. Soc., v. 29: 26, Nov. 26, 1954.

Abstract published in Phys. Rev., v. 98: 241, Apr. 1, 1954.

The photoprotons ejected from a 6 mg/sq cm thick C foil by 23-mev bremsstrahlung [braking radiation] have been observed in nuclear emulsions. The ranges of 408 protons which entered the emulsions in the proper direction were measured. The proton energy distribution has a peak at 5.5 mev and a width at half maxium of about 2.8 mev. These values confirm the previous determination of the giant resonance in C which had been obtained from yield curve data. The width of the proton spectrum is consistent with transitions from a single broad level in C^{12} to the ground state of B^{11}, but transitions to the first excited state of B^{11} appear to be inhibited. (Contractor's abstract)

PEN. 05:013

Pennsylvania U. [Dept. of Physics] Philadelphia.

EVIDENCE FOR AN INDEPENDENT PARTICLE STATE OF C^{12} AT HIGH EXCITATION, by A. K. Mann, W. E. Stephens, and D. H. Wilkinson. [Nov. 30, 1954] 4p. [AFOSR-TR-55-3] (AF 33(038)20381) (Also bound with its AFOSR-TR-54-37; final rept.; AD 51765 as Appendix B) AD 51765(b) Unclassified

Also published in Phys. Rev., v. 97: 1184-1185, Feb. 15, 1955.

Data are presented showing that the reaction C^{12} (γ, p) B^{11} indicates that the "giant resonance" state at about 22 mev excitation is of an independent particle character. It is simply related by its shell model description to the ground state of C^{12} and to the low-lying levels of B^{11}.

PEN. 06:001

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTON ABSORPTION CROSS SECTIONS IN BISMUTH AND TANTALUM, by J. Halpern, R. Nathans, and A. K. Mann. [1952] [2]p. incl. diagrs. refs. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 88: 679-680, Nov. 1, 1952.

Neutron-yield curves, excitation functions for neutron yield, and total cross section curves are shown for photon energies of 7-25 mev. The total integrated cross section for Ta is 2.8 mev-barns and for Bi, 3.0 mev-barns. In each case the γ 2n reaction contributes approximately 15% and the γ,n reaction the remainder. (C. A., 1953:3145i)

PEN. 06:002

Pennsylvania U. Dept. of Physics, Philadelphia.

(γpn) REACTION IN PHOSPHORUS, by J. Halpern, A. K. Mann, and R. Nathans. [1952] [1]p. incl. diagrs. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 88: 958, Nov. 15, 1952.

Absolute values for the cross section for the (γ, n) and (γ, pn) reactions in phosphorus were obtained by a measurement of the efficiency of a neutron detection apparatus using a Ra-Be source of known strength. The values 0.099 mev-barns and 0.047 mev-barns were obtained for the (γ,n) and (γ,pn) reactions, respectively.

PEN. 06:003

Pennsylvania U. Dept. of Physics, Philadelphia.

PHOTODISINTEGRATION OF THE DEUTERON AT 20 MEV, by J. Halpern and E. V. Weinstock. [1953] [6]p. incl. illus. diagrs. table. refs. (Sponsored jointly by [Air Force Office of Scientific Research] under AF 18(600)472, Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 91: 934-939, Aug. 15, 1953.

Counter techniques have been applied to a study of the proton angular distribution in the photodisintegration of the deuteron induced by bremsstrahlung photons from a betatron in the energy interval 18-22 mev. The measured distribution is given by $A + \sin^2\theta(1 + 2\beta\cos\theta)$, with $A = 0.132 \pm 0.041$ and $\beta \cong 0.1$. The total cross section is also measured. (Contractor's abstract)

PEN. 06:004

Pennsylvania U. Dept. of Physics, Philadelphia.

SYSTEMATICS OF PHOTONEUTRON REACTIONS, by R. Nathans and J. Halpern. [1953] [1]p. incl. diagrs. table. (AF 18(600)472) Unclassified

Published in Phys. Rev., v. 92: 207, Oct. 1, 1953.

Photoneutron yields were measured using a direct neutron detection method, of thirteen singly isotopic elements (C, P, V, Mn, Co, As, Nb, Rh, I, Ta, Au, Bi, U) when irradiated with betatron bremsstrahlung at energies from threshold to 24 mev. Excitation functions constructed from the total neutron yield data by the successive subtraction method show the characteristic large dipole resonance behavior for all the elements investigated. Significant parameters for the resonances are tabulated. The log-log plot is included of the bremsstrahlung energy where maximum cross section values occur ($E\sigma_m$) against mass number. The least-squares straight line through experimental points yields $E\sigma_m = 38.5A^{-0.19}$, in close agreement with previous determinations and predictions. A plot of the dipole resonance half-widths against neutron number shows a slow decrease in half-widths as N increases, with the exception of four elements having unusually narrow resonances. The correlation of these elements, C^{12} (N 6), V^{51} (N 28), Nb^{93} (N 52), and Bi^{209} (N 126), with the shell model is unusual for phenomena concerned with such high excitation energies.

PEN. 06:005

Pennsylvania U. Dept. of Physics, Philadelphia.

STUDIES IN PHOTONUCLEAR REACTIONS. Annual rept. Oct. 15, 1953 [8]p. incl. illus. (AF 18(600)-472) AD 19603 Unclassified

Progress in efforts directed to increasing the beam spread of a betatron, eliminating particle pile-up in counters, and developing a high-speed discriminator is briefly reviewed. The completed research is summarized. A large paraffin-BF_3 counter house was used to determine the (γ, n) yields and excitation functions of 14 singly isotopic elements. The parameters of the giant dipole γ-ray adsorption resonance were studied. Systematic trends in half width, position of the resonance maximum, the integrated cross section, and the value of the maximum cross sections were in accordance with the sum-rule predictions of Levinger and Bethe. The energy at peak cross section varied as $38.5A^{-0.186}$; the widths of the giant resonances showed a slowly decreasing behavior with atomic no. Ta, Pt, Pb, W, and Au showed photo-proton yields of 5.7×10^4, 2.9×10^4, 5.8×10^4, 5.2×10^4, and 1.9×10^4 protons/mol/roentgen, respectively, in measurements using ZnS screens and a spread x-ray beam at 22 mev. These yields were consistent with those obtained for heavy elements by Stephens with photographic plates. A rough determination of the (γ, p) angular distribution of Ag showed the same general features as the distributions from Cu and Co which were previously reported, but a larger quadrapole-interference term was obtained. A block diagram and the circuit of the fast pulse discriminator are presented.

PEN. 06:006

Pennsylvania U. Dept. of Physics, Philadelphia.

EXCITATION FUNCTION FOR THE PHOTODISINTEGRATION OF BERYLLIUM, by R. Nathans and J. Halpern. Nov. 15, 1953 [2]p. incl. diagrs. (AF 18-(600)472) Unclassified

Published in Phys. Rev., v. 92: 940-941, Nov. 15, 1953.

Using filtered betatron bremsstrahlung, the Be^9 (γ, n) excitation function was determined from threshold to 24 mev. The results showed two peaks, one due to excitation of the odd neutron and the second to the excitation of the Be^8 core. (Contractor's abstract)

PEN. 06:007

Pennsylvania U. Dept. of Physics, Philadelphia.

SYSTEMATICS OF PHOTONEUTRON REACTIONS, by R. Nathans and J. Halpern. [1954] [6]p. incl. diagrs. table, refs. (Sponsored jointly by [Air Force Office of Scientific Research, under AF 18(600)472],

PEN. 06:008 - PEN. 06:011

Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 93: 427-442, Feb. 1, 1954.

Properties of the giant dipole resonances for (γ, n) reactions have been measured for 14 singly-isotopic elements distributed throughout the range of z values. Systematics are reported for the behavior of the integrated cross sections, the energies at which the dipole resonances attain a maximum cross section, the values of the cross sections at these energies, and the widths of the resonances. Anomalously narrow widths are reported for elements with neutron numbers in the vicinity of the magic numbers. (Contractor's abstract)

PEN. 06:008

Pennsylvania U. [Dept. of Physics] Philadelphia.

SYSTEMATICS OF PHOTOPROTON REACTIONS, by E. V. Weinstock and J. Halpern. [1954] [4]p. incl. diagrs. table. refs. (Sponsored jointly be [Air Force Office of Scientific Research under [AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 94: 1651-1654, June 15, 1954.

The photoproton yields from the elements Ta, Pt, Pb, W, and Au have been determined for betatron bremsstrahlung bombardment at 22-mev peak energy by the use of zinc sulfide detectors and a 40-μsec betatron pulse duration. The yields, as measured in photoprotons per mole per roentgen are as follows; Ta, 5.7×10^4; Pt, 2.9×10^4; Pb, 5.8×10^4; W, 5.2×10^4; and Au, 1.9×10^4. These values, along with previous determinations, permit a study of general behavior of photoproton yields for all Z values throughout the periodic table. Compartsons with calculations based on the evaporation model show good agreement with experimental trends up to a Z of 50, after which the measured yields are too high by factors ranging from 10 to 10^4. Calculations based on the direct photoelectric process give better agreement. (Contractor's abstract)

PEN. 06:009

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTONEUTRON ANGULAR DISTRIBUTIONS (Abstract), by K. Geller, J. Halpern, and P. F. Yergin. [1954] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C. Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 659, July 15, 1954.

The angular distributions of photoneutrons produced by 22 mev bremsstrahlung on Pb, Ag, and Cu have been measured using a lucite-zinc sulfide fast neutron detector. The results do not show any significant nonisotropy. If the distributions are fitted to the form $A + B \sin^2\theta$, the value of B/A consistent with the data for any of the elements could not exceed 0.12. If we make approximate estimates of the neutron energy distributions for two different models, the evaporation model and Courant's direct photoeffect model, and if we assume that all of the nonisotropic component is the result of direct photoeffect, and take into account the measured energy sensitivity of the type of detector used, then the cross section for direct photoeffect production of the nonisotropic component is not more than 1 percent of the total cross section for Cu, and must be considerably less for Ag and Pb, for which the data is better. (Contractor's abstract)

PEN. 06:010

Pennsylvania U. [Dept. of Physics] Philadelphia.

SYSTEMATICS OF PHOTOPROTON YIELDS (Absiract), by E. V. Weinstock and J. Halpern. [1954] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 630, July 15, 1954.

The photoproton yields from the elements Ta, Pt, Pb, W, and Au have been determined for betatron bremsstrahling bombardment at 22-mev peak energy by the use of zinc sulfide detectors and a 50-μsec betatron pulse duration. The yields, as measured in photoprotons per mole per roentgen, are as follows: Ta, 5.7×10^4; Pt, 2.9×10^4; Pb, 5.8×10^4; W, 5.2×10^4; and Au, 1.9×10^4. These values, along with previous determinations, permit a study of general behavior of photoproton yields for Z values throughout the periodic table. Comparisons with calculations based on the evaporation model show good agreement with experimental trends up to a Z of 50, after which the measured yields are too high by factors ranging from 10 to 10^4. Calculations based on the direct photoelectric process give better agreement, though still too low by a factor of 10. (Contractor's abstract)

PEN. 06:011

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTONEUTRON CROSS SECTION IN He, N, C, F, Ne, and A, by G. A Ferguson, J. Halpern and others. [1954] [5]p. incl. dtagrs. table, refs. (Sponsored jointly by [Air Force, Office of Scientific Research under [AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 95: 776-780, Aug. 1, 1954.

The direct detection of neutrons from (γ, n) reactions induced by betatron bremsstrahlung has been applied to cross-section determinations using gaseous targets at approximately 100 atmospheres pressure. Results from oxygen are consistent with other determinations. The remaining elements represent new results and show the familiar giant dipole resonance for the photoneutron process. Parameters of the resonances are determined and related to the systematic behavior previously reported for other elements. (Contractor's abstract)

PEN. 06:012

Pennsylvania U. [Dept. of Physics] Philadelphia.

A ^{40}(γ, n) THRESHOLD AND THE MASS OF A^{39}, by J. Halpern, R. Nathans, and P. F. Yergin. [1954] [2]p. incl. diagrs. (Sponsored jointly by [Air Force] Office of Scientific Research under [AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 95: 1529-1530, Sept. 15, 1954.

The A^{40}(γ, n)A^{39} reaction is found to have a threshold at 9.85 + 0.15 mev. Using the most recent mass spectrograph measurements for the mass of A^{40}, the mass of A^{39} is calculated to have a value of 38.97681 + 0.00020. The relationship of this measurement to other reaction energy data is discussed. (Contractor's abstract)

PEN. 06:013

Pennsylvania U. [Dept. of Physics] Philadelphia.

(γ, n) CROSS SECTIONS IN Mg ^{24} and Mg ^{25} (Abstract), by R. Nathans and P. F. Yergin. [1955] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98:1198, May 15, 1955.

The cross sections have been measured by neutron detection using separated isotope targets from ORNL (1.77 and 0.50 g of isotope, respectively). Both "giant resonance" peaks occur at about 20 mev, as does the previously reported Mg^{25}(γ, n) peak. An unusual feature of our results is that both the peak and integrated (to 24 mev) cross sections for Mg^{25}(γ, n) are about twice those for Mg^{24}(γ, n). About ¾ of the integrated cross section for Mg^{24}(γ, n) is between threshold and the onset of the giant resonance. Our results are in contradiction to the report that the peak of the giant resonance for Mg^{25}(γ, n) is about 13 mev, which would result in far more protons than neutrons being emitted at the higher energies. These observations were described to threshold differences. The thresholds involved are: Mg^{24}(γ, n)16.6 mev, Mg^{25}(γ,p)12.1 mev; Mg^{25}(γ, n)7.3 mev. No such threshold effect was found.

PEN. 06:014

Pennsylvania U. [Dept. of Physics] Philadelphia.

(γ, n) CROSS SECTIONS IN Zr ^{90} and Zr ^{91} (Abstract), by R. Nathans and P. F. Yergin. [1955] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of Amer. Phys. Soc., New York, Jan. 27-29, 1955.

Published in Phys. Rev., v. 98: 1197, May 15, 1955.

The (γ, n) thresholds of these isotopes are widely separated (12.1 and 7.2 mev respectively) because Zr^{90} has a "magic number" (50) of neutrons. By direct neutron detection, using separated isotopes from ORNL, it was found that despite this the location and magnitude of the peak of the giant resonance is the same for each isotope and agrees well with the previously reported photoneutron systematics. The half-widths of the Zr^{90}, Zr^{91} and the previously measured Nb^{93} resonances increase progressively with the neutron numbers (50, 51, and 52 respectively) but all are narrower than expected from the systematics. This reinforces the previous observation that nuclides at or near the magic neutron numbers 28, 50, 82 and 126 have unusually narrow giant resonances.

PEN. 06:015

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTONEUTRON CROSS SECTIONS IN Mg ^{24}, Mg ^{25}, Zr ^{90}, Zr ^{91}, by R. Nathans and P. F. Yergin. [1955] [4]p. incl. diagrs. tables, refs. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 98: 1296-1299, June 1, 1955.

The variation of σ(γ, n) with E_γ from threshold to 2 mev has been measured by detecting neutrons produced from betatron bremsstrahlung irradiation of separated isotope samples in oxide form. Despite the large threshold differences (9.3 mev for the Mg isotopes and 5.0 mev for the Zr isotopes) the peaks of the giant dipole resonances are very close for each pair of adjacent isotopes: Mg^{24}, 19.5 mev; Mg^{25}, 20.3 mev; Zr^{90}, 16.4 mev; Zr^{91}, 16.3 mev. The half-widths of the Zr resonances are unusually small, 4.1 and 5.4 mev, compared to 8 mev for nearly nuclei observed previously. This is apparently a "magic number" effect. (Contractor's abstract)

PEN. 06:016

Pennsylvania U. [Dept. of Physics] Philadelphia.

Mg(γ, n) CROSS SECTION (Abstract) by P. F. Yergin

PEN. 06:017 - PEN. 06:020

and B. P. Fabricand. [1955] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 25-26, 1955.

Published in Phys. Rev., v. 100: 1249, Nov. 15, 1955.

The published data for natural Mg and for Mg^{25} disagree somewhat in the energy region below 11 mev where only $Mg^{25}(\gamma, n)$ can contribute to the neutrons detected. Above the $Mg^{26}(\gamma, n)$ threshold at 11.1 mev, however, a more serious disagreement occurs. If the measured Mg^{25} yield is subtracted from the published natural Mg yield, the resulting "$Mg^{26}(\gamma, n)$" cross section from its threshold to the $Mg^{24}(\gamma, n)$ threshold at 16.6 mev, is extremely different from that of Mg^{25} in the same region. This has been investigated by remeasuring the natural $Mg(\gamma, n)$ cross section, using a sample of MgO. Our yields disagree with the published values in the region in question. If the Mg^{25} yield is subtracted from our measured natural Mg yield, the resulting "$Mg^{26}(\gamma, n)$" yield resembles very closely that of Mg^{25} in the same region. Spectroscopic analysis of our sample showed no significant impurities. (Contractor's abstract)

PEN. 06:017

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTONEUTRON ANGULAR DISTRIBUTION FROM CARBON (Abstract), by B. P. Fabricand, B. Allison, and J. Halpern. [1955] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 25-26, 1955.

Published in Phys. Rev., v. 100: 1249, Nov. 15, 1955.

Previous measurements of the photoproton angular distribution arising from the giant dipole resonance in the reaction $C^{12}(\gamma, p)B^{11}$ have yielded a distribution of the form $2 + 3 \sin^2\theta$. This has been interpreted as evidence for an independent particle description of the giant resonance and for the LS coupling scheme. In the hope of studying the process of the direct emission of photoneutrons, the angular distribution was measured of neutrons from the giant dipole resonance in the reaction $C^{12}(\gamma, n)C^{11}$ using a zinc sulfide-paraffin-plastic scintillator as the neutron detector. In contrast to the results for photoprotons from carbon, the photoneutrons show a dip at 90° and a distribution that can be fitted by an expression of the form $a + b\cos^2\theta$. The results are analyzed from the standpoint of distributions expected from the possible channel spins involved. (Contractor's abstract)

PEN. 06:018

Pennsylvania U. [Dept. of Physics] Philadelphia.

$Sr^{86, 87, 88}$, Y^{89}, $Zr^{92}(\gamma, n)$ CROSS SECTIONS (Abstract), by P. F. Yergin and B. P. Fabricand. [1955] [1]p. [AF 18(600)472] Unclassified

Presented at meeting of Amer. Phys. Soc., Chicago, Ill., Nov. 25-26, 1955.

Published in Phys, Rev., v. 100: 1269, Nov. 15, 1955.

These cross sections were measured from threshold to 23 mev. All show the usual giant resonance, at about 16 mev. The width of the resonances show systematic variation not attributable to $(\gamma, 2n)$ or (γ, pn) contributions. They provide further evidence of the effect of the magic neutron number, 50, on the giant resonance width. The lesser widths are not associated with greater heights; instead the integrated cross section decreases substantially when the peak becomes narrower. It was also observed that the rise of the cross section into the peak, from 12.5 to 15.5 mev, is almost exactly the same in shape and magnitude for all 5 isotopes, as well as for the previously measured Zr^{90} and Zr^{91}. In agreement with the conjecture of Wapstra the $Sr^{86}(\gamma, n)$ threshold was found to be about 11.5 mev, not at 9.5 mev as previously reported. (Contractor's abstract)

PEN. 06:019

Pennsylvania U. [Dept. of Physics] Philadelphia.

BREMSSTRAHLUNG SPECTRUM FROM THE INTERNAL TARGET OF A 22-MEV BETATRON, by E. V. Weinstock and J. Halpern. [1956] [6]p. incl. diagrs. table, refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 100: 1293-1298, Dec. 1, 1955.

The intensity and energy distribution of the bremsstrahlung photons produced in a betatron operating at 22 mev have been determined by measurement of the energy spectrum of photoprotons ejected from deuterium. The protons were detected using a 0.15 cm thick NaI crystal followed by a 100-channel pulse-height analyzer. The photon beam was highly collimated in the forward direction. If one assumes the energy dependence of the cross section for the photodisintegration of deuterium as given by Hulthén, the computed bremsstrahlung energy distribution is in excellent agreement with the theoretical thin-target spectrum. The observed total intensity is that indicated by monitoring using an "R" thimble imbedded in 3.9 cm of Lucite. (Contractor's abstract)

PEN. 06:020

Pennsylvania U. [Dept. of Physics] Philadelphia.

ANGULAR DISTRIBUTION OF PHOTONEUTRONS FROM CARBON AND BERYLLIUM, by B. P. Fabricand,

B. A. Allison, and J. Halpern. [1956] [3]p. incl. diagrs. refs. (Sponsored jointly by Air Force Office of Scientific Research under [AF 18(600)472], Office of Naval Research, and Atomic Energy Commission)
Unclassified

Published in Phys. Rev., v. 103: 1755-1757, Sept. 15, 1956.

The photoneutron angular distributions from carbon and beryllium have been measured by using bremsstrahlung of maximum energies of 23 mev and 18 mev, respectively. The results are $1 + (1.35 \pm 0.88) \sin^2\theta$ for carbon and $(1.26 \pm 0.11) + \sin^2\theta$ for beryllium. (Contractor's abstract)

PEN. 06:021

Pennsylvania U. [Dept. of Physics] Philadelphia.

(γ, n) CROSS SECTIONS OF NUCLIDES NEAR NEUTRON NUMBER 50, by P. F. Yergin and B. P. Fabricand. [1956] [6]p. incl. diagrs. tables, refs. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 104: 1334-1339, Dec. 1, 1956.

Measurement of the (γ, n) cross sections of the nuclides Sr^{86}, Sr^{87}, Sr^{88}, Y^{89}, Zr^{92}, together with earlier measurements for the nuclides Zr^{90}, Zr^{91}, and Nb^{93}, show a pronounced narrowing of the giant dipole resonances in the region of neutron number 50, the narrowest resonances being those for the 50-neutron nuclides. Possible confusion of the interpretation of the data due to (γ, 2n) and (γ, pn) processes is shown to be inadequate to explain the observed effects, and the narrowing is concluded to be real, in agreement with the prediction of the prediction of the single-particle model of Wilkinson. The changes in widths are observed to occur entirely on the high-energy sides of the curves, the low-energy sides being remarkably similar for all 8 nuclides. A regularity in the behavior of the peak values of the cross sections is also observed. The (γ, n) threshold of Sr^{86} is observed to be at about 11.5 mev, in agreement with other reaction data, but in disagreement with an earlier tentative assignment based on neutron yield measurements on natural Sr. (Contractor's abstract)

PEN. 06:022

Pennsylvania U. [Dept. of Physics] Philadelphia.

PHOTONEUTRON YIELDS FROM NATURAL MAGNESIUM, by P. F. Yergin. [1956] [3]p. incl. diagrs. (Sponsored jointly by [Air Force Office of Scientific Research under AF 18(600)472], Office of Naval Research, and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 104: 1340-1342, Dec. 1, 1956.

Published measurements of the cross sections of the (γ, n) reaction in natural Mg and in Mg^{25} are in disagreement in the energy region where the other Mg isotopes do not contribute to the cross section of the natural sample, and imply a most unusual cross-section curve for the Mg^{26} isotope at slightly higher energies. A new measurement of the cross section for natural Mg is reported which disagrees strongly with the published data, but agrees with the Mg^{25} values, and implies a not-surprising cross-section curve for Mg^{26}. The origin of the disagreement in the natural-sample cross-section values is unknown. (Contractor's abstract)

PEN. 07:001

Pennsylvania U. Dept. of Physics, Philadelphia.

[NOISE IN ELECTRICAL DISCHARGE THROUGH GASES], by W. L. Fite. Final rept. Dec. 15, 1952-Aug. 31, 1954. iv. incl. illus. diagrs. refs. ([AF]-OSR-TR-54-28) (AF 18(600)487) AD 47514
Unclassified

Studies made on low frequency fluctuations (less than 300 kcps) in electrical discharges through gases at low pressure are described. Single- and double-probe techniques were applied to cold cathode glow discharges, hot cathode arc discharges, and radio-frequency electrodeless discharges. The fluctuations in positive ion beams from radio-frequency electrodeless discharge sources were examined, with the primary result being that ion-beam noise is very close to shot-effect noise. Some theoretical considerations of random effects are included. (Contractor's abstract)

PEN. 08:001

Pennsylvania U. Dept. of Physics, Philadelphia.

EFFECT ON DISTRIBUTION OF LATTICE DEFECTS WITHIN CRYSTALS OF LINEAR EXPANSION AND X-RAY LATTICE CONSTANT, by P. H. Miller, Jr. and B. R. Russell. [1953] [2]p. (AF 18(600)561)
Unclassified

Published in Jour. Appl. Phys., v. 24: 1248-1249, Sept. 1953.

It is asserted that for randomly distributed Frenkel defects the relative changes in x-ray lattice constant and in linear dimensions are virtually the same. The only cases in which Frenkel defects might give rise to an x-ray expansion differing from the macroscopic linear expansion are those for which the distribution of defects is spatially non-uniform within the crystal.

PEN. 08:002

Pennsylvania U. Dept. of Physics, Philadelphia.

THE THERMAL EXPANSION OF IONIC CRYSTALS, by L.-Y. Lin. Feb. 1954, 11p. incl. illus. (Technical

PEN. 08:003 - PEN. 08:005

rept. no. 2) ([AF]OSR-TN-54-32) (AF 18(600)561) AD 29701 Unclassified

The coefficient of thermal expansion of LiF and KI crystals was determined in the 20° to 300°C range with a capacitance type dilatometer. The instrument operates by measuring the variation in capacitance between a fixed and a movable plate. The device uses the variation in capacitance to change the resonant frequency of a HF oscillator, and a discriminator to convert the frequency changes into current changes; the latter are indicated by the deflection of a galvanometer. A limiting amplifier is used to free the instrument from errors which might otherwise be caused by amplitude variation in the discriminator input. The average values of the expansion coefficients agree within 1% in most cases to the dilatometer measurements made by Gott (Ann. Phys., v. 41: 520, 1942) for the same crystals. The x-ray measurements which Gott made of the thermal expansion of these crystals are believed to be in error by several percent.

PEN. 08:003

Pennsylvania U. Dept. of Physics, Philadelphia.

EFFECT OF DISTRIBUTION OF LATTICE DEFECTS WITHIN CRYSTALS UPON X-RAY LATTICE CONSTANT AND MACROSCOPIC LINEAR EXPANSION, by B. R. Russell. July 24, 1953 [14]p. incl. diagr. tables. (Technical rept. no 1) (AFOSR-TN-54-48) (AF 18(600)-561) AD 19715 Unclassified

Owing to a discrepancy between the results obtained by P. H. Miller and B. R. Russell (item no. PEN. 08:001) and those found by J. D. Eshelby, the original calculations were reviewed and new calculations were made. The original calculations involved the assumption of simple superposition of the effects produced by single defects; the new calculations consider the whole distribution of defects (in first approximation at least), andthe results indicate the effects of nonuniformity of the distribution quite clearly. By interpolating, it is concluded that for uniform distributions of Frenkel defects there is little, if any, difference betwenn the expansion measured by means of x-rays and that observed by means means of x-rays and that observed by means of a dilatometer. A check of the original calculations disclosed an error in 1 important case which was sufficient to account for the discrepancy first noted. All of the results now seem to be in substantial agreement.

PEN. 08:004

Pennsylvania U. [Dept. of Physics] Philadelphia.

CHANGE IN LENGTH OF ALKALI HALIDE CRYSTALS CAUSED BY X-RAY IRRADIATION (Abstract), by L.-Y. Lin and B. R. Russell. [1955] [1]p. [AFOSR-TN-55-53] [AF 18(600)561] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 657, July 15, 1955.

Potassium and sodium chloride crystals (about 12mm x 7mm x 1.5mm) at room temperature were irradiated with x-rays in a thermostated enclosure regulated to 10^{-2} °C. The crystals were about 2¼ inches from the x-ray tube beryllium window. The change in length of the largest dimension of the crystal was measured during the irradiation by a capacitance-type dilatometer with sensitivity 10^{-8}cm. The F center density calculated from the increase in length per unit length (assuming one ion pair at the surface for each pair of lattice vacancies) agreed within 5 percent with the number of color centers determined subsequently by optical absorption measurement. For example: $\Delta l/l = 6.1 \times 10^{-7}$, n (calculated) = 4.1×10^{16} cm^{-3}, n (optical, colored portion) = 3.9×10^{16} cm^{-3} for NaCl; $\Delta l/l = 1.36 \times 10^{-8}$, n (calculated) = 6.6×10^{16} cm^{-3}, n (optical) = 6.7×10^{16} cm^{-3} for KCl. These crystals were uncolored in about 30 percent of their volume as they were larger than the x-ray beam. Using a slightly smaller crystal to get uniform coloration throughout the whole crystal, $\Delta l/l = 4.3 \times 10^{-7}$, n (calculated) = 2.1×10^{16} cm^{-3}, n (optical) = 2.0×10^{16} cm^{-3} for KCl. (Contractor's absiract)

PEN. 08:005

Pennsylvania U. Dept. of Physics, Philadelphia.

THE CHANGE OF LENGTH OF IONIC CRYSTALS DUE TO X-RAY IRRADIATION, by L.-Y. Lin. June 1955, iv. incl. diagrs. tables, refs. (Technical rept. no. 3) ([AF]OSR-TN-55-103) (AF 18(600)561) AD 64017 Unclassified

In this study, the potassium chloride and sodium chloride crystals (about 12 mm by 8 mm by 1.5 mm) at room temperature both in air and in helium atmosphere are irradiated up to 3 hr with x-rays (48 kv at 18 ma). The crystals are placed in a thermostated enclosure regulated to 0.01°C, 2.5 in. from the x-ray tube beryllium window. The change in length of the largest dimension of the crystal is measured during the irradiation by a capacitance type dilatometer with sensitivity 10^{-8} cm. It is found that the number of F-centers/unit volume calculated from the increase in length/unit length agrees within 5% with the number of color centers/unit volume determined subsequently by optical absorption measurement. A series of measurements has been carried out with different irradiation times, and it is found that the relation between the relative expansion of crystal and the density of F-centers is linear. It is also found that the relative expansion of the crystal does not depend on the dimensions of the colored part of the crystal. Supplementary experiments indicate that this is caused by the formation of defects throughout the crystal even though only a small fraction of the volume is directly exposed to the x-ray beam. In all cases, a short time lag occurs between the start of the irradiation and the initial expansion of the crystal: for KCl the lag is about 20 min, and for NaCl it is about 30 min. In addition, the expansion is always found to continue for about 6 min

after the x-rays are turned off. Bleaching experiments have also been performed on crystals prevtously colored using light wave-length of 560 mμ for KCl and 450 mμ for NaCl. The crystats neither contract nor expand when the density of F-centers is reduced from about 10^{17} cm^{-3} to less than 10^{15} cm^{-3}. The time for bleaching is aboul 30-40 mtn. (Contractor's abstract, modified)

PEN. 08:008

Pennsytvania U. Dept. of Physics, Philadelphia.

RATE OF FORMATION OF F-CENTERS IN PARTIALLY X-RAY IRRADIATED ALKALI HALIDE CRYSTALS (Abstract), by L.-Y. Lin and M. E. Caspari. [1956] [1]p. [AF 18(800)561] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 213, Apr. 28, 1958.

The over-alt relative linear expansion of partially x-ray irradiated potassium and sodium chtoride crystals was found to be proportional to the average F-center concentration in the trradiated portion, but not to the F-center concentration averaged over the whole crystat. Further experiments have shown that the rate of formation of F-centers in partially x-ray irradiated crystats is directly proportional to the fraction of the votume which is exposed to the irradiation and that the F-center concentration after a certain period of irradiation in a previousty uncolored part is greatly increased by first irradiating an adjacent part. These experiments indicate the presence of a targe number of vacancies in the nontrradiated portion of the crystal. The diffusion of vacancies in alkali hatide crystals is not large enough to account for this rapid transfer of vacanctes, but slip processes may possibly explain the effects. (Contractor's abstract)

PEN. 08:007

Pennsylvania U. Dept. of Physics, Philadelphia.

EXPANSION OF POTASSIUM AND SODtUM CHLORIDE CRYSTALS DUE TO X-RAY IRRADIATION OF WEAK INTENSITIES, by L.-Y. Lin. [1956] [7]p. incl. illus. diagrs. tables, refs. [AF 18(800)581] Unclassifted

Published in Phys. Rev., v. 102: 988-974, May 15, 1956.

Rectangular cteaved samples of potassium and sodium chloride crystals having dimensions of about 12 x 10 x 15 mm were irradiated for times up to three hours with x-rays (48 kv at 18 ma) from a molybdenum target tube passing through a beryllium window at room temperature in air and in helium atmospheres. The crystals were placed tn a thermostatted enclosure regutated to within 0.01°C. The crystals were about 2¼ tn. from the x-ray tube beryllium wtndow. The change in length of the largest dtmenston of the crystal was measured during and after the irradiation by a capacitance-type dilatometer with a senstttvity of 10^{-8} cm. A series of measurements were carrted out emptoying different times of irradiation and it was found that the relation between the relative linear expansion of the crystat and the optically determtned average concentration of F-centers was linear with a constant of proportionality remarkably close to the value of $d^3/12$, where d is the tattice constant of the crystal. There was a time delay o' about 20-30 minutes before the expansion could be detected. This time delay was increased by ptastic deformation. The results did not depend on the fraction of the crystal volume which was irradtated. The rate of formation of a certain P-center concentration in the irradiated portion of the crystal was directly proportional to the fraction of the votume exposed to the irradiation. In partially irradiated crystats, the rate of formation of F-centers in the nonirradiated portion upon subsequent trradiation was greatly increased by the presence of the adjacent irradiated part. The merits of possible models to explain these results are discussed. (Contractor's abstract)

PEN. 09:001

Pennsylvania U. [Dept. of Physics] Phitadelphia.

EVIDENCE FOR AN INDEPENDENT PARTICLE STATE OF C^{12} AT HIGH EXCITATION, by A. K. Mann, W. E. Stephens, and D. H. Wilkinson. [1955] 2p. (Sponsored jointly by Atomic Energy Commission and [Air Force] Office of Sctentific Research under [AF 18-(600)894]) Unclassified

Published in Phys. Rev., v. 97: 1184-1185, Feb. 15, 1955.

Current evidence concerning the reaction C^{12} (γ, p)B^{11} shows that the "giant resonance" state at approximately 22 mev excitation is of an tndependent-particle character. It is simply related by its shell model description to the ground state of C^{12} and to the low-lying levels of B^{11}.

PEN. 09:002

Pennsylvania U. [Dept. of Physics] Philadelphia.

ELASTIC SCATTERING OF .41 AND .66 MEV GAMMA RAYS BY TIN AND LEAD (Abstract), by A. K. Mann. [1955] [1]p. [AF 18(800)894] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, ttl., Nov. 26-27, 1954.

Pubtished in Phys. Rev., v. 98: 234, Apr. 1, 1955.

Collimated beams of 0.41 and 0.66 mev gamma rays

PEN. 09:003 - PEN. 09:006

were scattered from tin and lead targets and the absolute differential cross sections for elastic scattering measured at five angles between 15 and 75 degrees. The scattered radiation was detected with a NaI scintillation counter to select only the energy region of elastic scattering. At the smaller angles, the degraded radiation from Compton scattering was subtracted empirically by comparing the tin and lead scattering with that from an aluminum target containing the same number of electrons. At these energies the predominant mode of elastic scattering should be Rayleigh scattering from the tightly bound electrons. Within the experimental error of about 10 percent the measured differential cross sections for lead at both 0.41 and 0.66 mev do not differ significantly from the calculation of Rayleigh scattering made by Franz using the Thomas-Fermi model. For tin at 0.66 mev the measured values at large angles appear to be less than those given by Franz, but no such disagreement is evident at 0.41 mev.

PEN. 09:003

Pennsylvania U. [Dept. of Physics] Philadelphia.

ENERGY SPECTRUM OF PHOTOPROTONS FROM CARBON (Abstract), by W. E. Stephens and A. K. Mann. [1955] [1]p [AF 18(600)894] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 26-27, 1954.

Published in Phys. Rev., v. 98: 241, Apr. 1, 1955.

The photoprotons ejected from a 6 mg per cm^2 thick carbon foil by 23-mev bremsstrahlung have been observed in nuclear emulsions. The ranges of 408 protons which entered the emulsions in the proper direction were measured. The proton energy distribution has a peak at 5.5 mev and a width at half-maximum of about 2.8 mev. These values confirm the previous determination of the giant resonance in carbon which had been obtained from yield curve data. The width of the proton spectrum is consistent with transitions from a single broad level in C^{12} to the ground state of B^{11} but transitions to the first excited state of B^{11} appear to be inhibited. (Contractor's abstract)

PEN. 09:004

Pennsylvania U. [Dept. of Physics] Philadelphia.

FINE STRUCTURE IN THE (γ,p) REACTION IN OXYGEN, by W. E. Stephens, A. K. Mann and others. [1955] [1]p. incl. diagrs. (Sponsored jointly by Atomic Energy Commission, Office of Naval Research, and [Air Force Office of Scientific Research under AF 18(600)894]) Unclassified

Published in Phys. Rev., v. 98: 839, May 1, 1955.

An oxygen gas target was bombarded with 25 mev bremsstrahlung. The photoprotons were observed with nuclear emulsions. Proton groups at 4.5 and 3.5 mev are identified with transitions to the 5.3 and 6.3 mev levels, respectively of N^{15}. A group at 2.4 mev is produced by transitions from the 14.7 mev resonance in oxygen to the ground state of N^{15}. The complete energy spectrum of photoprotons from oxygen, 0-12 mev, is transformed to a cross-section curve for proton absorption which gives rise to transitions to the ground state of N^{15} 12-25 mev.

PEN. 09:005

Pennsylvania U. [Dept. of Physics] Philadelphia.

ELASTIC SCATTERING OF GAMMA RAYS, by A. K. Mann. [1955] [16]p. incl. diagrs. refs. (AF 18-(600)894) Unclassified

Also published in Phys. Rev., v. 101. 4-8, Jan. 1, 1956.

Gamma rays of 0.411, 0.662, and 1.33 mev were scattered from tin and lead targets and the absolute differential cross sections for elastic scattering were measured at six angles between 15 and 90 degrees. At 0.411 and 0.662 mev, the scattering is expected to be almost entirely Rayleigh scattering from the tightly bound electrons, and these data should therefore provide a reasonably stringent test of the theory of that process. However, the only calculations of Rayleigh scattering presently available are form-factor calculations which are expected to be inadequate for several reasons — in particular, for neglect of electron binding in the intermediate state of the scattering process, and for certain nonrelativistic approximations — and consequently comparisons of experiment with the form-factor results are inconclusive. Nevertheless, for the scattering from tin at both 0.411 and 0.662 mev, there is fair but possibly fortuitous agreement between experiment and form-factor calculations using Dirac wave functions for the electrons; for lead at the same energies there are appreciable discrepancies particularly at the larger angles between the experimental results and similar calculations. In view of the latter discrepancies, it appears that unambiguous identification of the elastic scattering of gamma rays by the electric field of a nucleus, i.e., potential scattering, cannot be obtained from measurements of the total elastic scattering by lead at 1.33 mev without improvements in the theory of Rayleigh scattering. (Contractor's abstract)

PEN. 09:006

Pennsylvania U. [Dept. of Physics] Philadelphia.

SUMMARY OF RECENT MEASUREMENTS OF THE COMPTON EFFECT, by A. Bernstein and A. K. Mann. [1956] [6]p. incl. diagrs. table, refs. [AF 18-(600)894] Unclassified

Published in Amer. Jour. Phys., v. 24: 445-450, Sept. 1956.

The use of newly developed experimenial techniques has led to the performance of experiments that have verified wtth relatively high prectston both ihe assumptions and predtctions of the quantum theory of the Compton effect. Several of these recent expertments, including some on the simultaneity of appearance of the scattered photon and recotl electron, the conservation of energy and momentum and the differential and total scatiering crcss sections, are brtefly described. Thetr results are compared with ihose of earlter experimenis and wtth theory to tndicaie the degree of severtiy with which the theory is presently tested. (Contractor's abstract)

PEN. 09:007

Pennsylvanta U. Depi. of Phystcs, Philadelphta.

PHOTOPROTONS FROM Be, C, AND O, by L. Cohen, A. K. Mann and others. [1956] [7]p. incl. diagrs. iables, refs. (Sponsored jointly by Office of Naval Research, Atomtc Energy Commission, and [Atr Force Office of Scienitific Research under AF 18(600)894] Unclassified

Published in Phys. Rev., v. 104: 108-114, Oci. 1, 1956.

The photoprotons ejected from thin foils of berylltum, carbon and polyethylene and from oxygen gas by 25-mev beiatron bremssirahlung were observed in nuclear emulsions with good resolution. The energy distrtbutions and yields of photoprotons were determtned for Be, C, and O. Exctiation functions for iransttions to ihe ground siates of ihe residual nuclei have been consirucied from the observed photoproton energy distributions of C and O. Siructure is observed tn ihe proton energy dtsiributtons and hence appears in the correspondtng (γ, p) excitation functions. This siructure ts tn rough agreemeni wtih ihai observed in (γ, n) reactions in C and O. (Contracior's abstract)

PEN. 10:001

Pennsylvania U. Dept. of Physics, Philadelphia

DISPERSION RELATIONS FOR FIXED SOURCE MESON THEORIES, by A. Klein. June 1956, 20p. incl. diagr. refs. (Technical note no. 1) (AFOSR-TN-56-256) (AF 18(603)60) AD 88976 Unclassified

Also published in Phys. Rev., v. 104: 1131-1136, Nov. 15, 1956.

A study is being made to obtain exact consequences of ihe most general postulates of local field theories without making laborious calculations. Dispersion relations for a class of Hamiltonian operators describing meson theories with a fixed, extended source are derived for meson-nucleon scattering. The assumption is made that each meson field operator is coupled to its own source, and a restriction is imposed on the maximum number of temporal or spatial derivatives of the field operator that can occur in any one term; the interaction is not necessarily linear in the meson field. With these assumptions, nonrelativtstic verstons of all proposed relativisttc dtspersions are derived rigorously. In particular, the P-wave equattons of Chew and Low (Phys. Rev., v. 101: 1570, 1956) were obtained as well as a set of equations for the S-waves. Discusstons are presented on the forward scattering of neutral mesons and of symmetrical pseudoscalar mesons. The symmetry pseudoscalar theory is described.

PEN. 10:002

Pennsylvania U. Dept. of Physics, Philadelphia.

DISPERSION RELATIONS FOR FIXED SOURCE MESON THEORIES. II. EFFECTIVE RANGE RELATIONS, by A. Klein. July 1956 [20]p. incl. diagrs. (Technical note no. 2) (AFOSR-TN-56-288) (AF 18(603)60) AD 89499 Unclassified

Also published in Phys. Rev., v. 104: 1136-1141, Nov. 15, 1956.

Dispersion relations for boson-fermion scattertng have been shown to yield, tn the static limit, coupled tntegral equations for the scattering amplitudes of a definite orbtial angular momentum. The present investigation is devoted to the search for the "solutions" of these equations, or more accurately, to the problem of obtaining essentially real integral equations for the reciprocals of the scattering amplitudes, since such equations would form the basis for effective range approximations. The mathematical problem ts that of determining an analytic continuatton of the scattering amplitudes which has no zeros in the complex plane. It ts shown that for all cases constdered tn I, an analytic conitnuatton can be deftned, either for the scattering amplitude in a deftnite channel, or for a simple ltnear combtnation of these, which has the basic properties of Wtgner's R-functions and yields the required equations upon inversion. These inverstons contain as many arbitrary constants (or in some tnstances functions) as there are zeros in the ortginal amplitudes. It is shown that the procedures apply, without essential change, to the case where inelastic processes are permitted. No attempt is made to apply the resultant formulas to experiment.

PEN. 10:003

Pennsylvania U. [Dept. of Physics,] Phtladelphia.

SCATTERING OF K+ PARTICLES BY PROTONS, by A. Klein, B. H. McCormick, and R. Sternheimer. Sept. 1956 [13]p. incl. diagr. refs. (Technical note no. 4) (AFOSR-TN-56-418) (AF 18(603)60) AD 96227 Unclassified

In this study, the scattering of positive K mesons by protons is investigated under the hypothesis that K mesons emit and absorb π mesons singly. First, the potential acting between a K particle and a nucleon is

PEN. 10:004 - PIT. 02:001

calculated, including the exchange of at most 2 pions [π mesons]. The Schrödinger equation is then separated into partial waves, and the scattering amplitude, differential cross-section and total cross-section are related to the eigenphases and mixing parameters which define its solutions asymptotically. Novel features of the various formulas arise from the assumed parity doubling of the K-particle. (Contractor's abstract)

PEN. 10:004

Pennsylvania U. [Dept. of Physics] Philadelphia.

CONSTRUCTION OF THE ADIABATIC NUCLEAR POTENTIAL. 1. FORMALISM, by A. Klein and B. H. McCormick, July 1956, 38p. refs. (AFOSR-TN-56-419) (AF 18(603)60) AD 96228 Unclassified

Also Published in Phys. Rev., v. 104: 1747-1757, Dec. 15, 1956.

A new formalism is presented for the construction of the 2-nucleon potential, whose salient characteristic is that it involves an expansion only in the number of mesons exchanged, the self-mesic field of each nucleon being treated, in principle, exactly. Access to the potential is achieved through the intermediary of the scattering matrix. Alternative versions of the latter are derived with the neglect either of nonlinear meson propagation or of closed loops entirely. Only the form obtained under the second, more drastic assumption is exploited in this study. The connection between the scattering matrix and the potential is discussed; it is emphasized again that the transition between the 2 requires knowledge of nonenergy conserving matrix elements of the potential, which can be obtained only if the underlying Schrödinger equation is known. The potential involving the exchange of at most 2 P-wave mesons is computed and it is shown to depend on the renormalized coupling constant, the single-nucleon source function, and the total cross-sections for pion [π meson]-nucleon interaction. The numerical evaluation of these formulas is not attempted. (Contractor's abstract)

PIO. 01:001

Pioneer Industries, Inc., Reno, Nev.

AN INVESTIGATION OF COANDA EFFECT IN THREE DIMENSIONS, by W. E. Osborne and J. A. Bright. Preliminary rept. [1955] [22] p. incl. illus. diagr. refs. (AF 18(600)1568) Unclassified

A theoretical and experimental investigation of the three-dimensional Coanda effect, including an evaluation of a practical nozzle design, was undertaken. Two- and three-dimensional Coanda nozzles were studied to determine optimum configuration for flow induction.

See also Odin Associates, item no. OD1. 02:001.

PIS. 01:001

Pisa U. Inst. of Aeronautics (Italy).

THE AERODYNAMICS OF BODIES IN NON-UNIFORM FLOW, by E. Pistolesi and M. Marini. [1956] 1v. incl. diagrs. tables. (AFOSR-TR-56-37) (AF 61-(514)872) AD 96513 Unclassified

A study is made of the aerodynamics of airfoils immersed in a subsonic stream of compressible fluid adjacent to another similar stream of different subsonic velocity. The following cases are examined: (1) two semi-infinite streams; (2) a semi-infinite stream adjacent to a stream bounded by a rigid wall; and (3) a semi-infinite stream adjacent to a jet. Each case is explained for an airfoil of zero thickness disposed at some angle of attack and for an airfoil of finite thickness-chord ratio at zero angle of attack. The problem is defined by two restrictions: (1) the perturbation pressure must be the same on both sides of the interface between the streams; and (2) the flow inclination must be the same on both sides of the interface. By the use of the theory of small disturbances and Fourier integral representation, the values of the induced axial and transverse velocities on the airfoil are obtained. Consideration is also given to the problem of two semi-infinite streams of compressible fluid when one has a subsonic velocity and the other has a supersonic velocity.

PIT. 01:001

Pittsburgh U., Pa.

FIFTH SYMPOSIUM (INTERNATIONAL) ON COMBUSTION: COMBUSTION IN ENGINES AND COMBUSTION KINETICS, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, 802 p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1188, Office of Ordnance Research, and Office of Naval Research) Unclassified

A series of 101 papers are presented on the chemical aspects of combustion and combustion kinetics. Eleven review papers are included of problems on combustion in engines and kinetics of combustion processes; 90 papers are included on combustion of fuel droplets, propellant burning, combustion of solids, diffusion flames and carbon formation, combustion in engines, special research techniques, kinetics of combustion in engines, special research techniques, kinetics of combustion reactions, as well as flame spectra and dissociation energies. Panel discussions are summarized of heterogeneous burning and of the status of the theory of status of the theory of combustion kinetics.

PIT. 02:001

Pittsburgh U. [Sarah Mellon Scaife] Radiation Lab., Pa.

THE ZEEMAN SPLITTING OF NUCLEAR

QUADRUPOLE RESONANCES, by C. Dean. [1954] ([AF]OSR-TN-54-172) (AF 18(600)892) Unclassified

Also published in Phys. Rev., v. 96: 1053-1059, Nov. 15, 1954.

The theory of the Zeeman splitting of the pure quadrupole energy levels for nuclei of half integral spin is given in a form that is correct for any electric field gradient. The splitting of the spectra is discussed, and also the simplications that can be made in the theory when the magnetic field is parallel to any of the three principal axes of the electric field gradient. For spin 3/2 it is shown that the deviation of the gradient from cylindrical symmetry can be determined from the Zeeman spectrum, and detailed calculations are given for this case, along with a discussion of their experimental application. (Contractor's abstract)

PIT. 02:002

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

EFFECTS OF ANISOTROPY ON THERMODYNAMIC PROPERTIES OF ANTIFERROMAGNETS, by J. A. Eisele and F. Keffer. [Aug. 13, 1954] [21]p. incl. diagrs. table, refs. ([AF]OSR-TN-54-197) (AF 18-(600)892) Unclassified

Presented at meeting of the Amer. Phys. Soc., Detroit, Mich., Mar. 18-20, 1954.

Also published in Phys. Rev., v. 96: 929-933, Nov. 15, 1954.

In antiferromagnets, because of interplay with exchange energy, a small anisotropy can have a huge effect on thermodynamic properties. Detailed calculations are given, using spin-wave theory, of the effects of anisotropy on sublatlice magnetization, specific heat, and parallel susceptibility of a cubic antiferromagnet. Specific heat data are discussed and experiments are suggested on the relatively large spin specific heats of antiferromagnets with low Curie points. The theory is extended to orthorhombic symmetry, and reasonable agreement is found with existing experimental data on $CuCl_2 \cdot 2H_2O$. (Contractor's abstract)

PIT. 02:003

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

DIPOLAR FERROMAGNETISM AT O°K, by M. H. Cohen and F. Keffer. [Mar. 11, 1955] 24p. incl. table. ([AF]OSR-TN-55-86) [AF 18(600)892] AD 111075 Unclassified

Also published in Phys. Rev., v. 99: 1135-1140, Aug. 15, 1955.

A critical examination of the Holstein-Primakoff spin-wave technique has yielded explicit criteria for the stability of ferromagnetic arrays. These criteria have been applied to point dipoles on the 3 primitive cubic lattices for the shape most favorable to ferromagnetism that of a long, thin sample. The results show that: (1) dipolar ferromagnetism cannot occur in the simple cubic lattice; (2) the ferromagnetic state can be the lowest, or at least a metastable, state on the face-centered cubic and body-centered cubic lattices. The zero-point energies of ferromagnetic states are calculated for the $\langle 100 \rangle$, $\langle 011 \rangle$, and $\langle 111 \rangle$, directions, yielding 2 anisotropy constants, K_1 and K_2, for each lattice. The Holstein-Primakoff Hamiltonian is shown not to be diagonal for spin waves in the pathological region, i.e., of wavelengths comparable to the dimensions of the specimens. The properties of this region are shown to be unimportant in energy considerations but may effect stability. They are of great importance in effects such as ferromagnetic resonance which involve long-wavelength spin waves. (Contractor's abstract)

PIT. 02:004

Pittsburgh U. [Sarah Mellon Scaife Radiation Lab.] Pa.

CHLORINE NUCLEAR QUADRUPOLE RESONANCES IN SOLID SOLUTIONS, by C. Dean. June 8, 1955 [1]p. ([AF]OSR-TN-55-190) (AF 18(600)892) AD 110912 Unclassified

Published in Jour. Chem. Phys., v. 23: 1734-1735, Sept. 1955.

A study is reported briefly of the Cl^{35} nuclear quadrupole resonance in p: bromochlorobenzene (p: $Br\phi Cl$). Observations have been made at room temperature in several solid solutions of the above substance with p: dibromobenzene (p: $Br_2\phi$). At the lowest concentration utilized (2 mol-% p: $Br\phi Cl$), the narrowest resonance was found. As the concentration was increased, the resonances became broader, being too broad for positive identification in p: $Br\phi Cl$. For comparison, the Cl^{35} resonance was studied in a series of solid solutions of p: $Br_2\phi$ with the mol-% of p: $Cl_2\phi$ ranging from 1 to 50. These results indicate that relatively minute local variations in crystal structure are an important factor in broadening the quadrupole resonances.

PIT. 02:005

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

TEMPERATURE DEPENDENCE OF FERROMAGNETIC ANISOTROPY IN CUBIC CRYSTALS, by F. Keffer. Dec. 15, 1955 [7]p. incl. diagr. refs. ([AF]OSR-TN-55-197) [AF 18(600)892] AD 110913 Unclassified

Also published in Phys. Rev., v. 100: 1692-1698, Dec. 15, 1955.

Two theories of the temperature dependence of ferromagnetic anisotropy in cubic crystals, the nearest-neighbor quadrupole-quadrupole coupling theory of

PIT. 02:006 - PIT. 02:009

Van Vleck, and the more recent classical theory of Zener, seem to be contradictory. It is shown that these are, respectively, high- and low-temperature approximations to the same physical picture, i.e., an anisotropy which decreases with rising temperature due to statistical fluctuations from alignment of anisotropically-coupled neighbor spins. Zener's low-temperature approximation shows that the anisotropy decreases as the tenth power of the magnetization. Van Vleck's high-temperature approximation yields a lower power law. It is argued that most of the anisotropy has vanished before sufficiently high temperatures are reached for Van Vleck's approximation to be appropriate. Van Vleck's nearest-neighbor dipole-dipole coupling theory, which has no classical analog and cannot be compared with Zener's theory, is discussed from a spin-wave picture. (Contractor's abstract)

PIT. 02:006

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

RAPID PASSAGE EFFECTS IN ELECTRON SPIN RESONANCE, by A. M. Portis. Sept. 26, 1955 [2]p. incl. diagrs. ([AF]OSR-TN-55-341) (AF 18(600)892) AD 110914 Unclassified

Also published in Phys. Rev., v. 100: 1219-1221, Nov. 15, 1955.

Using the rapid passage theory of Bloch (Phys. Rev., v. 70: 460, 1946), relaxation effects which have been observed in electron spin resonance from F centers in alkali halides and from donor states in silicon are interpreted. The distinguishing characteristic of the 2 cases is that the line broadening is of the inhomogeneous type, arising from hyperfine interaction. The dispersion signal, obtained at room temperature from a sample of LiF irradiated with 220-kev x-rays for 18 hr, is plotted as a function of the magnetic field for several values of θ, the phase angle between modulation field and reference signal. An examination of these curves reveals 2 surprising results: (1) the LiF signal lags the modulation field by nearly 90°; and (2) the line shape of the LiF resonance more closely resembles an absorption curve than it does the derivation curve. In comparison, the copper sulfate signal appears quite normal. Bloch shows that under rapid passage, the sense of the dispersion line reverses with the direction of travel, and the intensity of the line is proportional to the value of S_z associated with the line. The observed phase shift of 90° and a line shape which reflects the local field distribution may be inferred directly from Bloch's results. Graphical plots are also presented of the absorption signal and dispersion signal in KCl.

PIT. 02:007

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

ELECTRON SPIN RESONANCE IN IRRADIATED ALKALI HALIDES (Abstract), by A. M. Portis and D. Shaltiel. [1955] [1]p. (AF 18(600)892) Unclassified

Presented at meeting of the Amer. Phys. Soc., Berkeley, Calif., Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 264, Apr. 1, 1955.

Electron spin resonance has been observed in samples of LiF and LiCl irradiated for a period of 36 hr with 220 kev x-rays. Both samples show inhomogeneous saturation of the resonance similar to that already reported for F centers in KCl, KBr, and NaCl. The g factors for both lines are within experimental error of the free electron g. Both resonances show a surprising response to the magnetic field modulation in that the signal lags the modulating field by nearly 90°. This effect can be understood in a direct way on the basis of hyperfine broadening of lines which are narrow compared with the modulation frequency. We find no resonance in the crystals before irradiation or after the F band has been bleached. The intensity of the resonance is in general agreement with the strength of the F band. We conclude from this evidence and the similarity with the F center resonances in other alkali halides that we are observing genuine F center resonances. We find no evidence for either the resolved spectrum of 19 lines or the broad peak with a g of 2.018 reported by Schneider (Phys. Rev., v. 93: 919, 1954). (Contractor's abstract)

PIT. 02:008

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

MAGNETIC RESONANCE IN SYSTEMS WITH SPECTRAL DISTRIBUTIONS, by A. M. Portis. Nov. 15, 1955, 44p. incl. diagrs. table, refs. (Technical note no. 1) (AFOSR-TN-56-7) (AF 18(600)892) AD 85870 Unclassified

A study is made of effects in magnetic resonance peculiar to situations where the conditions of excitation change rapidly compared with the relaxation time. The excitation of single resonance line and of a spectrum of resonance lines is discussed. The analysis shows that the amplitude, shape, and phase of the resonance line depend on the rate of relaxation to the lattice. Spin-spin relaxation for such systems is also considered by studying the effect of dipolar interaction on a system of spins distributed over a range of local fields that are large compared with their dipolar fields. The dipoles are assumed to be randomly distributed over some regular lattice, and no correlation is assumed to exist between the dipolar position and the magnitude of the local field.

PIT. 02:009

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

POLYMORPHISM OF PARA-DICHLOROBENZENE, by C. Dean and E. Lindstrand. Feb. 1956 2 p.

[AFOSR-TN-56-85] Also bound with its AFOSR-TR-58-46; AD 154185 (AF 18(600)892) AD 81538
Unclassified

Also published in Jour. Chem. Phys., v. 24: 1114-1115, May 1956.

A large shift in the pure quadrupole resonance frequency is cited as giving evidence for a third crystal structure (γ) in samples of para-dichlorobenzene containing one or two mole percent of para-xylene or a few percent of benzene.

PIT. 02:010

Pittsburgh U. [Sarah Mellon Scaife Radiation Lab.] Pa.

SPIN-SPIN RELAXATION IN SYSTEMS WITH TWO MAGNETIC INGREDIENTS (Abstract), by A. M. Portis. [1956] [1]p. [AF 18(600)892] Unclasstfied

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 124, Mar. 15, 1956.

Spin-spin relaxation has been investigated theoretically for systems like F-centers in alkali halides or donor centers in semiconductors, which have the following salient features: (1) the effect of the nuclear spins on the electron spins may be described by a resonance spectrum; (2) each electron spin may be identified with a definite position in the spectrum; (3) the electron spins are randomly distributed through the lattice; and (4) the position of an electron in the lattice and its position in the resonance spectrum are completely uncorrelated. The interaction between electron spins is treated by time-dependent perturbation theory and an expression for the life of an individual spin state is found. This time, τs equals $\Delta\omega/\Delta^2$, where Δ is a measure of the strength of the spin-spin interaction and $\Delta\omega$ is related to the width of the resonance spectrum. Macroscopic spin-spin relaxation is described in terms of the diffusion of spin excitation through the resonance spectrum. The behavior of the spin system in an rf field has been investigated by the substitution of a diffusion term for the usual spin-spin term in the Bloch equations. A characteristic diffusion time $\tau D = (\gamma H_1 \tau s)^2 \tau s$ is found. (Contractor's abstract)

PIT. 02:011

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

SPECTRAL DIFFUSION IN MAGNETIC RESONANCE, by A. M. Portis. [1956] [5]p. (Also bound with its AFOSR-TR-58-46; AD 154185) (AF 18(600)892)
Unclassified

Published in Phys. Rev., v. 104: 584-588, Nov. 1, 1956.

Electron spin-spin interaction is discussed for the case of strong hyperfine broadening. The hyperfine interaction is represented by a resonance spectrum of width $\Delta\omega$ and the electron interactions, which are taken to be dipolar, are treated by time-dependent perturbation theory. A characteristic relaxation time for electron spins, $\tau_3 = \Delta\omega/\Delta^2$, is found, where Δ is a measure of the strength of the dipolar interaction. The time-dependent theory suggests a modification of the Bloch equations to give a phenomenological description of systems of this kind. Spin-spin relaxation is represented by a term which gives diffusion of spin excitation through the resonance spectrum. Slow passage, rapid passage, and free relaxation are considered by using the modified equations. (Contractor's abstract)

PIT. 03:001

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

ROTATIONAL EXCITATION BY SLOW ELECTRONS, by E. Gerjuoy and S. Stein. Final technical rept. pt. 1. July 1954 [43]p. incl. diagrs. refs. ([AF]OSR-TR-54-21, Pt. 1) (AF 18(600)897) AD 74956
Unclassified

Also published in Phys. Rev., v. 97: 1671-1679, Mar. 15, 1955.

Cross-sections are calculated for rotational excitation of a homonuclear diatomic molecule by collisions with very slow electrons. The mechanism is assumed to be the long range quadrupole interaction. The Born approximation is shown to be correct in the low energy limit. The results are applied to calculation of energy losses in N_2, and comparison is made with values inferred from swarm and cross-modulation experiments. At energies below .29 ev, the threshold for vibrational excitation, losses are ~ twice the experimental values, but many times larger than the value (2m/M), where m = the electron mass and M = the molecular mass, for elastic losses only. (Contractor's abstract)

PIT. 03:002

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

ROTATIONAL EXCITATION BY SLOW ELECTRONS, by E. Gerjuoy and S. Stein. Final technical rept. pt. 2. Aug. 1955 [4]p. incl. diagrs. refs. ([AF]OSR-TR-54-21, Pt. 2) (AF 18(600)897) AD 74957
Unclassified

Also published in Phys. Rev., v. 98: 1848-1851, June 15, 1955.

Theoretical cross sections for the rotational excitation of homonuclear molecules by slow electrons are applied to calculation of the fractional energy loss/collision (λ) in H_2. The theoretical losses are not more than 2.5(2m/M) and except at the lowest energies studied (~0.1 ev) are smaller than observed. It would be desirable to have more direct experimental evidence of

PIT. 03:003 - POL. 01:003

rotational excitation. For this reason, λ has been calculated at 77°K in pure p-hydrogen and in normal hydrogen at that temperature. At electron energies ~0.075 ev, the 2 λ's should differ by about 50%. Similarly, because of the altered rotational distribution, λ for deuterium differs from λ for H_2. Such differences, if observed, could hardly be accounted for on any other basis than rotational excitation. (Contractor's abstract)

PIT. 03:003

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

ROTATIONAL EXCITATION OF HOMONUCLEAR MOLECULES (Abstract), by S. Stein, E. Gerjuoy, and T. Holstein. [1954] [1]p. (AF 18(600)897) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill., Nov. 27-28, 1953.

Published in Phys. Rev., v. 93: 934, Feb. 15, 1954.

Cross sections are calculated for excitation of rotation of diatomic homonuclear molecules by very slow electrons (energy ~0.1 ev) with neglect of exchange. It is assumed that the excitation results from interaction of the electron with the quadrupole field of the molecule; for this type of potential, use of the Born approximation is defensible at these low energies. For kinetic energies large compared to the separation of rotational levels, the cross section approaches a constant value ~10^{-17} cm^2, using measured quadrupole moments. The average fractional energy losses per collision in N_2 and H_2 are evaluated and are in moderately good agreement with recent measurements. (Contractor's abstract)

PIT. 03:004

Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

FEASIBILITY OF AN ELECTROSTATIC EXPLANATION FOR THE ADVANCE OF THE PERIHELION OF MERCURY, by E. Gerjuoy and G. Padawer. [1955] 6p. (AF 18(600)897) Unclassified

An argument is presented that an explanation along the lines of general relativity is "necessary" to account for the advance of Mercury's perihelion, in the sense that postulating other force fields must run into serious difficulties. The argument is illustrated by considering the possibility that the force between an electric charge on the sun and an induced dipole on Mercury could yield the observed advance. (Contractor's abstract)

POL. 01:001

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

[CONTRIBUTION TO METHODS IN THE FIELD OF ELECTROCHEMICAL KINETICS] Contributo ai metodi di studio della cinetica elettrochimica, by R. Piontelli. [1955] [21]p. incl. table, refs. (AF 61-(514)733-C) Unclassified

Published in Rend. Ist. Lombardo Sci. e Lett., v. 88: 51-71, 1955.

Some general aspects of the overvoltage measurements by means of tensiometric cells are discussed, with consideration of the systematic errors involved in the arrangements shown by Delahay (New Instrumental Methods in Electrochemistry, 1954, p. 393) who asserted that these errors did not exceed 10 mv. The devices used to avoid the errors for the tensiometric measurement in the thin strata (20-30μ) of solution around the electrodes, are described. The principles of new arrangements with probes of various kinds (isoelectrodic, 2nd-class electrodes, for pH-, or oxidation-reduction potentials of electrode stratum) are given together with those of the possible types giving compound-tensiometric cells. The meaning of the various voltages, with particular reference to the practically stationary condition, is discussed. (C. A., 1956:5428h)

POL. 01:002

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

OVERVOLTAGES AT THE ELECTRODE: MELTED $Pb/PbCl_2$ (Abstract), by R. Piontelli and G. Sternheim. July 1955 [1]p. incl. diagr. [AF 61(514)733-C] Unclassified

Published in Jour. Chem. Phys., v. 23: 1358, July 1955.

A cell was built suitable for measuring anode overvoltages at the electrode $Pb/PbCl_2$. It can be applied to a large range of conditions. Also by opportune coupling of at least 2 probes, useful information can be obtained on the "concentration polarization" effects, arising in systems whose bath composition is changing, as for instance the system $PbCl_2/PbCl_2$ + KCl.

POL. 01:003

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

OVERVOLTAGES IN MELTED ELECTROLYTES, by R. Piontelli and G. Sternheim. Oct. 1955 [2]p. incl. diagrs. (AF 61(514)733-C) Unclassified

Published in Jour. Chem. Phys., v. 23: 1971-1972, Oct. 1955.

Experimental methods were developed and employed to measure the electrode overvoltages of melted metals against metal electrolytes and the anodic and cathodic

behavior of the following electrodes: (a) $Pb/PbCl_2$ + KCl at 560°C + 670°C; (b) $Cd/CdCl_2$ and $Cd/CdCl_2$ + KCl (t.d.: 590°C); (c) $Sn/SnCl_2$ and $Sn/SnCl_2$ + KCl (t.d.: 350°C); (d) $Zn/ZnCl_2$ and $Zn/ZnCl_2$ + KCl (t.d.: 490°C).

POL. 01:004

Polttecnico di Milano. Laboratorto dt Elettrochimtca, Chimtca Fistca, e Metallurgia (Italy).

IMPROVED APPARATUS FOR CUTTING SINGLE CRYSTALS, by R. Piontelit, B. Rtvolta, and G. Sternheim, [1955] [1]p. (AF 61(514)733-C) Unclassified

Published in Rev. Scient. Instruments, v. 26: 1206, Dec. 1955.

The mechanical methods for cutting single crystals though followed by metallographtc polishing and etching, are unable togtve strain-free specimens as a consequence of the deep penetration of the deformation. A very tnteresting method of cutting stngle crystalltne dtsks from a rod, by means of chemical attack to avoid tntroductng strains, has been developed by Maddtn and Asher. This method uses an endless plastic thread (Saran) which ts led with the aid of pulleys through a bath containing the etchtng solution and over the specimen to be cut. This method has been applted tn this laboratory wtth good results on single crystals of Zn, Sn, and other metals. To shorten the time-consuming operation of cutting, the rate of attack has been tncreased by means of an electrolytic process. The rod to be cut is made the anode of a cell tn which the cathode (in form of a plattnum plate) is tmmersed tn the bath traversed by the plastic thread. The solutton carrted on the thread ts sufftctent to matntatn the conttnutty of the electrtc ctrcutt. Excellent results on cuttng rates and surface ftnish have been obtained on stngle crystals of tin, havtng a dtameter of the order of 20 mm, with a current of about 30 ma, ustng a 1.1 bath of HNO_3. The voltage applied depends tn practice on the length of thread between the bath and the rod. (Contractor's abstract)

POL. 01:005

Polttecnico di Mtlano. Laboratorto dt Elettrochimica, Chimica Fistca, e Metallurgia (Italy).

EXPERIMENTAL METHODS FOR MEASURING ELECTRODE OVERVOLTAGES, by R. Ptontelli and U. Bertocct. June t955 [40]p. incl. dtagrs. refs. (Technical note no. t) (AFOSR-TN-56-112) (AF 61(514)733-C) AD 82508 Unclasstfied

Research ts betng conducted on the anodic and cathodic behavtor of metals. General remarks on the measurements of electrode overvoltages are developed, and the theory of the systematic errors involved by the usual measurtng devices is discussed. A descrtption is presented of new types of tensiometrtc devtces which would eliminate the errors. The entire apparatus (electrolysts cell, tensiometric cell, supply, and measuring apparatus) necessary for measuring electrode overvoltages ts descrtbed in detail.

POL. 01:006

Politecnico dt Mtlano. Laboratorto di Elettrochtmica, Chimica Ftsica, e Metallurgia (Italy).

ELECTROCHEMICAL BEHAVIOR OF GOLD IN CHLORIDE SOLUTIONS, by G. Poli. July 1955, 21p. dtagrs. tables, refs. (Technical note no. 2) (AFOSR-TN-56-113) (AF 61(514)733-C) AD 82509 Unclassifted

Also published in Gazz. Chim. (Italy), v. 86: 526-550, May-July 1956.

An investigation was conducted of the anodtc and cathodtc behavtor of Au tn 0.1 M $AuCl_3$ and 0.1 M $KAuCl_4$ solutions with added KCl at 25°, 50°, and 75°C. The tnfluence of Cl^-, temperature, stirring, and Au^+ on voltage-current denstty curves was also tnvestigated. By determining the apparent valence of anodtc and cathodtc processes and calculating the ratio at which Au^+ and Au^{3+} partictpate tn the processes, voltage-current density curves were plotted for the following partial electrode processes: (I) $AuCl_2^- + \ominus \rightleftharpoons Au + 2\,Cl^-$ and (II) $AuCl_4^- + 3\ominus \rightleftharpoons Au + 4\,Cl^-$. For II, voltage-current density curves vertfied Tafel's law. Characterts-tic parameters for electrochemtcal kinetics were calculated for II. Three possible electrochemical reacttons which can occur at an Au electrode tn Cl solutions are I, II, and $AuCl_4^- + 2\ominus \rightleftharpoons AuCl_2^- + 2\,Cl^-$. Reactton I tndtcates an activation overvoltage which is lower than those of the other 2. Increasing the temperature or Cl^- concentration tended to activate the rate of tonic exchange of metal solutions.

POL. 01:007

Politecnico di Milano Laboratorto dt Elettrochtmtca, Chimtca Ftstca, e Metallurgia (Italy).

OVERVOLTAGE MEASUREMENTS ON ALUMINUM ELECTRODES IN CRYOLITE-ALUMINA BATHS, by G. Montanelit. Mar. t956 [34]p. incl. dtagrs. tables, refs. (Technical note no. 3) (AFOSR-TN-56-217) (AF 6t(514)733-C) AD 88023 Unclasstfied

By means of improved expertmental methods, the cathode and anode overvoltages have been determined at Al electrodes tn cryolite-alumtna bath with or without additives in conditions correspondtng to those of the industrial productton of the metal. The "exchange overvollage" tn the Al separation at 1000°C is as a maximum of the order of some mV even at c.d. of 100 A/dm^2. The concentration overvoltage depends essentially upon the decrease of AlF_3 concentration in the

POL. 01:008 - POL. 01:012

electrode layer and may correspond to some tenth of volt. These results support the hypothesis of the primary discharge of Al from "donors" in the cells, and explain the conditions in which the Na discharge may intervene as a "parasitic" process. (Contractor's abstract)

POL. 01:008

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

ELECTROCHEMICAL BEHAVIOR OF TIN, by U. Bertocci and G. Serravalle. Apr. 1956 [37]p. incl. diagrs. tables, refs. (Technical note no. 4) (AFOSR-TN-56-271) (AF 61(514)733-C) AD 89481 Unclassified

The electrochemical behavior of Sn in aqueous solutions, especially those containing fluoride ions was studied. The electrochemical kinetic behavior of Sn was "normal" in solutions containing either fluoride or other anions. Anodic and cathodic ionic exchange overvoltages of Sn were very low in all solutions. The high polarizations obtained in some cases apparently resulted from activity changes (concentration polarization). At sufficiently high current density, the most efficient stirring failed to overcome these changes. In cases where the excess of the constituent which leads to complexes is not too great, the overvoltage may attain very high values (over 100 mV) in the absence of stirring. The presence of free strong acids decreased the Sn complexity degree concurring with it to bond fluoride ions to form HF and HF_2^-. The anodic and cathodic dissolutions take place with practically theoretical efficiency with respect to Sn^{++}. The deposits were mainly macrocrystalline and often in the form of dendrites and plates. (Contractor's conclusions)

POL. 01:009

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

ELECTROCHEMICAL BEHAVIOR OF POLYCRYSTALLINE CADMIUM, by U. Bertocci and C. Tantardini. May 1956 [29]p. incl. diagrs. tables. (Technical note no. 5) (AFOSR-TN-56-303) (AF 61(514)733-C) AD 90017 Unclassified

Anodic and cathodic overvoltage measurements of polycrystalline Cd were carried out in perchlorate, sulfate, and chloride solutions having different free acid contents. The results of these experiments prove that the Cd has a "normal" electrochemical behavior, showing low overvoltages, both anodic and cathodic, at 25°, 40° and 55°C. Since the anodic attack and the cathodic deposition are limited to well defined regions of the surface, the actual Ci on the active surfaces is much higher than the apparent one, without leading to high overvoltages. The behavior of Cd, as an electrode, seems to be determined by the crystallographic factors, with probable inhibitive influences deriving from the H^+ or from the OH^- ions. The more deformable anions (in this case Cl^-) are especially efficient in activating the ion exchanges. The temperature increase exerts the usual activating influence. The law of the dependence of the overvoltages upon the apparent Cd does not agree with the usual formulations (as Tafel's law or combined exponential laws). (Contractor's abstract)

POL. 01:010

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

ELECTROCHEMICAL BEHAVIOR OF POLYCRYSTALLINE THALLIUM, by U. Bertocci and S. Ticozzi. Sept. 1956 [15]p. incl. diagrs. (Technical note no. 6) (AFOSR-TN-56-545) (AF 61(514)733-C) AD 110364 Unclassified

Also published in Rend. Ist. Lombardo Sci. e Lett., v. 91: 386-396, 1957.

Anodic and cathodic overvoltages for Tl have been measured in nitrate, perchlorate and hydroxide solutions, at different pH-values. Measurements were carried out and 25° and 40°C; the corresponding overvoltages are plotted vs c.d. The results of these experiments confirm the "normal" electrochemical behavior of Tl also in hydroxide solutions, not investigated before.

POL. 01:011

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

RESEARCH ON ANODIC AND CATHODIC BEHAVIOR OF METALS, by R. Piontelli. Sept. 1956 [10]p. refs. (Tecnical note no. 7) (AFOSR-TN-56-546) (AF 61(514)733-C) AD 110365 Unclassified

The purposes of the research were the completion and realization of improved methods and apparatus for measuring electrode overvoltages of metals in aqueous solutions and fused salts by the "direct method," but avoiding the usual sources of systematic errors; the conduction of systematic experiments on the anodic and cathodic behavior of a group of metals in form of polycrystalline electrodes in aqueous solutions, of a group of solid and melted metals in melted salts (in particular of melted aluminium in cryolite-alumina baths), and of a selected group of metals in the form of single crystals in aqueous solutions.

POL. 01:012

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

RESEARCH ON THE ELECTROCHEMICAL BEHAVIOR

OF POLYCRYSTALLINE ZINC, by U. Bertocci. Nov. 1956 [23]p. incl. diagrs. tables, refs. (Technical note no. 8) (AFOSR-TN-56-596) (AF 61(514)733-C)
AD 115023 Unclassified

Also published in Rend. Ist. Lombardo Sci. e Lett., v. 91: 39-54, 1957.

The electrochemical behavior of Zn is investigated in order to determine the individual anodic and cathodic overvoltages by good approximation through a choice of techniques and the choice of a zero value of the electrode voltage near the equilibrium voltage. The cause of the lack of symmetry between the anodic and cathodic overvoltages is investigated and found to disappear when the value, agreeing with the simple Zn electrode at equilibrium, is set equal to zero in the evaluation of overvoltages. Differences, corresponding to those of the anode overvoltage values of Zn, between the electrode voltages in absence of current and the equilibrium value of the simple Zn electrode are found to be greater in sulphate and especially, in perchlorate solutions than in chloride.

POL. 01:013

Politecnico di Milano. [Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia] (Italy).

[BEHAVIOR OF ELECTRODES IN FUSED SALTS] Comportement d'électrodes en milieu de sels fondus, by R. Piontelli, G. Sternheim, and M. Francini. [1956] [3]p. incl. diagr. [AF 61(514)733-C] Unclassified

Published in Compt. Rend. Acad. Sci., v. 242: 1301-1303, Mar. 5, 1956.

The apparent overpotentials, relative to a reference electrode, as a function of current were determined for the following electrodes: Mg (solid) | $MgCl_2$ (35%) + KCl (47%) + NaCl (18%) (by weight) at 550°; Al (solid)| $AlCl_3$ (70%) + NaCl (30%) at 220°. The overpotential was due entirely to an ohmic drop in the bath and not to exchange of ions between the bath and the metal. The graphs were linear, and the anodic and cathodic branches were symmetrical. This was true only when the bath was very pure (especially free from H_2O), the metal surfaces very clean, and passage of current limited and brief. This avoided passivating layers of oxide or oxychloride.

POL. 01:014

Politecnico di Milano. [Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia] (Italy).

[OVERVOLTAGE MEASUREMENTS ON ELECTRODES IN MOLTEN-SALT ELECTROLYSIS] Mesures de surtension d'électrode dans l'électrolyse ignée, by R. Piontelli, G. Montanelli, and G. Sternheim. [1956] [7]p. incl. diagrs. [AF 61(514)733-C] Unclassified

Published in Rev. Métall., v. 53: 248-254, Apr. 1956.

A cell for the measurement of the overvoltage in molten-salt electrolytes is described to be used at temperatures between 200° and 1000° in inert atmospheres of neon or argon. The following systems were investigated: $Pb/PbCl_2$ at 350°, $Cd/CdCl_2$ + KCl at 590°, $Pb/PbCl_2$ + KCl at 530° and 670°, and $Sn/SnCl_2$ at 350°. The results are shown in diagrams.

POL. 01:015

Politecnico di Milano. Laboratorio di Elettrochimica, Chimica Fisica, e Metallurgia (Italy).

OVERVOLTAGES AND PASSIVITY IN MELTED ELECTROLYTES, by R. Piontelli, G. Sternheim, and M. Francini. May 1956 [2]p. (AF 61(514)733-C) Unclassified

Also published in Jour. Chem. Phys., v. 24: 1113-1114, May 1956.

Investigations were carried out on electrode overvoltages with melted electrolytes. These studies were extended to electrodes at which a solid metal, whose electrochemical behavior in aqueous solutions is "intermedium" or "inert," exchanges ions with a bath of fused chlorides. Account is given of these studies and conclusions drawn.

Polytechnic Inst. of Brooklyn, N. Y.

N6ori-10503 and N6ori-9802, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI 11:131 - PRI. 11:141.

PIB. 01:001

Polytechnic Inst. of Brooklyn, N. Y.

DESIGN AND OPERATION OF INTERMITTENT SUPERSONIC WIND TUNNELS, by A. Ferri and S. M. Bogdonoff. May 1954, 108p. incl. illus. diagrs. refs. (NATO AGARDograph rept. no. 1) [AF 18(600)796] Unclassified

A study has been made of the operating characteristics of intermittent wind tunnels, particularly of the blow-down type. Considerations of low cost and flexibility are pointed out. Detailed performance of the components of such equipment are presented from calculation and experience. Typical construction, test set-up, instrumentation, and extension to the transonic and hypersonic region are discussed. Some examples of operating intermittent tunnels are also given.

PIB. 02:001

Polytechnic Inst. of Brooklyn, N. Y.

THE THERMAL EXPANSION OF CUBIC SODIUM TUNGSTEN BRONZES, by C. Rosen, B. Post, and E. Banks. Oct. 14, 1956, 7p. incl. diagrs. refs. (Technical note no. 1) (AFOSR-TN-56-462 [Pt. 1.]) (AF 18(600)1192) AD 97080 Unclassified

PIB. 02:002 - PIB. 03:003

Also published in Acta Cryst., v. 9: 477-478, June 1956.

The coefficients of thermal expansion of powdered cubic sodium tungsten bronzes (Na_xWO_3; $0.9 > x > 0.3$) from room temperature to 600°C have been determined. The expansion coefficients for all compositions studied are constant and essentially identical below transition temperatures (near 200°C) which vary with sodium content. At the transition temperatures, the expansion coefficients change sharply to lower values which vary with composition, going through a minimum near $x = 0.5$. The relation between these changes and a similar change in pure WO_3 is pointed out. (Contractor's abstract)

PIB. 02:002

Polytechnic Inst. of Brooklyn, N. Y.

THE THERMAL EXPANSION AND PHASE TRANSITIONS OF WO_3, by C. Rosen, E. Banks, and B. Post. Oct. 14, 1956, 2p. incl. diagr. (Technical note no. 2) (Bound with its Technical note no. 1; AFOSR-TN-56-462, Pt. 1; AD 97080) (AFOSR-TN-56-462 [Pt. 2]) (AF 18(600)1193) AD 97080(a) Unclassified

Also published in Acta Cryst., v. 9: 475-476, June 1956.

The thermal expansion of WO_3 from room temperature to 700°C has been measured by x-ray diffraction methods. The expansion of the a and c axes of the unit cell can be represented by a smooth curve for the entire range investigated. The b axis expands uniformly from room temperature to about 300°C and decreases slightly in length from 330° to 700°C. The monoclinic unit cell undergoes a transformation near 330°C to an orthogonal form, which is probably orthorhombic. (Contractor's abstract)

PIB. 03:001

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

SUPERSONIC FLOW OVER CONICAL BODIES WITHOUT AXIAL SYMMETRY, by A. Ferri, N. Ness, and T. T. Kaplita. Nov. 1952, 26p. illus. (PIBAL rept. no. 213) (AF 18(600)186) AD 201 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 563-571, Aug. 1953.

The method of superposing linear solutions to a nonlinear nonuniform flow field was applied to the analysis of conical flows without axial symmetry. The aerodynamic properties of cones with elliptical, drop-shape, and triangular cross sections were determined from these linearized solutions. For elliptical cones, the results indicated that at a constant free-stream Mach no. the shock-drag ratio decreases as the ratio of the minor to major axis of the ellipse decreases. For a given elliptical body at zero angle of attack, the drag ratio remained practically constant and less than unity for the Mach range considered. The effect of angle of attack was also analyzed, and the lift coefficient determined. The lift coefficient was similar to that of a triangular flat plate of the same plan form. For cones having drop-shape and triangular cross sections, the drag ratio remained practically constant and less than unity for a wide range of Mach nos. Some gain on the shock drag appeared obtainable with bodies having cross sections different from circular.

PIB. 03:002

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

TABULATED VALUES OF LINEARIZED CONICAL FLOW SOLUTIONS FOR SOLUTION OF SUPERSONIC CONICAL FLOWS WITHOUT AXIAL SYMMETRY, by N. Ness and T. T. Kaplita. Jan. 1954 [276]p. incl. tables. (PIBAL rept. no. 220) [AFOSR-TN-54-94] (AF 18(600)186) AD 31744 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 563-571, Aug. 1953.

The supersonic flow over conical bodies without axial symmetry may be obtained by superposing linear conical flows upon a basic nonlinear axially symmetric conical flow. The basic nonlinear axially symmetric conical flow was investigated, and tabulated values for this flow are given in Tables of Supersonic Flow Around Cones, technical report no. 1, MIT (1947). The superposed linear conical flow may be determined with the aid of the perturbation velocity components that are tabulated. A description is presented of the method for obtaining these components. The components are tabulated from the surface of the basic circular cone to the axially symmetric shock front produced by the basic circular cone, and are expressed by five digits. (ASTIA abstract)

PIB. 03:003

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

MIXED-TYPE CONICAL FLOW WITHOUT AXIAL SYMMETRY. SUMMARY OF THE RECENT WORK PERFORMED AT PIBAL, by A. Ferri, R. Vaglio-Laurin, and N. Ness. Dec. 1954 [38]p. incl. diagrs. (PIBAL rept. no. 264) ([AF]OSR-TN-54-303) (AF 18-(600)186) AD 62629 Unclassified

Some problems of mixed type conical flow are considered. Triangular wings with sharp supersonic leading edges at zero angle of attack are analyzed without the assumption of linearized theory. A procedure for the rapid calculation of the hyperbolic region by the method of characteristics is presented. The transonic region is considered from a mathematical and a physical point of view, and it is shown that two sonic lines defining

this regton can coexist. Methods for analyztng the elltptic regton and satisfying the boundary condttions are also dtscussed and outltned. (Contractor's abstract)

PIB. 03:004

Polytechnic tnst. of Brooklyn. Dept. of Aeronautical Engtneertng and Applted Mechanics, N. Y.

ANNALYTICAL AND NUMERICAL METHODS FOR HYPERBOLIC CONICAL FLOWS, by R. Vaglto-Laurtn and N. Ness. July 1955 [85]p. tncl. dtagrs. tables. (PIBAL rept. no. 273) ([AF]OSR-TN-55-212) (AF 18-(600)186) AD 69378 Unclasstfted

General equations of charactertstics and equattons of ltneartzed charactertstics are derived and arranged tn forms suttable for numertcal calculations. General equations for conical shocks are presented whtch determine the boundary condtions at the shock front. An analysis ts made of the hyperboltc flow over a conical body wtth sharp supersontc leadtng edges and a wedge proftle. Two modtftcattons of the general method of charactertstttcs are developed. In both cases, the flow properties are calculated dtrectly to a second-order approxtmatton. The linearized charactertstics method ts applted to determtne the relations between the curvatures of the body and the attached shock at the leadtng edge. The ltmttattons of this method are dtscussed, and the posstbtlity of tts extension to the analysts of the general behavior of curved conical shocks ts tndtcated.

PtB.03:005

Polytechnic tnst. of Brooklyn. Dept. of Aeronautical Engtneertng and Applted Mechanics, N. Y.

ON CONICAL FLOWS OF MIXED TYPE, by A. Ferrt and R. Vaglto-Laurtn. Ftnal rept. Apr. 1956, 17p. dtagrs. refs. (AFOSR-TR-56-21) (AF 18(600)186) AD 88031 Unclasstfted

Problems on elliptic and mtxed-type conical flow have been tnvestigated under thts contract with the atm of generaltzing the ltneartzed charactertstics method for the determinaiton of higher order approxtmattons tn a wtder class of supersontc flow ftelds. The major conclustons of prevtous reports are revtewed along with the latest results obtatned from the investigation of the transonic regton. On thts hasts a procedure ts outltned for calculattng the whole flow ftetd on the compresston stde of a trtangular wtng wtthout the assumptton of ltneartzed theory.

PIB. 04:001

Polytechnic tnst. of Brooklyn. Dept. of Aeronautical Engineertng and Applted Mechantcs, N. Y.

SUPERSONIC FLOW AROUND POINTED THREE-DIMENSIONAL BODIES. PART I. DESCRIPTION OF THE METHOD, by M. Vistch, Jr. July 1955 [33]p. incl. dtagr. refs. (PIBAL rept. no. 280-A) ([AF]-OSR-TN-55-266) (AF 18(600)693) AD 75347 Unclassifted

The methods of Ferrt, Ness, and Kapltta (Jour. Aeronaut. Sctences, v. 20: 563-571, 1953) and of Broglto are extended in order to determine the flow fteld about potnted 3-dtmenstonal bodtes represented by

$$\psi_B = \psi_{o_c} + \sum_{t=o}^{\infty}\sum_{n=o}^{\infty} \Lambda_{nl}\, r^t \cos n\theta;$$ r, θ, and ψ are

spherical coordtnates; the subscrtpts o and c refer to properties of the bastc axially symmetrtc conical flow and properties at the surface of the basic axially symmetrtc cone, respectively; B refers to properties at the surface of the actual body. The analysts ts based on the superposttion of ltnear conical soluttons on a nonltnear axially symmetrtc conical flow. Two methods

are presented for determining the body coefftctents Λ_{nl}.

The ftrst method entails spectfytng the coordtnates of the body at (N + 1)(I + 1) potnts to obtain an equation that deftnes the body exactly at the potnts specified. The second method assumes that a cross section of the body ts spectfted on the surface of a sphere of radtus r = k so that

$$\psi_{B_{r=R}} = \psi_{o_c} + \sum_{t=o}^{I}\sum_{n=o}^{N} \Lambda_{nl} R^t \cos n\theta$$

represents the body by a ftntte number of terms. The Λ_{nl} are then deftned as

$$\psi_{o_c} + \sum_{t=o}^{I} \Lambda_{ol} R^t = \frac{1}{\pi}\int_0^{\pi} \psi_{B_{r=R}}\, d\theta,$$

$$\sum_{t=o}^{t} \Lambda_{nl} R^t = \frac{2}{\pi}\int_0^{\pi} \psi_{B_{r=R}} \cos n\theta\, d\theta, \quad n = 1, 2, \ldots, N.$$

(ASTIA abstract)

PIB. 04:002

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engtneertng and Applted Mechanics, N. Y.

APPLICATION OF THE LINEARIZED CHARACTERISTICS METHOD TO THE DETERMINATION OF THE AXISYMMETRIC SUPERSONIC FLOW NEAR THE NOSE OF A BODY OF REVOLUTION, by L. G. Napolttano and A. Ferrt. Mar. 1955 [28]p. incl. dtagrs. (PIBAL rept. no. 279) ([AF]OSR-TN-55-339) (AF 18-(600)693) AD 75216 Unclassified

The ltneartzed charactertstics method ts applted to determtne the nonconical supersontc flow near the nose

PIB. 04:003 - PIB. 04:006

of a body of revolution at zero angle of attack with non-detached shock. In particutar a relation between the body and the shock curvatures tn meridian planes is devetoped. After the detailed presentation of the method, its limits of applicability are dtscussed. As an example the method is applied to the flow about the nose of the RM-10 at a Mach number of 3.18. (Contractor's summary)

PIB. 04:003

Potytechnic Inst. of Brooktyn. Dept. of Aeronauticat Engineering and Appited Mechanics, N. Y.

DIFFRACTION OF DtSTURBANCES AROUND A CONVEX RIGHT CORNER WITH APPLICATIONS IN ACOUSTICS AND WING-BODY INTERFERENCE, by L. Ting. Aug. 1956 [31]p. incl. diagrs. (PIBAL rept. no. 307) (AFOSR-TN-56-428) (AF 18(600)693) AD 96510 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 24: 821-844, Nov. 1957.

An integral equation is set up for the problem of finding the pressure disturbance when a given small disturbance passes around a 90° convex corner. The solution is obtained by the method of successive substitution. It is shown that the series given by this procedure converges faster than the power series of 1/2. The convergence of the series is accelerated by regrouping the terms so that the solutions corresponding to any one of the ordinal numbers of substitution possesses the correct behavior at the boundary of the domain. When the given disturbance is a plane weak (acoustic) shock, the solution corresponding to the second substitution is already in good agreement with the linearized conical solution. For the problems considered in this study, the series converges so fast, that there is no necessity to go beyond the second substitution. Based upon this solution and the procedure outlined previously (Jour. Math. and Phys., v. 32: 102-116, July-Oct. 1953), the pressure distribution on a rectangular barrier after it is hit by a weak shock is obtained. The problem of interference of a cylindrical body of rectangular cross section with a planar wing in supersonic flight can be reduced to the problem presented here and the one solved by Evvard's method (NACA Technical note no. 1382, July 1947). The pressure distrtbution is obtained for a body of square cross section mounted on a semi-infinite wedge. The numerical results agree with the tntegral relationship.

PIB. 04:004

Polytechntc tnst. of Brooklyn. Dept. of Aeronautical Engineertng and Applied Mechanics, N. Y.

AN ASSESSMENT OF BODY LIFT CONTRIBUTtONS AND OF LINEARIZED THEORY FOR SOME PARTtCULAR WING-BODY CONFtGURATIONS, by J. W. Reyn and J. H. Clarke. June t956 [71] p. incl. diagrs. tables, refs. (PIBAL rept. no. 305) (AFOSR-TN-56-429) (AF 18(600)693) AD 96511 Unclassified

A configuration composed of a circular half cone mounted beneath a swept wing with zero thickness is studied to determine whether the lift induced in the system by the cone in supersonic flow ts produced effictently enough to provide, at practical values of the lift coefficient, significant reductions in the pressure drag. The drag of this configuration is compared, at equal lift coefficient and Mach number, to tts inverted counterpart, to a configuration composed of the same wing and a symmetrically disposed cone with equal volume, and to the wing alone. For given values of the cone angle parameter and the sweep parameter, the drag of the high-wing configuration ts less than that of the low-wing configuration for all positive values of the lift coefficient. The drag of the high-wing configuration becomes successively less than that of the midwing configuration and that of the wing alone at certain critical values of the lift coefficient. The relative drag reductions in the three cited comparisons are a maximum at certain optimum values of the lift coefficient. Compared to the high delta wing-cone configuration, the high swept wing-cone configuration results in greater relative drag reductions at lower values of the lift coefficient, and therefore appears to be of much greater practical interest. Compared to the corresponding low-wing configuration, midwing configuration, and wing alone, the high swept-wing system can give drag reductions up to 36%, 10%, and 5%, respectively. Numerical calculations are reported of the supersonic flow field around cones and cone-cylinders at zero angle of attack which were made to assess the accuracy of the ltnearized theory tn wtng-body tnterference problems.

PIB. 04:005

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

SIMILARITY CONDITIONS FOR TESTING HIGH SPEED AIRCRAFT MODELS, by L. Ting. Nov. 1956 [50]p. tncl. dtagrs. refs. (PIBAL rept. no. 308) (AFOSR-TN-56-548) (AF t8(600)693) AD tt0367 Unclassified

The object of the report is to establish the least number of similarity conditions for testtng fundamental mathematical equations in several spectfic problems of aerodynamics, heat transfer and elasticity. Approximations justifted by facts or mathematical arguments effect this purpose. The conditions of external flow, temperature distrtbution and heat flow and quasistatic elastic deformation (and wings of low aspect ratio) are analyzed into a time dependent problem.

PIB. 04:006

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

A NOTE ON THE EFFECT OF CENTRIFUGAL FORCES

AND ACCELERATED MOTION ON THE INSTABILITY OF THE LAMINAR BOUNDARY LAYER ABOUT HIGHLY COOLED BODIES, by A. Ferri and R. Vaglio-Laurin. Dec. 1956 [13]p. (PIBAL rept. no. 313) (AFOSR-TN-56-579) (AF 18(600)693) AD 115002; PB 139282

Unclassified

For the hypersonic laminar boundary layer of a highly cooled surface with large curvature, a preliminary analysis of a possible transition mechanism is given. Particular emphasis is placed on the destabilizing effect of centrifugal forces in steady flight and the resultant inertia forces in unsteady flight in the presence of cooling. An intuitive description is given. A qualitative check by energy considerations is made along the lines of a problem by Prandtl.

PIB. 05:001

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

ON THE USE OF INTERFERENCE EFFECTS FOR SHOCK DRAG REDUCTION AT SUPERSONIC SPEEDS (Unclassified title), by A. Ferri and J. H. Clarke. July 1954, 51p. illus. refs. (PIBAL rept. no. 258) [AFOSR-TN-54-223] (AF 18(600)694) AD 41214

Confidential

PIB. 05:002

Polytechnic Inst. of Brooklyn. [Dept. of Aeronautical Engineering and Applied Mechanics] N. Y.

DRAG REDUCTION IN LIFTING SYSTEMS BY ADVANTAGEOUS USE OF INTERFERENCE (Unclassified title), by A. Ferri, J. H. Clarke, and A. Casaccio. May 1955, iv. incl. illus. tables, refs. (PIBAL rept. no. 272) ([AF]OSR-TN-55-132) (AF 18(600)694) AD 64266

Confidential

PIB. 05:003

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

A PROVISIONAL ANALYSIS OF TURBULENT BOUNDARY LAYERS WITH INJECTION, by J. H. Clarke, H. R. Menkes, and P. A. Libby. [1955] [6]p. incl. illus. diagrs. table. [AF 18(600)694] Unclassified

Published in Jour. Aeronaut. Sciences, v. 22: 255-260, Apr. 1955.

Prandtl's analysis of the incompressible turbulent boundary layer over a flat plate is extended in this report to include the effect of uniform, transverse fluid injection. The nondimensional parameters characterizing such a flow are deduced by dimensional reasoning. A velocity profile is generated by considering the flow over a plane wall; this distribution reduces to the universal log law when the mass transfer is zero. The expression also serves to relate the local skin friction to the boundary-layer thickness. When these relationships are used in conjunction with the von Kármán integral, the problem becomes mathematically specified. Since only a limited amount of experimental data is available, it is necessary to assign to certain parameters that arise in the velocity profile the constant values they have for no mass transfer. When more measurements are completed, it may be possible to adjust these parameters as or if required. The results give the variation of average skin-friction coefficient with the injection ratio and the Reynolds number based on the streamwise coordinate. The agreement between these results and the experimental data available is found to be satisfactory. The significant reductions in skin friction, and therefore in heat transfer, to be realized with small rates of injection are indicated.

PIB. 05:004

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

ON THE USE OF INTERFERING FLOW FIELDS FOR THE REDUCTION OF DRAG AT SUPERSONIC SPEEDS, by A. Ferri and J. H. Clarke. Mar. 1956 [71]p. incl. diagrs. refs. (PIBAL rept. no. 304) (AFOSR-TN-56-223) (AF 18(600)694) AD 88030

Unclassified

Also published in Jour. Aeronaut. Sciences, v. 24: 1-18, Jan. 1957.

A general outline has been given of possibilities for favorable interference between supersonic aircraft components. The interference between a 3-dimensional wing and a small reflecting surface in biplane arrangement has been discussed in terms of the linearized flow theory. Relationships have been developed which permit the analysis of such biplane configurations without the need for determination of the flow field. These relations apply in the linear approximation to a large class of such configurations. The method has been applied to several biplane arrangements of practical interest. It has been shown that the drag of the wing can be greatly reduced or that the volume near the root section of the wing can be considerably increased without penalty in drag. A discussion of the biplane from the engineering point of view indicated that the configuration appears to have some practical application, particularly in the higher Mach number range. (Contractor's abstract)

PIB. 05:005

Polytechnic Inst. of Brooklyn. [Dept. of Aeronautical Engineering and Applied Mechanics] N. Y.

AN INVESTIGATION OF THE ADVANTAGEOUS USE OF INTERFERENCE EFFECTS IN THE DESIGN OF

PIB. 05:006 - PIB. 06:003

SUPERSONIC INLETS. PART I. EXPERIMENTAL RESULTS OF A BIPLANE INLET AT A MACH NUMBER of 3.15 (Unclassified title), by M. Visich, Jr. Aug. 1956, iv. incl. illus. tables. (PIBAL rept. no. 309) ([AF]OSR-TN-56-436) (AF 18(600)694) AD 96519 Confidential

PIB. 05:006

Polytechnic Insi. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

DRAG OF A THIN BODY FAVORABLY INTERFERING WITH A WING IN SUPERSONIC FLOW, by J. H. Clarke and F. D. Hains. Oct. 1956 [57]p. incl. diagrs. refs. (PIBAL rept. no. 310) (AFOSR-TN-56-496) (AF 18-(600)694) AD 110310 Unclassified

A comparison is made between the drags of thin, wing-like bodies and slender bodies of revolution when these bodies enclose the same volume and immersed in the same supersonic stream. It appears that the sum of the wave drag and the viscous drag can be of comparable magnitude in each case when the chords are equal and the enclosed volume is sufficiently large. Interference of the biplane type between a high aspect ratio wing and a thin, wing-like body with pentagonal planform is analyzed. The body is considered to represent an external installation, such as a store or winged vehicle, which is placed in proximity to the wing. Solutions are found through employment of diaphragms and images and it is shown that interplanar induction is quasi two-dimensional in nature, for the problem considered, so that all detailed calculations required are of the planar type. The difference between the wave of the configuration and the wave drag of the isolated wing is presented as a function of the body planform parameters for given values of the volume enclosed by the body. This drag is always much less than the wave drag of the corresponding isolated body, and becomes zero and then increasingly negative as the span of the body is increased indefinitely. The values also compare favorably with the wave drag of Sears-Haack bodies, exhibiting small fineness ratios and containing equal values, over a range of the body planform parameters. A skin friction estimate, for a particular case, yields results which do not materially alter the latter comparison. (Contractor's abstract)

PIB. 06:001

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

ANALYSIS OF FRAMEWORKS IN THE PRESENCE OF STEADY CREEP, by P. G. Hodge, Jr. and B. Venkatraman. Nov. 1955 [28]p. incl. diagrs. tables, refs. (PIBAL rept. no. 333) ([AF]OSR-TN-55-455) (AF 18(600)1381) AD 81597 Unclassified

An analysis is presented of pinjointed frameworks in which the deformations are caused exclusively by steady creep. By means of the elastic analogue, the creep problem is first reduced to one in nonlinear elasticity. The elastic analysis is then shown to depend upon the solution of one or more nonlinear algebraic equations. Next, 2 distinct methods of finding approximate solutions are presented. These are based upon the 2 minimum principles of elasticity, and also upon the behavior of a rigid-perfectly plastic material. Finally, some examples are worked out by the exact and approximate analyses, the results being compared. (Contractor's abstract)

PIB. 06:002

Polytechnic Insi. of Brooklyn. [Dept. of Aeronautical Engineering and Applied Mechanics] N. Y.

APPROXIMATE SOLUTIONS OF SOME PROBLEMS IN STEADY CREEP, by P. G. Hodge, Jr. and B. Venkatraman. Aug. 1956 42p. incl. tables, refs. (AFOSR-TN-56-361) (AF 18(600)1381) AD 95447 Unclassified

If the elastic and primary creep strains in a structure can be neglected, than it can be shown that the resulting mathematical problem is equivalent to a problem in nonlinear elasticity. Further, if the creep strain rates satisfy a power law, then the classical minimum principles of elasticity are valid for the analogous elastic problem. Therefore, approximate solutions can be obtained by choosing appropriate functions containing certain arbitrary parameters and minimizing either the potential or complementary energy with respect to these parameters. If the exponent in the power law for creep strain rates is large, the stress-strain rate curve is very similar to that which characterizes a rigid-perfectly plastic material. This fact can be used to advantage in choosing appropriate functions for applications of the minimum principles. This concept is illustrated with respect to pin jointed frameworks and jointed plane frames. Exact and approximate methods are compared for some simple examples, and the power of the approximate methods is illustrated in more complex problems. (Contractor's abstract)

PIB. 06:003

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

BENDING OF RIGID FRAMES IN THE PRESENCE OF STEADY CREEP, by B. Venkatraman and P. G. Hodge, Jr. May 1956 [22]p. incl. diagrs. tables, refs. (PIBAL rept. no. 346) (AFOSR-TN-56-455) (AF 18-(600)1381) AD 97071 Unclassified

This paper is concerned with the creep behavior of rigid frames made of a material obeying a steady creep law. The creep problem is first reduced to one in nonlinear elasticity by means of the elastic analogue. The elastic problem is shown to depend upon the solution of one or more nonlinear algebraic equations. Next,

various methods of finding approximate solutions are presented. These stem from the behavior of a rigid-perfectly plastic material and are based upon potential energy analysis. Finally, some examples are worked out by the exact and approximate analyses to show the qualitative effect of creep in bending. (Contractor's abstract)

PIB.06:004

Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.

STRESS DISTRIBUTION IN THE PRESENCE OF CREEP, by N. J. Hoff. Sept. 1956 [18]p. incl. diagrs. refs. (PIBAL repl. no. 362) (AFOSR-TN-56-456) (AF 18(600)-1381) AD 97072 Unclassified

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 8: 211-218, 1957.

When the material of a structure creeps, the law governing the creep deformations, or a law combining elastic and creep deformations, takes the place of Hooke's law in the statement of the problem of stress distribution. The creep laws obtained from creep tensile tests, and their generalizations applicable when the state of stress is biaxial or triaxial and when the stress varies, are discussed. The existence of elastic and plastic analogues for steady and for transient creep is shown and the use of the analogues in stress analysis is explained. The theory of the buckling of columns whose material is subject to creep is presented.

PIB.06:005

Polytechnic Inst. of Brooklyn. [Dept. of Aeronautical Engineering and Applied Mechanics] N. Y.

BUCKLING AT HIGH TEMPERATURES, by N. J. Hoff. [1956] [40]p. incl. illus. diagrs. refs. (AF 18(600)-1381) Unclassified

Presented at Symposium on "Structural Problems of High Speed Flight," College of Aeronautics, Cranfield (England), Aug. 20-23, 1956.

High temperatures affect buckling because the properties of the materials change and because thermal stresses and creep develop. A survey is given of the known solutions of problems arising in consequence of these phenomena.

PIB.07:001

Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.

LONG-LIVED STATES IN PHOTOCHEMICAL REACTIONS: II. PHOTOREDUCTION OF FLUORESCEIN AND ITS HALOGENATED DERIVATIVES, by A. H. Adelman and G. Oster. [Mar. 1956] [17]p. incl. diagrs. tables, refs. (AFOSR-TN-56-130) [AF 18-(600)1182] AD 86007 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 3977-3980, Aug. 20, 1956.

A comparison is made among the constants characterizing the photoreduction of fluorescein and several of its halogenated derivatives in the presence of allyl thiourea. The quantum yield of production of the long-lived excited state changes slightly with halogenation. Similarly, the lifetimes of these states do not vary among the halogenated members and are about 10^{-4} sec in water at room temperature. Internal conversion from the first singlet excited state to the ground state increases with halogenation. There is extensive quenching of the metastable state by the dye in the ground state as well as by a wide variety of foreign substances. The diversity of effective substances suggests that a diffusion-controlled quenching mechanism is operative as opposed to an energy transfer mechanism. Comparison of phosphorescence quenching in a highly viscous medium with the retardation of photoreduction indicates that the metastable state is the triplet state. (Contractor's abstract)

PIB.07:002

Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.

LONG-LIVED STATES IN PHOTOCHEMICAL REACTIONS. I. PHOTOREDUCTION OF EOSIN, by G. Oster and A. H. Adelman. [1956] [4]p. incl. diagrs. refs. (AF 18(600)1182) Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 913-916, Mar. 5, 1956.

A mechanism for the photoreduction of eosin Y with allyl thiourea is presented which necessitates the postulation of a long-lived excited state of the dye. Extensive quenching of this metastable state by dye in the ground state is shown to occur. Kinetic and quenching data are used to evaluate the extent to which the unexcited dye, reducing agent, potassium iodide and p-phenylenediamine interact with the metastable excited state of the dye. Further, these data are used to calculate an approximate lifetime of the long-lived excited state which was found to be about fifty thousand times greater than that of the first excited singlet state. (Contractor's abstract)

PIB.07:003

Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.

FLUORESCENCE AND INTERNAL ROTATION: THEIR DEPENDENCE ON VISCOSITY OF THE MEDIUM, by G. Oster and Y. Nishijima. [1956] [4]p. incl. diagrs. refs. (AF 18(600)1182) Unclassified

PIB. 07:004 - PIB. 08:001

Presented at meeting of the Amer. Chem. Soc., Dallas, Tex., Apr. 1956.

Published in Jour. Amer. Chem. Soc., v. 78: 1581-1584, Apr. 20, 1956.

Substances possessing substituted phenyl groups which are capable of internal rotation increase their fluorescence with increasing viscosity of the medium. The fluorescence yield ϕ of auramine 0, a substituted diphenylmethane dye, measured in glycerol at various temperatures and in dextrose-glycerol-water mixtures at room temperature followed the relation $\phi = (\eta/T) / [\alpha + \beta (\eta/T)]$ where α and β are constants, η is the viscosity and T is absolute temperature. The results are interpreted as being due to one of the fluorescence quenching steps passing via a rotational diffusion process. We calculate that this step takes place if during the period of excitation of the light-excited dye the groups on the molecule have rotated relative to one another by more than 2°. (Contractor's abstract)

PIB. 07:004

Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.

PHOTOREDUCTION OF TRIPHENYLMETHANE DYES IN THE BOUND STATE, by G. Oster and J. S. Bellin. [June 26, 1956] [5]p. incl. diagrs. refs. (AF 18-(600)1182) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 294-298, Jan. 20, 1957.

Triphenylmethane dyes do not undergo photoreduction unless they are bound to water-soluble high polymers. In contrast to their behavior in the light, the reduction of these dyes in the dark by strong reducing agents is actually inhibited when the dyes are bound. In several respects the photochemical behavior of the bound dyes is different from that of free fluorescein-type dyes. Whereas, with the latter, when free, the quantum yield increases with increasing dye concentration. Nitrobenzene retards the rate of fading of free dyes, while in the case of bound dyes, the reaction is inhibited until all the nitrobenzene is consumed, after which the reaction proceeds at a rate equal to that for the inhibitor-free system. Analysis of t e kinetic data shows that bound long-lived excited dye molecules react with the reductant to give colorless products. Interaction between bound dye molecules in the ground state and those in the first electronically excited singlet state is the principal mechanism for the formation of long-lived excited dye molecules. Confirmation of this reaction step is the fact that self-quenching of the fluorescence of bound dye molecules occurs at abnormally low concentrations. An analogy is drawn between these systems and those occurring in photosynthetic systems.

PIB. 07:005

Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.

PHOTOREDUCTION OF EOSIN IN THE BOUND STATE, by J. S. Bellin and G. Oster. [Nov. 30, 1956] [4]p. incl. diagrs. refs. (AF 18(600)1182) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 2461-2464, May 20, 1957.

The spectral and photochemical properties of eosin Y bound to polyvinylpyrrolidone differ considerably from those of the free dye. The bound dye exhibits self-quenching of phosphorescence (in rigid media) the opposite is true. Furthermore, p-phenylenediamine which quenches the phosphorescence of the free dye is without effect on the bound dye. Nitrobenzene retards the photoreduction of free eosin but inhibits the photoreduction of bound eosin, the duration of the inhibition period being proportional to the concentration of the inhibitor. p-Phenylenediamine both inhibits and retards the photoreduction of bound eosin while it only retards the reaction for free dye. For small dye concentrations the quantum yield of photoreduction of bound eosin increases with increasing dye concentration while for free dye the opposite is the case. These rate studies suggest that a bound dye molecule in the first electronically excited state rapidly exchanges energy with a bound dye molecule in the gound state to produce a long-lived excited species which reacts with the reducing agent (here ascorbic acid). A mechanism is proposed for dye-sensitization in silver halide photography based on photoreduction of bound dye. (Contractor's abstract)

PIB. 08:001

Polytechnic Inst. of Brooklyn. [Inst. of Polymer Research] N. Y.

IONIC POLYMERIZATION, by C. G. Overberger and A. B. Finestone. June 1955, 27p. incl. tables, refs. (Technical note no. 2) ([AF]OSR-TN-55-191) (AF 18-(600)970) AD 68543 Unclassified

An attempt was made to synthesize from vinyl monomers an asymmetric polymer which would be capable of producing asymmetric polymers by ionic polymerization. The use of optically active cocatalysts, l-menthoxyacetic acid and d-π-camphorsulfonic acid, in the cationic-catalyzed copolymerization of styrene and p-chlorostyrene, failed to give an asymmetric polymer synthesis. Ammonium p-toluenesulfinate, Na p-toluenesulfinate, and triethylsulfonium bromide were studied with vinyl monomers containing electron-withdrawing groups to explore their use as anionic catalysts in vinyl polymerization. The catalyst did not initiate polymerization. The use of active amylmagnesium bromide in the anionic-catalyzed polymerization of methyl methacrylate failed to give an asymmetric polymer synthesis. This Grignard reagent was not a catalyst for the polymerization of sec-butyl methacrylate. X-ray diagrams demonstrated that polystyrene and polymethyl methacrylate obtained by Alfin-catalyst polymerization were completely amorphous. The use of an optically active alcohol, d-sec-butanol, as one of the components of the Alfin catalyst also failed to give any

increased orientation in the polymer. The Alfin catalysis failed to polymerize sec-butyl methacrylate. (ASTIA abstract)

PIB. 08:002

Polytechnic Inst. of Brooklyn. Inst. of Polymer Research, N. Y.

PREPARATION OF o-VINYLBENZYL-d-s-BUTYL SULFIDE. AN ATTEMPTED ASYMMETRIC POLYMER SYNTHESIS, by C. G. Overberger and L. C. Palmer. June 1955, 17p. incl. diagrs. refs. (Technical note no. 1) ([AF]OSR-TN-55-192) (AF 18(600)970) AD 68544 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 666-669, Feb. 5, 1956.

The preparation of o-vinylbenzyl-d-s-butyl sulfide is described. This optically active monomer was polymerized and copolymerized with a free radical catalyst in an attempt to effect an asymmetric polymer synthesis. After quantitatively removing the sulfur and the optically active group by hydrogenolysis with Raney nickel, the resulting polymer and copolymer were found to be optically inactive and an x-ray diagram of a stretched polymer film showed it to be nonoriented. (Contractor's abstract)

PIB. 08:003

Polytechnic Inst. of Brooklyn. Inst. of Polymer Research, N. Y.

ASYMMETRIC POLYMER SYNTHESIS, by C. G. Overberger, A. B. Finestone, and L. C. Palmer. Final technical rept. Oct. 31, 1955, 4p. [AFOSR-TR-55-34] (AF 18(600)970) AD 78665 Unclassified

The work accomplished on the preparation of asymmetric polymers is reviewed. Abstracts are presented for the technical notes submitted under this task, contract no. AF 18(600)970.

PIB. 09:001

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

REARRANG[E]MENT COLLISIONS, by B. A. Lippmann. Dec. 14, 1955 [16]p. (Research rept. no. R-454-55; PIB-384) ([AF]OSR-TN-55-468) (AF 18(600)1505) AD 84600 Unclassified

The quantum mechanical theory of rearrangement collisions is discussed. In particular, are considered: (a) the transformation of the state vector from the original basis to the basis of the rearranged system; (b) the conditions for the equivalence of the "post" and "prior" interactions when computing matrix elements; and, (c) the extension of Schwinger's variational principle to rearrangement collisions. (Contractor's abstract)

PIB. 09:002

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

DESIGN OF FEEDBACK SYSTEMS, by E. J. Angelo, Jr. Jan. 31, 1956 [22]p. incl. diagrs. refs. (Repl. no. R-449-55; PIB-379) (AFOSR-TN-56-146) (AF 18-(600)1505) AD 86305 Unclassified

An examination is made on the relationship between system configuration and system performance with the objective of establishing practical guides to aid in choosing the configuration to be used. This study revealed that the dynamic performance of a linear feedback system depends primarily on the over-all transmission (closed-loop transfer function), T_0, and the sensitivity function, S; it is independent of the system configuration used to realize these functions. In order to achieve an optimum design, attention should be directed toward the choice of optimum transfer and sensitivity functions; the system configuration can then be chosen for greatest convenience in realizing these functions. This statement implies a design procedure consisting of 2 parts: (1) the choice of optimum functions for T_0 and S, and (2) the choice of system components and configuration to realize these functions when certain components (such as the servo motor) are specified. (ASTIA abstract)

PIB. 09:003

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

PROCEEDINGS OF THE SYMPOSIUM ON MODERN NETWORK SYNTHESIS, NEW YORK, APR. 13-15, 1955, Vol. V, ed. by J. Fox. Ann Arbor, Mich., Edwards Brothers, Inc., 1956, 528p. incl. diagrs. tables, refs. (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Signal Corps under [AF 18(600)1505]) Unclassified

A broad review is presented of significant contributions to network synthesis during the period from approximately 1951 to 1955. It deals with passive and reciprocal networks, nonreciprocal networks, and active networks. The following papers are presented: (1) Passive Network Synthesis, by R. M. Foster; (2) Synthesis of Nonreciprocal Networks, by H. J. Carlin; (3) Synthesis of Active Networks, by W. R. Bennett; (4) Driving-Point Impedance Synthesis Using Maximally Lossy Elements, by J. H. Westcott; (5) Networks without Mutual Reactance, by A. D. Fialkow; (6) On Pseudo-Scattering Matrices, by Y. Oono; (7) New Methods of Driving-Point and Transfer Impedance Synthesis, by E. A. Guillemin; (8) On the Synthesis of Networks

Containing Two Kinds of Elements, by F. H. Effertz; (9) Synthesis of Four-Wire Conference Networks and Related Problems, by V. Belevitch; (10) A Fourier Method for Time Domain Synthesis, by M. Strieby; (11) Optimum Pulse Shape for Digital Transmission, by A. E. Laemmel; (12) Linear Least Squares Filtering and Prediction of Sampled Signals, by S. P. Lloyd and B. McMillan; (13) Some Applications of the Laurent Schwartz Distribution Theory to Network Problems, by P. A. Clavier; (14) Time Domain Filter Operations, by G. R. Lang; (15) Algebraic and Topological Foundations of Network Synthesis, by S. Okada; (16) Duality, Partial Duality and Contact-Transformations, by E. Colin Cherry; (17) Transfer Impedance of Reciprocal Passive Two-Ports with Prescribed Transfer and Reflection Coefficients, by H. Piloty; (18) Reflectionless Transmission through 2N-Terminal-Pair Networks, by J. F. Klinkhamer; (19) Tchebycheff Approximations for Amplitude and Delay with Rational Functions, by D. Helman; (20) Network Response in Terms of Behavior at Imaginary Frequencies, by A. Papoulis; (21) Network Theorems for Wideband Transistor Amplifiers, by G. L. Matthaei and G. P. Ploinikoff; (22) The Synthesis of Active Filters, by J. G. Linvill; (23) Internal Feedback and Neutralization of Transistor Amplifiers, by A. P. Stern, C. A. Aldridge, and W. F. Chow; (24) Transient Analysis of Feedback Systems with Time Delay, by K. Kupfmuller. The symposium is concluded with a round table discussion on the practical implications of modern network.

PIB. 09:004

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

PROCEEDINGS OF THE SYMPOSIUM ON NONLINEAR CIRCUIT ANALYSIS, NEW YORK, APR. 25-27, 1956, Vol. VI, ed. by J. Fox and M. Crowell. Ann Arbor, Mich., Edwards Brothers, Inc., 1956, 456p. incl. illus. diagrs. tables, refs. (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1505, Office of Naval Research, and Signal Corps) Unclassified

A survey of fundamental principles of nonlinear circuits with illustrative examples. Included are: advances in nonlinear theory; stability theory; applications of nonlinear theory; properties of closed loop systems; importance of initial conditions; mathematical aspects of subharmonic response; a new describing function; equivalent linearization; dynamic programming; final value systems; Markov process distribution; feedback system synthesis; nonlinear sampled data systems; piecewise linear analysis and synthesis; general energy relations; and complex convolution as applied to nonlinear problems.

PIB. 09:005

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

ACTIVE NETWORK SYNTHESIS, by I. M. Horowitz. [1956] [6]p. incl. diagrs. [AF 18(600)1505] Unclassified

Presented at I. R. E. National Convention, New York, Mar. 19-21, 1956.

Published in I. R. E. Convention Record, Part 2: 38-45, 1956.

A discussion is presented of synthesis of transfer functions in the form of unbalanced structures utilizing resistors, capacitors, and active elements (transistors or tubes). Three experimental networks and results are presented.

PIB. 09:006

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

NETWORK THEORY IN THE PRACTICAL DESIGN OF CONTROL SYSTEMS, by J. G. Truxal. [1956] [5]p. incl. diagrs. [AF 18(600)1505] Unclassified

Presented at I. R. E. National Convention, New York, Mar. 19-21, 1956.

Published in I. R. E. Convention Record, Part 2: 3-7, 1956.

Typical applications of realization techniques, feedback theory, and measurement techniques in the field of network theory are described. Some of the problems which are of interest to the control engineer are analyzed. The correlation of network theory and feedback control system design is discussed.

PIB. 09:007

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

SYNTHESIS OF NONRECIPROCAL NETWORKS, by H. J. Carlin. [1956] [34]p. incl. diagrs. refs. [AF 18(600)1505] Unclassified

Presented at Symposium on Modern Network Synthesis, New York. Apr. 13-15, 1955.

Published in Proc. of the Symposium on Modern Network Synthesis, New York (Apr. 13-15, 1955), Ann Arbor, Mich., Edwards Brothers, Inc., v. 5: 11-44, 1956.

Some of the synthesis techniques which can be used for n-terminal-pair nonreciprocal networks are described. Items discussed include: (1) single frequency and frequency invariant networks, (2) synthesis of reactance networks in the frequency domain, (3) synthesis of general passive networks in the frequency domain, and (4) synthesis of active networks.

PIB. 09:008

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

MODIFICATION OF THE BRILLOUIN-WIGNER PERTURBATION METHOD, by B. A. Lippmann. [1956] [2]p. (AF 18(600)1505) Unclassified

Published in Phys. Rev., v. 103: 1149-1150, Sept. 1, 1956.

By using the method of Goldhammer and Feenberg, a simple, generally valid prescription for improving the Brillouin-Wigner perturbation procedure is derived. (Contractor's abstract)

PIB. 09:009

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

R-C TRANSISTOR NETWORK SYNTHESIS, by I. M. Horowitz. [1956] [12]p. (AF 18(600)1505; continued by AF 18(603)105) Unclassified

Presented at National Electronics Conference, Chicago, Ill. Oct. 1-3, 1956.

Published in Proc. National Electronics Conference, v. 12: 818-829, 1956.

The transistor with its numerous attractive features lends itself readily to exploitation as a circuit element. In conjunction with resistors and capacitors, it may be used to synthesize transfer functions otherwise requiring inductors. Synthesis procedures for this purpose have been described in the literature. One gap in these procedures has been the lack of any unrestricted method for realizing non-minimum phase transmission zeros in the form of simple unbalanced networks. This paper fills this gap with an R-C-transistor synthesis technique for realizing transmission zeros. The synthesis philosophy is in the tradition of Brune, Darlington and Dasher in that a driving-point-impedance is developed in ladder form by means of a cascade of canonical sections. Each section, consisting of a T structure of four passive elements in parallel with one transistor, realizes one pair of zeros and in the process, reduces the degree of the driving-point impedance by two. Alignment is thus considerably simplified because there is no interaction between sections with respect to their transmission zeros. Experimental examples are given and methods are described for making the transfer function so insensitive to the transistors, as to permit interchange of transistors of different manufacturers, with negligible effect on the network characteristics. (Contractor's abstract)

PtB. 10:001

Polytechnic Inst. of Brooklyn. Microwave Research Inst , N. Y.

NON-RECIPROCAL NETWORK THEORY APPLIED TO FERRITE MICROWAVE DEVICES (Abstract), by H. J. Carling. [1956] [1]p. (AF 18(603)105; continuation of AF 18(600)1505) Unclassified

Presented at meeting of the British Inst. of Electrical Engineering, London (England), Oct. 29, 1956.

The network expressions for the physical realizability of non-reciprocal structures are briefly examined. These are then applied to a discussion of the properties of linear ferrite microwave devices. Applications include properties and equivalent circuits for one-way lines, multiport circulators, multiport power dividers, variable directional couplers, phase shifters, and ferrite duplexers. Some discussion is also given to the use of non-reciprocal circuit concepts in the measurement of the terminal properties of linear ferrite devices by means of equivalent circuits, and by the application of a theorem which separates reciprocal and non-reciprocal effects in measurement techniques. Finally a brief introduction is given to the use of symmetry operators in analyzing the circuit properties of microwave junctions containing ferrites. (Contractor's abstract)

PtB. 10:002

Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.

SENSITIVITY CONSIDERATIONS IN ACTIVE NETWORK SYNTHESIS, by J. G. Truxal and I. M. Horowitz. [1956] [11]p. incl. diagrs. (AF 18(603)105) Unclassified

Presented at Second Midwest Symposium on Circuit Theory, East Lansing, Mich., Dec. 3-4, 1956.

Published in Proc. Second Midwest Symposium on Circuit Theory, p. 6-1-6-11, 1956.

Attempt is made to indicate the increased flexibility attainable in feedback system realization if the input signals can be characterized as belonging to a restricted class — for example, pure sinusoids with only the network gain of interest, damped sinusoids or decaying exponentials, or typical transient test signals such as step functions. In the first case, the real part of the classical sensitivity function must be evaluated at real frequencies in the band of interest; in the second case, the value of the classical sensitivity function at a specified, complex value of frequency is pertinent; and in the third case, the root-locus method indicates the configuration and realization by which the loci can be made to move so as to preserve the desired characteristics of the transient response (e.g., radially expanding or contracting to leave the overshoot unaltered by changes in ζ). In each case, the active, feedback network can possess self-calibration properties (low sensitivity) without the high loop gain.

POM. 01:001 - POM. 01:004

POM. 01:001

[Pomona Coll. Dept. of Physics, Claremont, Calif.]

SUBMICROSCOPIC STRUCTURE DETERMINATION BY LONG WAVELENGTH X-RAY DIFFRACTION, by B. L. Henke and J. W. M. DuMond. [1955] [15]p. incl. illus. diagrs. refs. (Bound with its AFOSR-TN-57-436; AD 136426) [AF 18(600)1045] Unclassified

Also published in Jour. Appl. Phys., v. 26: 903-917, July 1955.

This paper reviews the theory of low angle x-ray diffraction as applied in the long wavelength region for the determination of particle sizes and shapes and other structural features in the submicroscopic size range and emphasizes the advantages to be gained by employing the longer x-ray wavelengths (8 to 25 A). It also is intended to serve as an introduction to a description of an entirely new instrumental technique developed for this long wavelength range utilizing a diffraction apparatus consisting of a special gas-filled x-ray tube and a total reflection camera in which the primary radiation is simultaneously monochromatized and made to converge to a point focus. The sample for study is placed in the converging part of the primary beam and the diffraction patterns are formed around the point focus on a photographic film. (Contractor's abstract)

POM. 01:002

Pomona Coll. [Dept. of Physics] Claremont, Calif.

DIFFRACTION MICROSCOPY — A LIGHT MICROSCOPE METHOD FOR THE MEASUREMENT OF SUBMICRON PARTICLES (Abstract), by B. L. Henke. [1956] [1]p. [AF 18(600)1045] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 34, Jan. 30, 1956.

Submicroscopic particles can be detected by using the conventional dark-field illumination which consists of an intense hollow cone of radiation that converges from the substage condenser to a point on the sample and then spreads out with sufficient angle to "miss" the objective. By reducing the size of the aperture stop of the objective and the angular "thickness" of the illuminating cone, the radiation which forms a point image is characteristic of a particular angle of scattering from a particle. A method has been developed for varying this half-angle of the illuminating cone and for measuring the light flux which forms an image point. Information is thus obtained as to the angular distribution in the forward direction of energy which is scattered from a single particle. The deduction of particle size becomes relatively straightforward for the important class of problems involving a small difference between the refractive index of the particle and that of the surrounding medium — a condition which usually obtains for biological materials in solution, for example. The diffraction theory as applied in low angle x-ray diffraction techniques can be used for the case of "soft" scatterers in the 0.1 μ to 1 μ range. (Contractor's abstract)

POM. 01:003

Pomona Coll. [Dept. of Physics] Claremont, Calif.

SEMIEMPIRICAL METHOD FOR THE COMPUTATION OF MASS ABSORPTION COEFFICIENTS FOR THE LONG WAVE-LENGTH X-RAY REGION (Abstract), by R. White and B. L. Henke. [1956] [2]p. [AF 18-(600)1045] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30–Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 34-35, Jan. 30, 1956.

The measurement of absorption coefficients in the x-ray wavelength region of 5 to 50 Å is usually very difficult because of the necessity for working in vacuum and for obtaining and measuring very small sample thicknesses. A considerable amount of work has been accomplished on the theoretical derivation of photoelectric absorption cross sections, but none of these seems to constitute a practical basis for an extensive computation of mass absorption coefficients. Nevertheless wave-mechanical theory does suggest that a "universal" absorption equation should exist for this long wavelength region of the form $(\mu/\rho)(A/\lambda) = f_K(\lambda/\lambda_1) + f_L(\lambda/\lambda_2)\ldots$ in which (μ/ρ) is the mass absorption coefficient, A is the atomic weight, λ_1 and λ_2 are characteristic wavelengths which "measure" the binding of electrons in the K and L shells and which consequently depend on the atomic number of the element, and f_K and f_L are universal functions. An empirical method has been developed which has permitted the determination of these universal functions and the characteristic wavelengths from available absorption data. The "universal" functions have been expressed in both tabulated and equation form and do permit a rapid and precise computation of mass absorption coefficients for wavelengths in the 5 to 50 Å region which lie below the critical L-absorption edge for the particular element. (Contractor's abstract)

POM. 01:004

[Pomona Coll. Dept. of Physics, Claremont, Calif.]

SLIDE RULE FOR RADIOGRAPHIC ANALYSIS, by B. L. Henke. [1956] [3]p. incl. illus. diagr. table. (Bound with its AFOSR-TN-57-436; AD 136426) [AF 18(600)1045] Unclassified

Also published in Rev. Scient. Instruments, v. 27: 1043-1045, Dec. 1956.

A simple slide rule has been developed which will permit a rapid and accurate determination of radiographic sample transmission, of absorption index, μm, and of the photographic film density corresponding to the direct x-ray beam by means of a single setting of the sliding scale. (Contractor's abstract)

Princeton U., N. J.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:142-PRI. 11:160.

Princeton U. Aeronautical Engineering Lab., N. J.

N6ori-10503, Project Squid see under Princton U. James Forrestal Research Center, N. J. (Project SQUID) item no. PRI. 11:161.

PRI. 01:001

Princeton U. [Aeronautical Engineering Lab.] N. J.

HYPERSONIC VISCOUS FLOW OVER A FLAT PLATE (Abstract), by L. Lees and R. F. Probstein. [1952] [1]p. [AF 33(038)250] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 31, Feb. 1-2, 1952.

Published in Phys. Rev., v. 86: 600, May 15, 1952.

The steady hypersonic flow of a viscous, heat conducting gas over a semi-infinite flat plate is examined in a region away from the leading edge. As a result of the curvature of the relatively thick boundary layer, variations in pressure are propagated into the main stream along Mach lines, with a subsequent interaction between the "inviscid" field and the boundary layer growth. Solution of this problem shows that the important generating parameter is $M^3/(Re_x)^{1/2}$, where, M is the free stream Mach number and Re_x the Reynolds number based on distance from the leading edge. By successive iterations between the "internal" and "external" fields, asymptotic expansions in terms of $M^3/(Re_x)^{1/2}$ are found for the flow quantities such as pressure, velocity, temperature, etc. The zero-pressure gradient flat-plate boundary layer solution is the first approximation in the expansions. It is shown that there is a wedge-like domain where the "higher order" viscous terms in the x-momentum equation can be neglected. In addition to the horizontal pressure gradient, the gradient normal to the plate is evaluated. From the results, the region of validity of the zero pressure gradient boundary layer solution, as well as the error made in the skin friction and heat transfer rate determined by this solution, can be found. When $M^3/(Re_x)^{1/2}$ is not small, compared to one, the error is considerable. (Contractor's abstract)

PRI. 01:002

Princeton U. Aeronautical Engineering Lab., N. J.

ON THE BOUNDARY LAYER EQUATIONS IN HYPERSONIC FLOW AND THEIR APPROXIMATE SOLUTIONS, by L. Lees. Sept. 20, 1952, 10p. incl. diagrs. (Rept. no. 212) (AF 33(038)250) ATI-169812 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 143-145, Feb. 1953.

Analytical solutions of the Prandtl boundary layer equations are obtained for the problem of the "strong" interaction between the leading-edge shock and the viscous layer over a flat plate at hypersonic velocities.

PRI. 01:003

Princeton U. Aeronautical Engineering Lab., N. J.

ON A SOLUTION OF THE ENERGY EQUATION FOR A ROTATING PLATE STARTED IMPULSIVELY FROM REST, by R. F. Probstein. Sept. 20, 1952, 10p. refs. (Rept. no. 213) (AF 33(038)250) ATI-169813 Unclassified

The problem of the steady, laminar incompressible flow of a fluid over an infinite plate rotating at a constant velocity was first solved by von Kármán. Recently the associated heat transfer problem for the von Kármán example was calculated by Millsaps and Pohlhausen. The purpose of this paper is to show that when heat conductivity is included a solution for the initial phase of the impulsive start may be obtained. Apart from an academic viewpoint, this solution offers an interesting mathematical analogy to the steady hypersonic laminar flow over a semiinfinite flat plate with a "self-induced" pressure gradient.

PRI. 01:004

Princeton U. Aeronautical Engineering Lab., N. J.

ON THE RECOVERY FACTOR FOR HYPERSONIC FLOW WITH A SELF-INDUCED PRESSURE GRADIENT, by R. F. Probstein and L. Lees. [1953] [2]p. (AF 33(038)250) Unclassified

Published in Jour. Aeronaut. Sciences, v. 20: 291-292, Apr. 1953.

This paper gives in closed form the first approximation for the wall temperature in hypersonic flow with a self-induced pressure gradient due to the laminar boundary layer. The equilibrium wall temperature has exactly the same value as for zero pressure gradient. Thus Busemann's conclusion that the recovery temperature is unaffected by pressure gradient for Pr = 1 is generalized to arbitrary Pr, at least for the case of weak interaction in hypersonic flow. (Appl. Mech. Rev. abstract)

PRI. 02:001 - PRI. 02:005

PRI. 02:001

Princeton U. Aeronautical Engtneering Lab., N. J.

STABILITY OF THE LAMINAR BOUNDARY LAYER WITH INJECTION OF COOL GAS AT THE WALL, by L. Lees. May 20, 1948, 24p. dtagrs. (Rept. no. 139) (Sponsored jotntly by [Offtce of Naval Research and Atr Force Office of Scientiftc Research] under N6ort-27006) Unclasstfied

The mtnimum critical Reynolds number, or "stabtlity limtt" for the laminar boundary flow of a hot gas over a porous-cooled flat plate ts calculated as a function of the rate of coolant tnjection from the computed velocity and temperature dtstrtbutions across the boundary layer. The result is found that for low rates of coolant injection, the stabtltzing effect of the heat transfer at the wall is dominant, and the laminar flow ts actually more stable than the tsothermal blastus flow over a non-porous flat plate. For large injection rates the mtnimum crttical Reynolds number declines extremely rapidly, and the flow ts almost certainly turbulent. (Contractor's summary, modified)

PRI. 02:002

Princeton U. Aeronautical Engtneering Lab., N. J.

INTERACTION BETWEEN THE LAMINAR BOUNDARY LAYER OVER A PLANE SURFACE AND AN INCIDENT OBLIQUE SHOCK WAVE, by L. Lees. Jan. 24, 1949, 45p. (Repi. no. 143) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-27006 and Bureau of Ordnance under NOrd-7920, Task no. PRN-2-E) U6017; ATI-55006 Unclassified

The problem of the interaction between the laminar boundary layer over a plane surface and an oblique shock wave incident on the surface is treated by separating the flow in the immediate vicinity of the "shock" from the rest of the flow in the viscous gas layer adjacent to the surface.

PRI. 02:003

Princeton U. Aeronautical Engineering Lab., N. J.

STABILITY OF THE SUPERSONIC LAMINAR BOUNDARY LAYER WITH A PRESSURE GRADIENT, by L. Lees. Nov. 20, 1950, 27p. diagrs. tables, refs. (Rept. no. 167) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-27006) U15373; ATI-93359 Unclassified

The effect of a negative pressure gradient on supersonic laminar boundary-layer stability was qualitatively considered. Approximate minimum critical Reynolds numbers (Re) were calculated for several insulated symmetrical circular-arc airfoils at Mach numbers (M) of 1.5, 2.0, and 3.0. Velocity and temperature distributions were obtained by the Dorodnitzyn-Pohlhausen method based on the von Karman momentum integral equation. The boundary layer was completely stabilized at low M's for parameters $\lambda \sim \frac{\delta^2}{\nu} \frac{d v}{dx} f(M)$ which exceeded a critical value dependent only on M and the gas properties, where δ is the boundary-layer thickness, v the gas velocity in adiabatic steady flow, x the surface distance, and f (M) a function of M. The aerodynamic-heating destabilizing effect was dominant at M= 2 and the minimum critical Re increase was small until $\Lambda - 11$. The negative pressure gradient was not influential at M= 3 for insulated surfaces. Comparisons between the stability-limit distribution over the airfoil at M=1.5 and the Re increase based on δ indicated (1) the existence of an unstable laminar-layer flow in the forward half of foil 6% thick at an angle of attack $\alpha = 0°$ with the complete stabilization at the 70% chord station for $Re > 7.5 \times 10^5$, (2) a small unstable region at $\alpha = 0°$ for foil 10% thick until $Re > 3 \times 10^6$ with stabilization at midchord, (3) a large unstable region on the upper surface of foil 6% thick at $\alpha = 4°$ and $Re = 7.5 \times 10^5$ and an insignificant region on the lower surface until $Re > 3 \times 10^6$, (4) complete stabilization below the given Re values, and (5) complete instability at M= 2 and $\alpha = 0°$ for both foils with $Re = 7.5 \times 10^5$. Transition on the airfoil was apparently delayed at low M's to a greater extent than insulated flat plates for $7.5 \times 10^5 \leq Re \leq 5.0 \times 10^6$. A stronger stabilizing effect α was postulated on the lower rather than the upper surface. The negative pressure-gradient effect is expected to increase with the thickness ratio.

PRI. 02:004

Princeton U. Aeronautical Engineering Lab., N. J.

A PRELIMINARY INVESTIGATION OF A SHOCK WAVE - TURBULENT BOUNDARY LAYER INTERACTION, by S. M. Bogdonoff and A. H. Solarski. Nov. 30, 1951, 14p. illus. diagrs. (Repi. no. 184) (Sponsored jotnily by Office of Naval Research and Air Force Office of Scientific Research under N6ori-27006) U21272; ATI-134070 Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, N. Y., Jan. 31, Feb. 1-2, 1952.

Also published in Phys. Rev. v. 86: 601, May 15, 1952.

Preliminary data in the form of static and pitot pressure distributions and shadow and Schlieren photographs have been obtained for the interaction of a 2.09 pressure ratio shockwave with a turbulent boundary layer on a flat wall at M = 2.97. Separation of the boundary layer appears to be incipient, and a model of the interaction has been constructed.

PRI. 02:005

Princeton U. Aeronautical Engineering Lab., N. J.

A MIXING THEORY FOR THE INTERACTION

BETWEEN DISSIPATIVE FLOWS AND NEARLY-ISENTROPIC STREAMS, by L. Crocco and L. Lees. Jan. 15, 15, 1952, 1v. incl. diagrs. refs. (Rept. no. 187) (Sponsored jointly by Offtce of Naval Research and [Air Force] Office of Sctentiftc Research under N6ori-27006) U21273; ATI-134246 Unclassified

Also published in Jour. Aeronaut. Sctences, v. 19: 649-676, Oct. 1952.

By means of a simplified theoretical "model", this report treats the general class of flow problems characterized by the tnteraction between a vtscous, or dtssipative flow near the surface of a solid body, or tn tis wake, and an "outer" nearly-tseniroptc stream.

PRI. 02:006

Princeton U. Aeronautical Engtneering Lab., N. J.

ON THE STABILITY OF LAMINAR BOUNDARY LAYER FLOW, by S.-I. Cheng. [1952] 24p. tncl. refs. (Rept. no. 211) (Sponsored jointly by Offtce of Naval Research and [Air Force] Offtce of Scientiftc Research under N6ori-27006; conlinued by N6onr-27006) U24723; ATI-168952 Unclassifted

Also published in Quart. Appl. Math., v. 11: 346-350, Oct. 1953.

The stabtltiy of ihe laminar boundary layer is determined by the local flow properties for both the compressible and the incompresstble flow wlihin the order of approximation attempted by previous invesligaiors. It is concluded thai the vertical velocity componeni is the most critical facior thai had been neglected in previous siability investigations of the laminar boundary layer flow.

PRI. 03:001

Princeton U. [Dept. of Aeronautical Engineering] N. J.

A PRELIMINARY STUDY OF REYNOLDS NUMBER EFFECTS ON BASE PRESSURE AT M = 2.95, hy S. M. Bogdonoff. June 12, t95t, 11p. incl. illus. (Rept. no. 182) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006; continuation of N6ori-27006) U18319; ATI-111230 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 19: 201-206, Mar. 1952.

A preliminary study was carried out to determine the effect of Reynolds number on the base pressure of a simple cone-cylinder body of revolution. Tests were made at M = 2.95 over a range of Reynolds numbers from 0.6×10^6 to 18×10^6. The body was tested in the smooth condition and with transition fixed by several different roughness bands. Detailed results are given.

PRI. 03:002

Prtnceton U. Depi. of Aeronautical Engtneertng, N. J.

ON THE FLOW AT THE REAR OF A TWO-DIMENSIONAL SUPERSONIC AIRFOIL WITH THICKNESS, by R. F. Probstetn. May 1, 1953, 3p. (Rept. no. 228) (Sponsored jointly by Offtce of Naval Research and [Air Force] Offtce of Scientiftc Research under N6onr-27006) AD 9822 Unctasstfted

Published in Jour. Aeronaul. Sctences, v. 20: 580-581, Aug. 1953.

A correction ts given to a treatment of the problem of the flow deflection tmmediately rearward of a two-dtmenstonal supersonic atrfoil by Kahane and Lees tn 1948. The authors expressed the change in dynamtc pressure through an tseniroptc wave as

$$\Delta q = q_1 (\pm G_1 \theta + G_2 \theta^2 \pm G_3 \theta^3 + \ldots.),$$

and ihrough a shock wave as

$$\Delta q = q_1 (\pm G_1 \theta + G_2 \theta^2 \pm (G_3 - H) \theta^3 + \ldots.),$$

where $q = \rho W^2/2$ (ρ = density, W = flow velocity), θ is the deflection, posiitve in a counterclockwise sense, and q_1 ts ihe dynamtc pressure ahead of the wave. The correcied value for G_3 should be

$$G_3 = \frac{\frac{(1+\gamma)(2-\gamma)}{12} M^{10} + \frac{(-4\gamma^2 + 17\gamma - 16)}{12} M^8 + \frac{(21 - 4\gamma)}{3} M^6 + \frac{1}{3} M^4 + \frac{14}{3} M^2 + \frac{4}{3}}{(M^2 - 1)^{7/2}}$$

where M is the flow Mach number ahead of the wave.

PRI. 03:003

Princeton U. Depi. of Aeronauitcal Engineering, N. J.

A STUDY OF SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTION AT M = 3, by S. M. Bogdonoff, C. E. Kepler, and E. Sanlorenzo. July 1953, 1v. tncl. illus. diagrs. refs. (Rept. no. 222) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 16740 Unclasstfted

An experimental study has been made of the effect of the interaction of varying strength shock waves with a turbulent boundary layer at a Mach number of about 2.9.

PRI. 03:004

Princeton U. [Dept. of Aeronautical Engineering] N. J.

INTERACTION OF A TURBULENT BOUNDARY LAYER WITH A STEP AT M = 3, by C. E. Kepler and S. M. Bogdonoff. Sept. 1, 1953, tv. incl. illus. diagrs. refs. (Rept. no. 238) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N6onr-27006) AD 20686 Unclassified

An experimental investigation of the flow over a two-dimensional step was carried out at a Mach number of 2.92. The separation of a turbulent boundary layer and the associated shock wave pattern were studied as

PRI. 03:005 - PRI. 03:008

the step height was varied from 1/3 to 2 times the boundary layer thickness. The interaction was observed by Schlieren and shadowgraph techniques, supplementing the wall static pressure surveys and detailed total head surveys through interaction. Reverse flow regions were investigated by using a minute total head tube which would face downstream as well as upstream.

PRI. 03:005

Princeton U. [Dept. of Aeronautical Engineering] N. J.

REMARKS ON "INTERACTIONS BETWEEN WHOLLY LAMINAR OR WHOLLY TURBULENT BOUNDARY LAYERS AND SHOCK WAVES STRONG ENOUGH TO CAUSE SEPARATION" [BY G. E. GADD], by S. M. Bogdonoff. Nov. 17, 1953, 2p. incl. illus. (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 49151 Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 138-139, Feb. 1954.

Gadd's analysis of interactions between laminar or turbulent boundary layers and shock waves strong enough to cause separation (Jour. Aeronaut. Sciences, v. 20: 729, Nov. 1953) is discussed briefly by Bogdonoff of the Gas Dynamics Laboratory (GDL), James Forrestal Research Center. It is pointed out that data obtained at GDL differ considerably from the experimental results of Gadd. The GDL investigations, carried out at M~3, show separation occurring at a wall-static-pressure ratio between 2.0 and 2.1, as compared with Gadd's 2.5. A plot of the Gadd and GDL data concerning the effect of pressure ratio on the "influence regions" (those regions as defined by Gadd as the theoretical point of impingement of the incident shock to the beginning of the interaction divided by the displacement thickness of the boundary layer ahead of the interaction) reveals further disagreement. It is conjectured that this disagreement may have resulted from Gadd's use of generators that did not span the wind tunnel, and his assumption of the basic velocity profile at the reattachment point is questionable. Therefore, it is believed that the results of the Gadd analysis as applied to the prediction of the interaction of a turbulent boundary layer with a shock are not completely valid.

PRI. 03:006

Princeton U. Dept. of Aeronautical Engineering, N. J.

SEPARATION OF A SUPERSONIC TURBULENT BOUNDARY LAYER, by S. M. Bogdonoff and C. E. Kepler. Jan. 1954, 18p. illus. refs. (Rept. no. 249) [AFOSR-TN-54-44] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 27902 Unclassified

Presented at annual meeting of the Inst. of the Aeronaut. Sciences, New York, Jan. 25-29, 1954.

Also published in Jour. Aeronaut. Sciences, v. 22: 414-424, June 1955.

The separation of a supersonic turbulent boundary layer under the effect of a strong adverse gradient has been studied at M~3 by examining in detail the phenomena of flow over a step and shock wave-boundary layer interaction. Wall static pressures, total head surveys and optical techniques, including the use of color Schlieren, were used to provide a model of the separation phenomena. It was found that: (1) When the separated region is small, the phenomena appears to be quite different than when the separated region is large. For small regions the gradients are stronger and large changes can occur for small changes in the disturbance. (2) Separation at M~3 occurred at a pressure ratio of about 2, about two to three boundary layer thicknesses from the start of the interaction and was quite unaffected by the flow downstream. (3) A considerable pressure rise occurs after the separation point. The peak pressure ratio of about 2.6 occurs approximately six to eight boundary layer thicknesses downstream of the start of the interaction. (4) These results, combined with other investigations, indicate a very small change in separation pressure ratio with Mach number. (5) The effect of Reynolds number on the phenomena appears to be negligible. (6) The detailed model, showing considerable pressure rise after separation, appears to be susceptible only to the type of theoretical treatment proposed by Crocco and Lees. However, considerably more results on mixing rates are needed for its direct application.

PRI. 03:007

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE PEAK PRESSURE RISE ACROSS AN OBLIQUE SHOCK EMERGING FROM A TURBULENT BOUNDARY LAYER OVER A PLANE SURFACE, by L. Crocco and R. F. Probstein. Mar. 1954 [35]p. incl. diagrs. refs. (Rept. no. 254) ([AF]OSR-TN-54-105) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 45651 Unclassified

A method is given for predicting the peak pressure rise across an oblique shock wave emerging from a turbulent boundary layer over a plane surface, for conditions both up to and beyond those necessary to separate the flow. The generalized parameters of the Crocco-Lees Mixing Theory are utilized in the analysis. (Contractor's summary)

PRI. 03:008

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE TRANSVERSE CURVATURE EFFECT IN COMPRESSIBLE AXIALLY-SYMMETRIC LAMINAR BOUNDARY LAYER FLOW, by R. F. Probstein and D. Elliott. Apr. 1954 [63]p. incl. diagrs. tables, refs. (Rept. no. 261) [AFOSR-TN-54-124] (Sponsored jointly by

Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 45752
Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 208-224, 236, Mar. 1956.

The viscous transverse curvature effect in compressible axially symmetric laminar boundary layer flow was investigated. The effect was characterized by the parameter Δ/r_0 which is the ratio of the boundary-layer thickness to body radius. By a generalization of Mangler's transformation, the boundary layer equations are reducible to an almost 2-dimensional form. This simplifies the analysis for 2 asymptotic flow regions characterized by $\Delta/r_0 >> 1$ and Δ/r_0 less than or of the order of unity. For the latter case, the additional term in the momentum and energy equation, which differentiates it from the 2-dimensional form, behaves like an axial pressure gradient. The asymptotic solutions for the velocity and temperature can be found for zero pressure gradient when the body shapes go like $r_0 = ax^n$ and $r_0 = ae^{bx}$. The zeroth approximation is the Mangler result. The first order correction to the Mangler formulation Pr = 1 shows that in the case of the cone and cylinder the effect on both the skin friction coefficient and heat transfer rate can become appreciable in the range where Δ/r_0 is less than or of the order of unity. At a constant Δ/r_0, the effects are increased in magnitude when either the ratio of wall to free stream temperature, or Mach number, is increased. Also, all other conditions being equal, for the same value of Δ/r_0 the skin friction coefficient and heat transfer increase on the cylinder is greater than that on the cone. (ASTIA abstract)

PRI. 03:009

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE TRANSVERSE CURVATURE EFFECT IN COMPRESSIBLE AXIALLY-SYMMETRIC LAMINAR BOUNDARY LAYER FLOW INCLUDING THE EFFECTS OF PRESSURE GRADIENT, by D. Elliott. July 1954 [106] p. incl. diagrs. tables, refs. (Rept. no. 269) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) Unclassified

The viscous transverse curvature effect in compressible axially-symmetric laminar boundary layer flow has been investigated, and it is found that the effect is characterized by the parameter Δ/r_0 which is essentially the ratio of the boundary layer thickness to the body radius. It is shown that the Busemann and Crocco integrals of the two-dimensional energy equation for Pr = 1, are still valid for axially-symmetric flow in which the transverse curvature effects are considered. By a generalization of Mangler's transformation it is then shown that the boundary layer equations are reducible to an almost two-dimensional form, making the analysis simpler for two asymptotic flow regions characterized by $\Delta/r_0 >> 1$ and Δ/r_0 less than or of the order of unity. It is with the latter region that the present paper is primarily concerned, and for this case it is shown that the additional term in the momentum and energy equations which differentiates them from the two-dimensional form, behaves like an axial pressure gradient, on quantities such as the skin friction and heat transfer coefficients. On this basis, the results of previous authors are interpreted. Except for the cases of a "near paraboloid" with zero pressure gradient, and a cylinder with linear external velocity distribution, where similar profiles can be found for all values of Δ/r_0, it is necessary to obtain the "exact" solutions in the range where Δ/r_0 is less than or possibly of the order of unity, by means of asymptotic expansions in ascending powers of a parameter which is small compared to unity but proportional to Δ/r_0. It is shown how the asymptotic solutions can be found for, (1) the velocity and temperature distributions for the compressible zero pressure gradient case when the body shapes are given by $r_0 = ax^n$ and $r_0 = ae^{bx}$, and (2) the velocity distribution for incompressible flow with an external velocity of the form $u_e = bx^m$ past a body given by $r_0 = ax^n$. The zeroth approximation is the Mangler result. In the case of the cone and cylinder with zero pressure gradient where the equations have been numerically integrated for Pr = 1, the first order correction to the Mangler formulation shows that the effect on both the skin friction and heat transfer coefficients can become appreciable in the range where Δ/r_0 is less than, or of the order of unity. At a constant Δ/r_0, the effects are increased in magnitude when either the ratio of the wall to free stream temperature, or Mach number, is increased. Also, all other conditions being equal, for the same value of Δ/r_0 the skin friction coefficient and heat transfer increase on the cylinder, is greater than that on the cone. For flows with pressure gradient, the transverse curvature term behaves again like a favorable pressure gradient, and tends to delay both separation and transition when compared with axi-symmetric flows in which the transverse curvature effect is neglected. (Contractor's summary)

PRI. 03:010

Princeton U. Dept. of Aeronautical Engineering, N. J.

VISCOUS EFFECTS IN SUPERSONIC FLOW. Final rept. Mar. 1, 1955 [21] p. incl. diagrs. refs. [AFOSR-TR-55-11] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6onr-27006) AD 63163
Unclassified

A review is presented of the studies conducted on viscous effects in supersonic flows. The supersonic wind-tunnel facilities are briefly described. Using these wind tunnels, experimental base pressure investigations were carried out, and studies of laminar- and turbulent-boundary layers in strong, adverse gradients were made.

Princton U. [Dept. of Aeronautical Engineering] N. J. For contract Nonr-03201 see item nos. PRI. 12:001-PRI. 12:004.

PRI. 04:001 - PRI. 04:004

PRI. 04:001

Prtnceton U. Dept. of Aeronautical Engtneertng, N. J.

SOME ASPECTS OF UNSTEADY LAMINAR BOUNDARY LAYERS, by S.-I. Cheng. July 1, 1955 [64]p. tncl. diagrs. tables. (Rept. no. 311) ([AF]OSR-TN-55-172) (AF 18(600)498; conttnuation of N6onr-27006) AD 76587 Unclasstfted

Also published in Quart. Appl. Math., v. 14: 337-352, Jan. 1957.

The viscous flow over a semttnfinite flat plate started to move with velocity u = 0 for t ≤ 0 and u∼t^n for t ≥0 ts analyzed tn detatl with the boundary-layer equattons. Particular emphasts ts put on the jotntng of the solution at downstream tnfintty where the flow field is substantially x-tndependent and the solution in the upstream regton near the leading edge where the flow fteld is deftnitely x-dependent. The method of trying to perturb the downstream x-tndependent Rayletgh-type solution, including the possibility of stngular perturbations, fatls to introduce any nonvanishing x-dependent perturbations. This may be due to the parabolic nature of the boundary layer equattons, but it can also be conceived physically that such a process is invalid. A series solution is then constructed from the leading edge under the boundary-layer assumption that vortictty does not dtffuse in the longitudinal dtrection. Numerical results show that for practically all values of n, the skin friction approaches the value given by the x-dependent Rayleigh type solution to wtthin a % or 2 when the distance from the leadtng edge is about 4/10 of the distance travelled by the plate. Conttnuation of the solution into the downstream region for the flow field near the plate can be effected by regular perturbations. It is seen that such a continuation must eventually approach the Rayletgh-type solution in the far downstream regton; hence, the solution so determined posses the proper limiting behaviors at both small x and large x. The limiting bet aviors of the solution at small t and large t are also found to be proper. (Contractor's abstract)

PRI. 04:002

Princeton U. Dept. of Aeronautical Engineering, N. J.

A STUDY OF THE ANTICLASTIC DEFLECTIONS OF THIN PLATES IN BENDING, by J. J. Ginoux. Aug. 1955 [19 p. tncl. diagrs. (Rept. no. 320) ([AF]OSR-TN-55-198) (AF 18(600)498) AD 93809 Unclassified

A theory developed by Y. Yoler (The anticlastic bending of thin plates, Calif. Inst. of Tech. Thesis, 1952) is used to compute the maxtmum values of anticlastic deflections obtained in the bending of thin plates. Three separate regimes characterized by different types of deflections are obtained for the case of constant spanwise curvature and no support effects. The maximum positive and negative deflections are computed as a function of the width and thickness of the plate. The results, which are of tnterest tn supersonic nozzle construction, are presented in the form of eastly used charts.

PRI. 04:003

Princeton U. Dept. of Aeronautical Engineering, N. J.

INTERACTION OF A SHOCK WAVE WITH A TURBULENT BOUNDARY LAYER AT M = 3.85, by I. E. Vas and S. M. Bogdonoff. Apr. 1955, 9p. illus. dtagrs. refs. (Rept. no. 294) (AFOSR-TN-55-199) (AF 18-(600)498) AD 201644 Unclassified

The results of an experimental tnvestigation of the interaction between incident shock waves and a turbulent boundary layer at M = 3.85 are presented. The pressure ratio across the shock wave was varied from 1.5 to 3.0. Schlteren and shadowgraph pictures were taken, static pressures were measured along the wall, and the separation pressure ratio was determined. The phenomena observed were, in general, similar to those observed at M = 2.92. For low incident shock pressure ratios (on the order of 1.6), the pressure along the wall rose smoothly to a maximum value with no separation. For a shock pressure ratio greater than about 2.2, an inflection point occurred tn the static pressure dtstrtbution, and separation was observed. For incident shock pressure rattos ≥ 2.6, the over-all phenonenon remained similar, only the scale of the tnteractton changed. The measured pressure ratio at the separatton point was 2.4, as compared to a value of about 2.1 at M = 2.92. (Contractor's abstract)

PRI. 04:004

Princeton U. Dept. of Aeronautical Engineering, N. J.

INTERACTION OF A TURBULENT BOUNDARY LAYER WITH A STEP AT M = 3.85, by I. E. Vas and S. M. Bogdonoff. Apr. 1955 [57]p. incl. illus. diagrs. table. (Rept. no. 295) (AFOSR-TN-55-200) (AF 18-(600)498) AD 201645 Unclassified

This experimental investigatton of the flow of a turbulent boundary layer over a forward-facing step was carried out at a Mach number of 3.85. The effects of Mach number upon the phenomenon were determined, and a comparison was made with results obtained previously at M = 2.92. The separation and shock wave pattern were obtained for steps varying from .25 to about 2-boundary-layer thicknesses. Schlieren and shadowgraph pictures were taken, static pressures were measured ahead of the step, and the pressure ratio needed to separate the boundary layer was found. The measured peak pressure ratio agreed with the peak pressure value of Crocco-Probstein. A detailed total head study was made of the flow field ahead of one of the larger steps. The maximum reverse velocities measured in the separated region were in the order of 0.7 M. (Contractor's abstract, modified)

PRI. 04:005

Princeton U. Dept. of Aeronautical Engineering, N. J.

A DETAILED STUDY OF THE INTERACTION OF A 14° SHOCK WAVE WITH A TURBULENT BOUNDARY LAYER AT M = 2.9, by I. E. Vas. Apr. 1955 [50]p. incl. illus. diagrs. (Rept. no. 296) (AFOSR-TN-55-201) (AF 18(600)498) AD 210241 Unclassified

A detailed study has been made of the 2-dimensional interaction between a shock wave and a turbulent boundary layer. The shock was generated by a 14° wedge located in the free stream at a Mach number of 2.92. Total head profiles were taken of the entire interaction region. The separation region extended about 6-1/2 boundary layer thicknesses in length and 3/4 boundary layer thicknesses in height. The maximum reverse velocity measured was 0.39 M. The pressure at the separation point was about 2.1 times the free stream static pressure. The pressure at which separation occurred was also determined for wedges varying from 8° to 13°. No separation was evidenced for the 8° shock generating case. The pressure ratio at separation was found to be relatively independent of shock strength. (Contractor's abstract)

PRI. 04:006

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE EFFECT OF SUPPORT INTERFERENCE ON THE BASE PRESSURE OF A BODY OF REVOLUTION AT HIGH REYNOLDS NUMBERS, by K. R. Sivier and S. M. Bogdonoff. Oct. 1955 [41]p. incl. illus. diagrs. refs. (Rept. no. 332) (AFOSR-TN-55-301) (Sponsored jointly by Office of Naval Research under N6onr-27006 and Air Force Office of Scientific Research under AF 18-(600)493) AD 79169 Unclassified

An experimental investigation has been made of the effect of a rear support sting on the base pressure of an ogive-cylinder body at a Mach number of 2.97 and at Reynolds numbers from 10×10^6 to 40×10^6. The body was mounted on wings to permit the measurement of a free base pressure. Stings having diameters from 0.6 to 0.0625 times the body's base diameter were employed to check the sting effect. Checks were made to assure that the present results were not affected by finite sting length. A second ogive-cylinder body, without mounting wings, was supported on a rear sting to check the effect of the wing on the base pressure. For the range of Reynolds numbers considered in this investigation, no critical sting diameter was found to exist. In fact, the variation of base pressure with sting diameter was greatest for the smallest diameters. The error in base pressure introduced by a sting of any given diameter was found to be a function of Reynolds number. Although the curves of base pressure vs sting size showed a tendency to level off at the lower sting diameters, the assumption by several investigators that this indicated a critical sting size was found to be in error. (Contractor's abstract)

PRI. 04:007

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE CRITICAL STUDY OF A BOUNDARY CONDITION ON PRANDTL'S BOUNDARY LAYER THEORY AND ITS APPLICATIONS, by S.-I. Cheng. Sept. 1955, 36p. (Rept. no. 329) ([AF]OSR-TN-55-340) (AF 18-(600)498) AD 74767 Unclassified

A method is presented whereby the physical argument of similitude or qualitative experimental information can be circumvented in constructing the boundary layer solutions. The necessity of additional assumptions or information is regarded as due to the incomplete mathematical formulation of Prandtl's boundary layer theory. The absence of longitudinal diffusion of vorticity according to the boundary layer theory does provide an x-wise boundary condition which leads to a unique determination of the x-wise expansion parameters for constructing the downstream boundary layer solution. The ordinary subsonic and supersonic steady boundary layer problems for a thin body in a uniform stream are discussed, and different types of series expansions are deduced for different types of inflow. The steady hypersonic boundary layer problems are treated, and proper series expansions are determined without making any assumption with regard to the matching procedure. The results of applying this method to unsteady problems are quoted from previous work by Cheng (Princeton U. Dept. of Aeronautical Engineering rept. no. 311, 1955) and by Cheng and Elliott (rept. no. 318, to be published). The generality of the principle, and the method involved suggests that this boundary condition be supplemented to the mathematical formulation of Prandtl's boundary layer theory. This supplement appears necessary, not only from the mathematical point of view, but also from the physical point of view that the boundary layer theory should suffice a solution without additional physical arguments. (Contractor's abstract)

PRI. 04:008

Princeton U. Dept. of Aeronautical Engineering, N. J.

INTERACTION OF BOUNDARY LAYER AND COMPRESSIBLE FLOW, by L. Crocco. [1955] [38]p. incl. illus. diagrs. refs. (AF 18(600)498) Unclassified

Published in Proc. Conference on High Speed Aeronautics, Polytechnic Inst. of Brooklyn, N. Y. (Jan. 20-25, 1955), 1955, p. 75-112.

A number of facts are pointed out. (1) Both laminar and turbulent compressible boundary layer on insulated walls can be treated by a unified theory based only on the following assumption that: (a) the stagnation temperature is uniform in the whole field; (b) the incompressible laminar and turbulent boundary layers constitute two distinct one-parameter families; and (c) the velocity distribution of any compressible laminar

PRI. 04:009 - PRI. 04:011

or turbulent boundary layer can be obtained from that of a corresponding incompressible boundary layer through the Howarth y-transformation. (2) For arbitrarily high Mach numbers the laminar boundary layer on a flat plate has a subsonic behavior and is able to propagate upstream the effects of applied disturbances. (3) For high supersonic velocities the turbulent boundary layer on a flat plate exhibits a supersonic behavior and is unable to propagate disturbances in the upstream direction unless it first switches to subcritical conditions. (4) The switch of a turbulent boundary from supercritical to subcritical conditions can take place through a "jump," that is, a concentrated region where fast changes of pressure, velocity and distributions take place, and within which the boundary layer assumptions fail to be satisfied. (5) The jump is impossible (or only exceptionally possible) starting from subcritical (laminar) conditions. (6) A separated flow is always subcritical. (7) When a supersonic turbulent boundary layer becomes reattached to the wall, it must go from subcritical to supercritical conditions through a critical point, separating an upstream region where an additional disturbance can be propagated upstream, from a downstream region from which no such propagation is possible. (Contractor's conclusions, modified)

PRI. 04:009

Princeton U. Dept. of Aeronautical Engineering, N. J.

SOME EXPERIMENTAL STUDIES OF THE SEPARATION OF SUPERSONIC TURBULENT BOUNDARY LAYERS, by S. M. Bogdonoff. June 1955 [18] p. incl. diagrs. refs. (Rept. no. 336) (AFOSR-TN-56-64) (AF 18(600)498) AD 81056 Unclassified

Also published in Heat Transfer and Fluid Mech. Inst. - Preprint of papers, Calif. U., Los Angeles, June 1955, preprint no. 5.

Studies were conducted of several simple geometries, i.e., fully developed turbulent boundary layers and gradients, impressed by shock waves, which are generated within the layers under investigation or impressed from external flows. Tests indicated that the wall static pressure ratio at which separation occurs is approximately a linear function of Mach number in the 1.35 to 3.85 range; it varies from a pressure ratio of about 1.4 at M = 1.35 to approximately 2.4 at M = 3.85. Strong changes occur in the interaction phenomenon when the separation region is small. The peak pressure ratios, which are a combination of the separation pressure ratio and an additional ratio resulting from mixing, indicate an increased effect of mixing with increasing Mach number. A study of the pressure ratios which can be obtained before separation occurs indicates a linear relation with Mach number which is higher than the separation pressure ratio or peak pressure ratio once the separation occurs. Results provide for the prediction of separation, the peak pressure ratios, and the pressure ratio before separation occurs for supersonic turbulent boundary layers in the range from M = 1 to 3.85. (ASTIA abstract)

PRI. 04:010

Princeton U. Dept. of Aeronautical Engineering, N. J.

THE UNSTEADY LAMINAR BOUNDARY LAYER ON A FLAT PLATE, by S.-I. Cheng and D. Elliott. Sept. 1955 [95] p. incl. diagrs. tables, refs. (Rept. no. 318) (AFOSR-TN-56-115) (AF 18(600)498) AD 82511 Unclassified

Also published in Trans. Amer. Soc. Mech. Engineers, v. 79: 725-733, May 1957.

The unsteady laminar boundary layer on a flat plate moving with an arbitrary velocity $U_w(t)$ into an incompressible fluid at rest has been investigated. The motion is taken to start from rest at a time $t = 0$ with $U_w(t)$ continuous at $t = 0$ and infinitely differentiable for all $t > 0$. Under these conditions, a solution is constructed which is valid for all t and x, where x is the distance from the leading edge of the plate. The solution is also shown to be valid for the flow after a long time when $U_w(t)$ does not satisfy the above conditions. The effect of compressibility for small Mach numbers has been discussed briefly. (Contractor's abstract)

PRI. 04:011

Princeton U. Dept. of Aeronautical Engineering, N. J.

AN APPROXIMATE THEORY OF TURBULENT BOUNDARY LAYER SHOCK WAVE INTERACTION, by A. G. Hammitt. Apr. 1956 [44] p. incl. illus. diagrs. table, refs. (Rept. no. 340) ([AF]OSR-TN-56-160) (AF 18(600)498) AD 86320 Unclassified

The shock wave turbulent boundary layer problem was investigated in the absence of skin friction and momentum addition from the free stream. The analysis presented is based on 2 main assumptions: (1) momentum and mass are conserved in the boundary layer through the interaction and (2) the turbulent boundary layer is essentially a 1 parameter family. It is shown that, to a first approximation, most of the experimental observations for oblique shock wave boundary layer interactions, with the exception of the lengths of the interaction region, can be explained by flow models which do not include momentum changes caused by shear forces. The boundary layer contains enough momentum to overcome the pressure rises encountered. Methods which were developed make it possible to calculate the boundary layer conditions behind any particular interaction, and to consider the effects of a disturbed boundary layer before an interaction. The cases of flow through an incident reflected shock wave, in a corner, and over a forward facing step are treated. The differences between various shock wave configurations can be explained by using flow models which correspond to these configurations. The way in which

the pressure forces are applied to the boundary layer accounts for the different results obtained with the various configurations.

PRI. 04:012

Princeton U. Dept. of Aeronautical Engineering, N. J.

A SIMPLE METHOD FOR THE CONSTRUCTION OF FIXED TWO DIMENSIONAL WIND-TUNNEL NOZZLES WITHOUT MACHINED CONTOURS, by S. M. Bogdonoff. Sept. 1955 [11]p. incl. illus. diagr. (Rept. no. 321) ([AF]OSR-TN-56-167) (AF 18(600)498) AD 86588 Unclassified

A simple and inexpensive method for the construction of accurately shaped 2-dimensional wind-tunnel nozzle blocks has been developed. No templates are required, and the only accurate machine work is limited to drilling holes at fixed positions using a jig borer. Plate-backing by any of several techniques has been successful, with plastic materials offering the best possibility for future applications. (Contractor's abstract)

PRI. 04:013

Princeton U. [Dept. of Aeronautical Engineering] N. J.

THEORY OF COMBUSTION INSTABILITY IN LIQUID PROPELLANT ROCKET MOTORS, by L. Crocco and S.-I. Cheng. London, Butterworths Scientific Publications, 1956, 200p. incl. diagr. tables, refs. (NATO AGARDograph repl. no. 8) (Sponsored jointly by Bureau of Aeronautics under [N6ori-27006] and [Air Force Office of Scientific Research] under AF 18(600)-498) Unclassified

Using present knowledge of the combustion process attempt is made in this paper: (1) to establish a rational explanation for the existence of a detrimental and of a non-deirtmental type of rough combustion, (2) to distinguish a number of mechanisms which may be responsible for the appearance of the detrimental type, (3) to give for some of these mechanisms plausible quantitative formulations, and (4) to analyze in detail the results of the theoretical developments.

PRI. 04:014

Princeton U. Dept. of Aeronautical Engineering, N. J.

UNSTEADY LAMINAR BOUNDARY LAYER ON A FLAT PLATE, by S.-I. Cheng and D. Elliott. [1956] [18]p. (AF 18(600)498) Unclassified

Published in Heat Transfer and Fluid Mech. Inst. - Preprints of Papers, Stanford U., Calif., June 1956, preprint no. 14.

Study is made of the boundary layer on a flat plate occupying the positive half of the x axis when the main stream velocity u_e is a function of the time t only and $u_e(0) = 0$. A series expansion centered on the leading edge is developed, and it is asserted that the solution possesses the correct behavior at small t or large x.

PRI. 04:015

Princeton U. [Dept. of Aeronautical Engineering] N. J.

ON THE INTERACTION OF SUPERSONIC TURBULENT BOUNDARY LAYERS AND SHOCK WAVES, by S. M. Bogdonoff. [1956] [10]p. incl. illus. diagr. [AF 18(600)498] Unclassified

Published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium), (Sept. 5-13, 1956), v. 4: 145-154, 1957.

As part of an overall study of viscous effects in supersonic flows, a combined experimental and theoretical program has been carried out in attempt to arrive at a better fundamental understanding of the interaction of supersonic turbulent boundary layers and shock waves. The pertinent results obtained to date are briefly reviewed. An experimental framework is developed which can be used to predict separation, pressure ratio, peak pressure ratio, and the pressure ratio for incipient separation for supersonic turbulent boundary layers at Mach numbers up to 4. The basis is provided for a theoretical investigation which neglects the skin friction and mixing from the external stream.

PRI. 05:001

Princeton U. Dept. of Electrical Engineering, N. J.

NONLINEAR CONTROL SYSTEMS RESEARCH PROJECT. Final interim progress rept. July 1, 1952 - June 30, 1953. July 1, 1953 [86]p. incl. illus. (AF 33(038)22614) AD 45751 Unclassified

The basic properties of certain classes of feed-back control systems using nonlinear components were investigated. Elements possessing nonlinear operating characteristics greatly complicate the problem of determining the stability of feed-back systems and may give rise to certain non-unique modes of response to an input signal. The investigation included: (1) the study of the philosophy underlying the design of nonlinear control systems in an attempt to develop logical and systematic methods of control network synthesis which will result in improved performance while also insuring stable operation of the system for all possible types of excitation; and (2) the study of the operation of certain special types of nonlinear servomechanisms which are of considerable practical importance and which can be used as tests of the theoretical design methods.

PRI. 05:002 - PRI. 06:002

PRI. 05:002

Prtnceton U. Dept. of Electrical Engineering, N. J.

NONLINEAR CONTROL SYSTEMS RESEARCH PROJECT. PART I. A NONLINEAR COMPENSATING CONFIGURATION FOR SATURATING SERVOMECHANISMS. PART II. PERFORMANCE OF POSITIONAL SERVOMECHANISMS USING TWO-PHASE INDUCTION MOTORS, by R. C. Willmott and D. R. Scally. Termination rept. Dec. 31, 1954, 1v. incl. illus. refs. (AF 33-(038)22614) AD 65494 Unclasstfied

Two theses are presented which treat the following topics: (1) nonlinear compensation of a saturating servomechanism; and (2) the performance of posttional servomechanisms using 2-phase induction motors.

PRI. 05:003

Prtnceton U. Dept. of Elecirtal Engineering, N. J.

NONLINEAR CONTROL SYSTEMS RESEARCH PROJECT. PART I. NONLINEAR COMPENSATION OF A SATURATING SERVOMECHANISM, by R. C. Wtllmoit. [Dec. 31, 1954] 53p. tncl. tllus. refs. (Pt. 1 of tis termtnation repi. AD 65494) (AF 33(038)22614) AD 65494(a) Unclasstfied

A study ts presented which considers the problem of compensation for a servomechanism whose power amplification elemeni operales in saturation over a good part of the duty cycle. The problem may be viewed as thai of finding the simplesi possible compuier network thai will allow attaining certatn spectfications on outpui responses to given inputs. The condttion is imposed thai the system outpui be absoluiely siable at the error null. The condttion of an oscillation of amplitude less than the outpui error toleration is also eltmtnated.

PRI. 05:004

Princeton U. Dept. of Electrical Engineering, N. J.

NONLINEAR CONTROL SYSTEMS RESEARCH PROJECT. PART II. PERFORMANCE OF POSITIONAL SERVOMECHANISMS USING TWO-PHASE INDUCTION MOTORS, by D. R. Scally. [Dec. 31, 1954] 31p. illus. (Pt. 2 of tis terminaiion rept. AD 65494) (AF 33(038)22614) AD 65494(b) Unclassified

A study was made of the switching transient effect on a high-performance positional servomechanism. Step-voltage inputs were applied at different points in the reference voltage cycle, and the transient responses were taken. The effect of the system's inertia, in decreasing the switching transient effect, was investigated, together with the effect of saturation upon the system's frequency response. Investigation was also made of a dual-field control system. This system was compared to that with single-field control, on the basis of dynamic performance and switching transient effect. The advantages and disadvantages of the system are pointed out.

PRI. 06:001

[Prtnceton U. Dept. of Mathematics, N. J.]

STATIONARITY, BOUNDEDNESS, ALMOST PERIODICITY OF RANDOM-VALUED FUNCTIONS, by S. Bochner. Nov. 1955, 36p. incl. refs. (Rept. no. 2) ([AF]OSR-TN-55-365) (AF 18(600)1379) AD 79170 Unclassified

Also publtshed in Proc. Third Berkely Symposium on Mathematical Statistics and Probability, Calif. U., v. 2: 7-27, 1954-1955.

Prevtous work by Bochner (Proc. Nat. Acad. Sci., v. 40: 289-294, 1954) relative to the following problem is extended. Let x(t) be a random-valued function on $-\infty < t < \infty$, and let $y = \Lambda x$ be a linear operation which is commutative with translations on the t axis. In paritcular, let Λx donate the difference-dtfferential operator $\sum_{\rho=0}^{r}\sum_{\sigma=0}^{s} C_{\rho\sigma}\frac{d^{\rho}x(t-\tau_{\sigma})}{dt^{\rho}}$ wtth constant complex coefficients $C_{\rho\sigma}$ and arbitrary real spans τ_{σ} for some $r \geq 0$, or the more general operator $\sum_{\rho=0}^{r}\int_{-\infty}^{\infty} x^{\rho}(t-\tau)dC_{\rho}(\tau)$, tn which $C_0(\tau), \ldots C_r(\tau)$ are complex functions of bounded vartation, $\int_{-\infty}^{\infty} |dC_{\rho}(\tau)| < \infty$, $\rho = 0, \ldots, r$. Several nonequivaleni versions of the following result are established. If y(t) ts stationary, and if there exists a solution x(t) whtch ts bounded tn t tn a suitable sense, then some other solution $x^0(t)$, which need not be x(t) itself, is again stationary. (ASTIA absiract)

PRI. 06:002

Princeton U. [Dept. of Mathematics] N. J.

ON GENERALIZED STURM-LIOUVILLE OPERATORS, by W. Feller. [1955] [20] p. [AF 18(600)1379] Unclassified

Published in Proc. Conference on Differential Equations, Maryland U., College Park, (Mar. 17-19, 1955), 1956, p. 251-270.

The author continues his study of the generalized Sturm-Liouville operators (Ann. Math., v. 61: 90-105, 1955; Comm. Pure Appl. Math., v. 8: 203-216,

1955). He again considers the class of nontrivial linear operators Ω whose domain and range are in the space of continuous functions and which are of local character and have the minimum property. The work of the previous papers is greatly reduced by assuming Ω to be regular in the sense that there are two linearly independent solutions of $\Omega w = 0$ in the neighborhood of each point. It is shown that there exist strictly increasing functions $s(x)$ and $m(x)$, s being continuous such that if $w(x)$ is any non-vanishing (real or complex) solution of $\Omega w = 0$, the operator Ω has the representation

$$\Omega f = \frac{1}{w} D_m \left[w^2 D_s \left(\frac{f}{w} \right) \right].$$

Here D_m and D_s are generalized derivatives with respect to m and s respectively. Using this representation, the Weyl limit point limit-circle classification and related existence theorems are developed in a Hilbert space whose norm is $\int f(x)^2 dm(x)$ so that Ω is self-adjoint in this space. The following typographical errors were noted: (a) in (5.3) the inequality is reversed; (b) in (7.11) and (7.19) the lower limits of the first integrals should be s rather than s_0; (c) the inequality two lines below (9.3) should be $\Omega F(\xi) \geq 0$. (Math. Rev. abstract)

PRI. 06:003

Princeton U. Dept. of Mathematics, N. J.

STURM-LIOUVILLE AND HEAT EQUATIONS WHOSE EIGENFUNCTIONS ARE ULTRASPHERICAL POLYNOMIALS OR ASSOCIATED BESSEL FUNCTIONS, by S. Bochner. [1955] [26]p. incl. refs. (AF 18-(600)1379) Unclassified

Published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 23-48.

For fixed $\gamma \geq 0$ let $P_n(x) = P_n(\gamma)(x)$ $(n = 0, 1, \ldots)$, be the polynomial solution of $(1 - x^2)P'' - (2\gamma + 1)xP' = -\lambda_n P$ where $\lambda_n = n(n + 2\gamma)$, normalised by $P_n(1) = 1$, and write $\rho_n = 1/\int_{-1}^{1} \{P_n(x)\}^2 (1 - x^2)^{\gamma - \frac{1}{2}} dx$. For $f(x)$ $(-1 \leq x \leq 1)$ with absolutely convergent Fourier expansion $\sum \rho_n a_n P_n(x)$ consider the mapping $f(x) \to f(x;y)$ given by $f(x;y) \sim \sum \rho_n a_n P_n(x) P_n(y)$. The first part of the investigation centers round the fact that this mapping has "property P", namely that $f(x) \geq 0$ in $-1 \leq x \leq 1$ implies $f(x;y) \geq 0$ in $-1 \leq x, y \leq 1$. There is a continuous analogue of this result in terms of, in effect, Bessel functions. Apparently distinct examples of property P can be constructed from functions on a group in terms of group-representations. In the next section a study of the partial differential equations $(1 - x^2) f_{xx} - (2\gamma + 1)x f_x = f_t$ leads to the kernel $K(x, y;t) \sim \sum \rho_n \exp(-t\lambda_n) P_n(x) P_n(y)$.

The fact that $K(x, y;t) \geq 0$ is deduced in a rather striking way from a study of the semi-ring of bounded sequences $\{c_n\}$ such that $\sum \rho_n a_n P_n(x) \geq 0$ in $-1 \leq x \leq 1$ (postulating absolute convergence) implies $\sum \rho_n a_n P_n(x) \geq 0$ in $-1 \leq x \leq 1$. General expressions are found for such $\{c_n\}$, and also for a "homogeneous stochastic process" $\{c_n(t)\}$ (for definitions and formulae see the review of the author's previous note, Proc. Nat. Acad. Sci. U.S.A. 40 (1954), 1141-1147; MR 16, 834). Continuous analogues, corresponding to $f_{xx} + (2\gamma/x) f_x = f_t$, are also formulated. Finally, in connection with the probabilistic interpretation, the author outlines the role of "subordinators" in assessing the relative primacy of homogeneous processes, as explained more fully in his book, Harmonic analysis and the theory of probability (Univ. of California Press, 1955, Ch. 4; MR 17, 273). (Math Rev. abstract)

PRI. 06:004

[Princeton U. Dept. of Mathematics, N. J.]

CURVATURE AND BETTI NUMBERS IN REAL AND COMPLEX VECTOR BUNDLES, by S. Bochner. [1956] [29]p. [AF 18(600)1379] Unclassified

Published in Univ. e Politec. Torino. Rend. Sem. Mat., v. 15: 225-253, 1955-56.

The theory of differential geometry for vector bundles based on tensor calculus as previously developed (Canad. Jour. Math., v. 3: 460-470, 1951) is reviewed and extended. An N-dimensional vector bundle over an n-dimensional space M_n was described by a so-called matrix structure, a system of transition matrices $a^B_A(y; x)$ between any two intersecting elements (x) and (y) in a fixed covering of M_n by a system of neighborhoods, the $a^B_A(y; x)$ being subjected to the consistency properties $a^A_B(z; y)a^B_C(y; x) = a^A_C(z; x)$ and $a^B_A(x; x) = \delta^A_B$. A generic point of the vector bundle is either a contravariant vectoroid u^A with the transition relations $u'^A(y) = a^A_B(y; x)u^B(x)$ or a covariant vectoroid t_A with the transition relations $t'_A(y) = a^B_A(x; y)t_B(x)$. More generally, matrix structures of the form $a^{A_r}_{B_r}(y; x)$ $(r = 1, 2, \ldots s)$ of various dimension N_r with no connection between them, likewise have a structure as their Kronecker product.

A general mixed tensoroid of the type $t^{A_1 A_2 \ldots A_p}_{B_1 B_2 \ldots B_q}$ can be defined, while ordinary tensors are defined with respect to the classical structure $\partial y^1 / \partial x^1$. The tensor algebra and tensor analysis in such metric and non-metric bundles are developed in the first two sections of the present paper. The following are proved in the third section. (1) On a compact metric M_n, if a vectoroid τ_A satisfies an equation of the form

$$g^{rs}\, \tau_{A,\,r,\,s} = S_{AB} P^{BC} \tau_C,$$

where the comma denotes covariant differentiation leaving the metric invariant, and if the tensoroid S_{AB} is positive definite, then τ_A is identically zero. If

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S_{AB} is only positive semi-definite, then $\xi_{A,r} = 0$ and $S^{C}_{A} \cdot \xi_{C} = 0$. (II) On a non-compact M_n, the entire conclusion holds if the vectoroid has "boundary value zero" in the following sense. To each $\varepsilon > 0$ there corresponds a compact subset M_n^{ξ} of M_n such that $g^{AB}\xi_A\xi_B < \varepsilon^2$ for all points outside M_n^{ξ}. A symmetric or skew-symmetric tensoroid is then considered of the type $\xi_{A_1A_2\ldots A_sB}$ in a compact M_n; the general theorem is then applied to the harmonic" tensoroid $\xi_{Ai_1i_2\ldots i_p}$ defined as a tensoroid satisfying

$$\xi Ai_1i_2\ldots i_p, j = \sum_{q=1}^{p} \xi Ai_1i_2\ldots j\ldots i_p, i_q \text{ and}$$

$$g^{ij}\,\xi_{Ai_1i_2\ldots i_{p-1}i,j} = 0.$$

The last section is devoted to complex vector bundles.

PRI. 06:005

[Princeton U. Dept. of Mathematics, N. J.]

[SYSTEMS OF PARTIAL DIFFERENTIAL EQUATIONS RELATED TO GREEN'S FORMULAS] Systémes des équations aux dérivées partielles qui se rattachent aux formules de Green, by S. Bochner. [1956] [8]p. [AF 18(600)1379] Unclassified

Presented at a Colloqutum organized by the French Center of Scientific Research, Nancy (France), Apr. 9-14, 1956.

The solution is investigated of a system of partial differential equations in a bounded domain, in terms of the solution of a related system of equations in the neighborhood of the frontier, and of Green's integral and Green's formula. A consideration is included of the analytic continuation of the solution of such a system of equations. The paper is presented as an outgrowth of earlier and similar results which were given as terms of two special cases (analytic and meromorphic continuation by means of Green's formula. Ann. Math., v. 44: 652-673, 1943).

PRI. 07:001

Princeton U. Dept. of Physics, N. J.

SHOCK LOADING OF RECTANGULAR STRUCTURES, by W. Bleakney. Jan. 10, 1952, 57p. illus. diagrs. tables, refs. (Technical repl. no. II-11) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordance Research under N6ort-10502) U21736; ATI-163038 Unclassified

The shock loading of two-dimensional rectangular blocks has been investigated as a function of length to height ratio, shock strength, and time after impact. A shock pressure ratio of about 1.95 was used for diffraction experiments on blocks having length: height - 1:8 (thin wall), 1:1, 3:1, and ∞:1 front and back (step up and step down). In addition, the 1:1 block was studied at shock strengths of 1.26, 1.48, 3.05, and 5.00. Pressure distributions are also given for these same strengths. A peaked shock having a pressure ratio of 1.48 has been obtained in the shock tube, and although the pressure drops only to about half of its maximum value, effects appear which are not predicted by straight-forward modification of flat-top shock data. These include the rapid decrease of the average pressure on the front face to a value below the free stream pressure and the persistence of average pressure on the back above that corresponding to free air pressure. (Contractor's abstract)

PRI. 07:002

Princeton U. Dept. of Physics, N. J.

A METHOD FOR MODIFICATION OF THE PRESSURE PROFILE IN A SHOCK TUBE, by D. R. White and D. K. Weimer. Apr. 1952, 9p. diagrs. (Technical repl. no. II-12) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10502) U22733; ATI-158692 Unclassified

A thin piece of sheeting suspended across a shock tube acts as a piston which may be accelerated by the incident shock and decelerated by a wire grid. The wide range of pressure profiles thus made possible should facilitate study of blast loading of structures, shock formation from a compression and effects due to conditions within the shock front. A wave form of 150 μsec. positive duration was produced in tests with a grid of 1/8-in. hardware cloth to catch the 0.0011-in. paper diaphragm and a shock of inverse pressure ratio of 0.8.

PRI. 07:003

Princeton U. Dept. of Physics, N. J.

THE CYLINDER AND SEMICYLINDER IN SUBSONIC FLOW, by H. H. Bingham, D. K. Weimer, and W. Griffith. July 1952, 10p. illus. diagrs. (Technical rept. no. II-13) [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research and Office of Ordnance Research under N6ort-10502] U24210; ATI-168948 Unclassified

This is a continuation of investigations at Princeton on the transient flow induced by a shock wave striking an object. The attempt is made to observe transition to steady conditions. The research here is related to a similar study of the cylinder in transonic flow. An Evaluation Procedure for Interferometry of Density Fields With Cylindrical Symmetry, by G. P. Wachtell is appended. (Contractor's summary)

PRI. 07:004

Prtnceton U. Dept. of Physics, N. J.

OPTICAL STUDIES OF BOUNDARY LAYER PHENOMENA ON A FLAT PLATE AT MACH NUMBER 2.35, by R. [W.] Ladenburg and D. Bershader. Final tech. rept. Dec. 15, 1952, Iv. tncl. tllus. diagrs. tables, refs. [Sponsored jotntly by Offtce of Naval Research, Air Force Offtce of Sctentiftc Research, and Offtce of Ordnance Research under N6ori-I0502] AD 3321 Unclasstfied

A supersonic, "blow-down" type wind tunnel of 3 in. x 3 tn. test section and maxtmum flow duration of 6 sec has been constructed and applied to the optical study of boundary-layer growth along the flat stde of narrow, steel half-wedges at zero angle of attack tn a uniform stream where M = 2.35 ± one per cent. Denstty measurements were made with a 5 tn. Zehnder-Mach tnterferometer and supplemental data were obtained by schlieren and shadow photography, static pressure readtngs, thermocouple temperature measurements and a new phosphorescence technique for tndtcating surface temperatures. (Contractor's summary, modtfted)

Prtnceton U. Frick Chemtcal Lab., N. J.

N6ori-I0503, Project Squid <u>see under</u> Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID) <u>ttem nos.</u> PRI. 11:I62-PRI. II:I72.

PRI. 08:001

Prtnceton U. [Frick Chemtcal Lab.] N. J.

MEASUREMENT OF DIELECTRIC CONSTANT AND LOSS, by J. G. Powles and C. P. Smyth. [1954] [54]p. tncl. dtagrs. refs. [AF 18(600)I33I] Unclasstfted

<u>Published in</u> Phys. Methods Org. Chem., v. I: 2279-2332, 1954.

This is a revtew artlcle coverttng the following toptcs: I. Theory of dielecirtc constant and loss. II. Introductton to measuremeni techniques. III. The frequency range 60 to 10^8 cycles per second. (1) measuring cells; (2) bridges; (3) resonance methods; (4) combtnation apparatus; and (5) elecirode polarizaiton effecis. IV. The microwave region, 3×10^9 to 6×10^{10} cycles per second. (1) resonator methods; and (2) transmission methods. V. The frequency range 10^8 to 3×10^9 cycles per second. VI. Frequencies below 60 cycles per second. There are 104 foreign and domestic references ctted covering a ltme period from 1895 to 1953.

PRI. 08:002

Prtnceton U. [Frick Chemical Lab.] N. J.

DIELECTRIC RELAXATION OF SOME SPHEROIDAL MOLECULES, by R. C. Miller and C. P. Smyth. [Oct. 18, 1955] [2.p. tncl. table. [AFOSIt-TN-55-376] [AF 18(600)1331] Unclassified

Presented at National Research Council Conference on Electrical Insulation, Pocono Manor, Pa., Oct. I9, 1955.

In this study, the effect of dtpole orientation on relaxation time tn nonspherical molecules was constdered. The crttical wavelengths and vtscosities of trtoxane (I), pyrtdtne (II), paraldehyde (III), and collidtne ($(CH_3)_3\ C_5H_2N$) (IV) were measured at a number of temperatures, the results obtained at 60°C betng presented tn a table. It is pointed out that I and II are nearly the same in molecular shape and stze; however, tn I the moment is normal to the ring, while tn II tt ts in the plane of the ring. Both the crttical wavelength and the viscostty of I are 1.7 times as large as those of II. Therefore, tf tt ts assumed that the critical wavelength is proportional to vtscostty, the data tndicate that direction of the moment has no effect on the critical wavelength. III and IV are nearer tn shape and stze than are I and II as tndtcated by thetr almost equal viscosities and molar volumes. Nevertheless the crttical wavelength of III, havtng tts moment normal to the rtng, is twtce as large as that of IV. This result and that for I ts explained by the fact that both I and III are disc-like tn shape, making tt necessary for them to turn over tn becoming ortented tn a field. This "turning over" dtsturbs neighbortng molecules much more than rotation about the axis of symmetry as tn the cases of II and IV; thus, the relaxation times of the dtsc-like molecules are expected to be longer. The effect is greater for the 2 trimethyl-substituted compounds which are more extended tn the plane of the disc.

PRI. 08:003

Princeton U. Frick Chemical Lab., N. J.

MICROWAVE ABSORPTION AND MOLECULAR STRUCTURE IN LIQUIDS. XV. THE CRITICAL WAVELENGTHS OF SOME SHORT-CHAIN ALIPHATIC AND CYCLIC KETONES AND OF PHENYL ETHER, by J. H. Calderwood and C. P. Smyth. Oct. 14, 1955 [3]p. tncl. tables. (AFOSR-TN-55-384) (AF 18-(600)1331) AD 106080 Unclassified

<u>Also published in</u> Jour. Amer. Chem. Soc., v. 78: 1295-1297, Apr. 5, 1956.

The dielecirtc constants and losses of acetone, n-heptanone-2, n-heptanone-4, cyclohexanone, acetophenone, 2-acetonaphthone, benzophenone and phenyl ether have been measured at wavelengths of 1.24, 3.22 and 10.4 cm at temperatures between 1° and 90°. The low frequency dielectrtc constants, refractive indices, denstties, and viscosities have also been measured. Cole and Cole arc plots have been drawn and have been used to calculate the crttical wavelengths at which the loss is a maximum. The crttical wavelengths and the ratios of crttical wavelength to viscosity are examined in their relations to molecular size and shape. The crttical wavelength of 2-acetonaphthone is larger and that of phenyl ether is smaller than would be expected. As observed in

PRI. 08:004 - PRI. 08:007

previous work, marked changes in molecular shape may cause marked irregularities in the relations between molecular volume, critical wavelength and viscosity. (Contractor's abstract)

PRt. 08:004

Prtnceton U. Frick Chemtcal Lab., N. J.

DtPOLE MOMENTS AND STRUCTURES OF TWO HETEROPOLAR CYANINE DYE MOLECULES, by A. J. Petro, C. P. Smyth, and L. G. S. Brooker. July 7, 1956 [4]p. tncl. tables, refs. (AFOSR-TN-55-477) (AF t8(600)1331) Unclassified

Presented at Delaware Valley regional meeting of the Amer. Chem. Soc., Philadelphia, Pa., Feb. 16, 1956.

Published in Jour. Amer. Chem. Soc., v. 78: 3040-3043, July 5, 1956.

The molecular dipole moments of 2 cyanine dyes have been measured in very dtlute solutions tn dioxane. Compartson of the observed moment values 9. 8 and t3. 3 x t0^{-t8} wtth those calculated for the posstble resonating structures indicates that a full, or nearly full, electronic charge is carried by the acidic radical of the molecule, while an equal positive charge is divided equally between the nitrogens of the 2 basic nuclei. (Contractor's abstract)

PRt. 08:005

Princeton U. Frick Chemical Lab., N. J.

DIELECTRIC BEHAVIOR AND STRUCTURE. by C. P. Smyth. New York, McGraw-Hill, t955, 441p. incl. diagrs. tables, refs. [AF 18(600)t331] Unclassified

The theory of dielectric behavior as exemplified in dielectric constant and loss is presented in the first two chapters, the experimental information and interpretation in the next three, and the methods of measurement in Chapter VI. Information on the determination of dipole moments is given in Chapters Vt and VIt, a general account of their relations to molecular structure in Chapter VIti, and a detailed tabulation and interpretation of the moments of the principal types of compound in Chapters IX to XII. Amino acids, peptides, and proteins are treated tn Chapter XIIi, and induced polarization, particularly optical refraction, in the last Chapter.

PRI. 08:006

Prtnceton U. Frtck Chemtcal Lab., N. J.

MICROWAVE ABSORPTION AND MOLECULAR STRUCTURE IN LIQUIDS. XVI. DIPOLE DIRECTION AND RELAXATION TIME tN PYRIDINE, TRIOXANE, AND THEIR SYMMETRICAL TRIMETHYL DERIVATtVES, by R. C. Mtller and C. P. Smyth. Feb. 2, t956, 9p. tncl. tables, refs. (AFOSR-TN-56-51) (AF t8(600)1331) AD 81043 Unclasstfted

Also published in Jour. Phys. Chem., v. 60: 1354-1356, Oct. 1956.

Measurements of dtelectrtc constant and loss have been carried out at wavelengths of t. 24, 3. 22, and 10. 4 cm and 300 m and at temperatures from 20° to 80°C upon collidtne, or 2, 4, 6-trtmethylpyridtne (I), sym-trtoxane, and paraldehyde. The vtscostties and denstties have also been measured. The results are combined with those previously published for pyrtdtne to tnvestigate the effect of dipole ortentation tn the molecule upon dielectric relaxation. Paraldehyde and I, in spite of much larger molecular size, have virtually the same viscosity as pyridine; however, the critical wavelength, at which the dielectric loss is a maximum, has a value for I approximately 4 times that for pyridine, probably because of close-packing of the trtangular I molecules tn the liquid and, also, because of thetr larger stze. Paraldehyde, which has a molecule simtlar tn stze and shape to that of I, has a critical wavelength about twice as large, presumably, because the dipole is perpendicular to the molecular triangle instead of parallel to it as in I, thus requiring the triangular slabs to turn over instead of rotating in their plane when ortentatton occurs tn the applted fteld. (Contractor's abstract)

PRt. 08:007

Prtnceton U. Frick Chemtcat Lab., N. J.

MICROWAVE ABSORPTION AND MOLECULAR STRUCTURE tN LtQUIDS. XVII. DtELECTRIC RELAXATtON TIMES AND SHAPES OF RIGID MOLECtILES, by C. P. Smyth. Mar. 13, 1956 [6]p. incl. table, refs. (AFOSR-TN-56-119) (AF 18(600)1331) AD 82515 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 234-239, May 1956.

Abstract published in Science, v. t23: 675, 1956.

The relaxatton times and vtscostites of 5 homologous series of compounds with more or less flexible molecules were calculated from measured dielectric constants and losses. The results obtatned showed a tendency of the molecular relaxation time and the vtscosity to tncrease with tncreasing molecular stze in a pure ltqutd and of the relaxatton time to tncrease with viscosity, as required by the equatton $\tau_M = 4\pi\zeta a^3/kT$, where τ_M ts the molecular relaxatton ttme, a the sphere of radtus, and ζ the tnternal frtctton coeffictent. Many exceptions to thts tendency occur, and apparently the increase tn relaxatton ttme with viscosity may be the result of the increase tn molecular stze, whtch also tncreases the vtscosity. Although the attachment of a CH_3 group to a rtng may

not impede viscous flow, and may even facilitate it, apparently its protrusion impedes the molecular rotation necessary for orientation in an applied field, and thus lengthens the relaxation time.

PRI. 08:008

Princeton U. [Frick Chemical Lab.] N. J.

DIELECTRIC RELAXATION AND MOLECULAR SHAPES OF SOME ALKYL-SUBSTITUTED BENZENES, PYRIDINES, AND NAPHTHALENES, by A. J. Peiro, R. W. Rampolla, and C. P. Smyth. [June 1956] 6p. incl. tables. (AFOSR-TN-56-255) [AF 18(600)1331] AD 88975 Unclassified

Also published in Proc. 130th meeting of the Amer. Chem. Soc., Atlantic City, N. J., Sept. 16-21, 1956.

In this study of the relationships between molecular size and shape and dielectric relaxation in liquids, a group of benzene-, pyridine-, and naphthalene derivatives are considered in order to determine the effect of substitution on the aromatic ring. As a result, the dielectric constants and losses of several alkyl-substituted benzenes, pyridines, and naphthalenes have been measured in the pure liquid state at wavelengths of 1.25 and 3.22 cm and at temperatures between 1° and 60°C. In addition, results have been obtained for dilute solutions of pyridine in benzene. The low-frequency dielectric constants, refractive indices, densities, and viscosities have also been obtained. From these data, Cole-and-Cole arc plots have been drawn, being used to determine the critical wavelengths at which the loss is a maximum. These results are collected in a table. For some of the compounds, molecular relaxation times, ratios of relaxation times, viscosity at 20°C, and activation energies for viscous flow and dielectric relaxation are presented.

PRI. 08:009

Princeton U. Frick Chemical Lab., N. J.

MICROWAVE ABSORPTION AND MOLECULAR STRUCTURE IN LIQUIDS. XVIII. THE RELAXATION TIMES OF FOUR RIGID POLAR MOLECULES SURROUNDED BY NONPOLAR MOLECULES OF SIMILAR SIZES AND SHAPES, by R. C. Miller and C. P. Smyth. Sept. 1956, 10p. incl. tables. (AFOSR-TN-56-416) (AF 18(600)1331) AD 96225 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 308-310, Jan. 20, 1957.

In this study, the dielectric constant at 300-m wavelength and the dielectric constant and loss at 10.66-cm wavelength were measured for quinoline (I) and isoquinoline (II) over a range of temperatures. The results were combined with those of previous measurements to revise critical wavelength values. The corrected values agree well with the earlier values for I, but differ somewhat from those for II. Similar measurements were obtained for dilute solutions of pyridine (III) and s-trioxane in C_6H_6, and of I and II in naphthalene at 577 m and 3.22 and 1.244 cm. Comparison of the values of the molecular relaxation times calculated for the 4 substances in the pure liquid state with the relaxation times for the solutions indicates that, for these molecules, the method of calculating the molecular relaxation time and the assumption of its proportionality to liquid viscosity are not bad approximations. The closeness of the molecular relaxation times of III and trioxane to each other suggests that the III molecule may rotate with almost equal ease around axes in the plane of the ring, and perpendicular to this plane. The relaxation times of the C_6H_6 and naphthalene molecules are considered in the light of those of III and trioxane in C_6H_6 solution, and of I and II in naphthalene solution, respectively. The difference between the relaxation times of I and II shows a considerable amount of orientation of both molecules by rotation out of the plane of the rings. (C.A., 1957:6256d)

PRI. 09:001

Princeton U. James Forrestal Research Center, N. J.

SOUND DISPERSION IN CIS- AND TRANS-DICHLOROETHYLENE VAPORS, by M. [J.] Boudart. [1953] [2]p. (AF 33(038)23976) Unclassified

Published in Jour. Chem. Phys., v. 21: 955-956, May 1953.

Contrary to Seite et al. (Jour. Chem. Phys., v. 20: 1899-1902, Dec. 1952), trans-dichloroethylene cannot be considered as an ideal gas. The values of v_0 (sound velocity reduced to zero pressure), calculated for both isomers using the second virial coefficients of the Berthelot equation of state, yield single dispersion waves for each isomer, there being no marked difference in the behavior of the isomers.

PRI. 09:002

Princeton U. James Forrestal Research Center, N. J.

FLAME PROPAGATION RATES AND THE CHEMICAL NATURE OF THE ATTACHMENT SURFACE, by L. Lapidus, J. B. Rosen, and R. N. Wilhelm. Apr. 1953 [31]p. incl. diagrs. tables, refs. (Technical rept. no. 1) (AF 33(038)23976) AD 13156 Unclassified

Also published in Indus. Engineering Chem., v. 49: 1181-1186, July 1957.

Experimental results and theoretical deductions are presented concerning the effect of catalytic-chemical properties of surfaces on the boundary conditions of stabilized flames. Normalized flame velocity-vs-percentage CH_4 curves were obtained with a slot rate

PRI. 09:003 - PRI. 09:006

burner and CH_4-air combustible mixiures for combinations of the following conditions: 2 differeni geomeirically shaped brass burner tips, and wei and dry surfaces of brass, MgO, and Pi. The surfaces were maintained at 32° and 81°C with total volumetric flow raies of 1.44 and 1.70 cu fi/min, respectively. Flame propagation rates were identical for all surfaces when they conialned moisture either in equilibrium with thai in the room air or when thoroughly weiied. Propagation raies for moisture-laden surfaces and the raie for dry MgO were the same. Pi, the mosi poieni chain breaker, exhibited the greaiesi difference beiween the wei and dry velocity. The flame velocity increased with an increasing CH_4/air ratio with a maximum ai the siolchiomeiric ratio; ai higher concenirations, the fiames became turbuleni and produced a sharp increase in the propagation rate. Simultaneously, differences beiween surfaces with respeci io the substrate or moisiure condition disappeared. A theoretical analysis is included of the raie of surface combination of free radicals and the resulting effect on the flame propagation rate. The surface recombination coefficients compare favorably with literature values of the recombination of H atoms on differently conditioned surfaces.

PRI. 09:003

Princeton U. James Forresial Re arch Cenier, N. J.

KINETICS AND MECHANISMS OF THE "WATER-GAS" REACTIONS, by W. M. Graven and F. J. Long. May 1953 [37]p. incl. diagrs. iables, refs. (Technical rept. no. 2) (AF 33(038)23976) AD 14060
Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 2602-2607, May 20, 1954.

A kinetic study was made of the 2 opposing reactions comprising the H_2O-gas equilibrium. Experimental measurements were made with a quartz vessel at 900°C and a flow rate which allowed a reaction time of about 0.5 sec. The following rate expressions were obtained:

$$d/dt[H_2O] = \frac{9.5 \times 10^{10} e^{\frac{-57,000}{RT}} [H_2]^{1/2}[CO_2]}{1+2.5[CO]/[H_2]} \text{ and}$$

$$d/dt[CO_2] = \frac{5.0 \times 10^{12} e^{\frac{-67,300}{RT}} [CO]^{1/2}[H_2O]}{(1+8.0[H_2]/[CO])^{1/2}}$$

for the CO_2-H and CO-steam reactions, respectively. Homogeneous chain mechanisms involving the chain-propagating steps $OH + CO \rightleftharpoons H + CO_2$ and $H + H_2O \rightleftharpoons OH + H_2$, initiation by dissociation of H or steam, and termination by atom or atom-radical recombination substantially agreed with the data. (Contractor's abstract)

PRI. 09:004

Princeton U. James Forrestal Research Center, N. J.

CONTRIBUTION TO THE THEORY OF FAST REACTION RATES, by R. De Vogelaere and M. Boudari. July 1953 [42]p. incl. diagrs. (Technical repi. no. 3) (AF 33(038)23976) AD 14057 Unclassified

Also published in Jour. Chem. Phys. v. 23: 1236-1244, July 1955.

Classical calculations were made of the motion of a mass poini on a poiential surface. The surface corresponds to a reaction of the type AB + A = A + BA and is characierized by a single saddle poini. For the mathematically similar problem of the allowed cone of cosmic radiation, a description is given of the possibility of a subsiantial decrease of the iransmission coefficieni above a critical energy of the sysiem. Unstable secondary periodic orbits appear above the critical energy; the region on the surface between 2 secondaries is designated the pseudobasin. The appearance of a pseudobasin may result in a substantial decrease of the reaction yield. The average distance of the boundaries of the pseudobasin from the ridge is 0.5 ai E = 1.5 E_s and 1 ai E = 2E_s, where E is the iotal energy and E_s is the saddle-point energy. The resuli is independeni of the analyiical expression of the surface. Consequences of the phenomenon are discussed.

PRI. 09:005

Princeton U. James Forresial Research Cenier, N. J.

THEORY OF LAMINAR FLAME STABILITY, by J. B. Rosen. July 1953 [75]p. incl. diagrs. tables, refs. (Technical repi. no. 4) (AF 33(038)23976) AD 16739
Unclassified

Also published in Jour. Chem. Phys., v. 22: 733-748, Apr. 1954.

The stability of the steady-state solution of the flame equations is investigated both generally and by means of a specific numerical example. The method is to solve the linearized system of partial differenial equations resulting from an instantaneous heat release perturbation of the steady-state solution. A complete numerical solution of this partial system, obtained by the use of a high-speed digital computer, is presented. A stability condition, based on an approximate analytic solution, is given. The existence of stability limits is suggested as an explanation of inflammability limits. (Contractor's abstract)

PRI. 09:006

Princeton U. James Forrestal Research Center, N. J.

THE OXIDATION OF CARBON MONOXIDE IN THE

PRESENCE OF OZONE, by D. Garvin. Sept. 1953 [34]p. incl. dtagrs. tables, refs. (Technical rept. no. 5) (AF 33(038)23976) AD 18439 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 1523-1527, Mar. 20, 1954.

The rate and mechanism of CO oxidation was studied in mixtures of CO, O, N, and O_3 at atmospheric pressure and from 430° to 565°K. The slight production of CO_2 was explained by the reaction $CO + O + M \rightarrow CO_2 + M$ whtch has no activation energy and occurs every 10^3 3-body collision. The O aiom was supplied by the decomposition of O_3. The stmtlartties between the activation energies from the emplrical analysis and those of the Jahn mechanism (Zeitschr. anorganische Chem., v. 48: 260, 1906) for O_3 decomposition and the agreement of pre-exponential factors with photochemical work made this explanation more plausible than one based upon a dtrect $CO + O_3$ reaction. The results are tabulated and graphic relationships are presented.

PRt. 09:007

Prtnceton U. James Forrestal Research Center, N. J.

KINETICS OF THE OXIDATION OF CYCLOHEXANE WtTH DtNITROGEN PENTOXIDE, by J. C. D. Brand. Jan. 1954 [25]p. tncl. tllus. refs. (Technical repi. no. 8) [AFOSR-TN-54-t9] (AF 33(038)23976) AD 25265 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 2703-2707, May 20, 1955.

Quantitative measurements on the velocity of oxidation of cyclohexane by N_2O_5 tn CCl_4 solution at 0° and 20°C are descrtbed. The resulis are tnterpreted in terms of a mechanism tn which the hydrocarbon oxidation ts tnitiated by attack of an NO_3 radical generated by dissoctation of N_2O_5. The prtncipal products of the reacttion are cyclohexyl nitrate and nitrocyclohexane whtch are formed tn btmolecular, parallel reactions of the cyclohexyl radical wtth NO_2. Cyclohexyt nttrtte was an tntermedtate tn the formatton of cyclohexyl nitrate. NO_2 retarded the reaction by lowertng the steady-siate concentratton of NO_3. The tnitial rate of reacttion at 20°C was tndepen'ent of the presence of HNO_3 between 0 and 0.2 .iol/1.

PRt. 09:008

Princeton U. James Forrestal Research Center, N. J.

EXPERtMENTAL STUDtES OF HYDROGEN SUPEROXIDE FORMATtON, by J. D. McKinley, Jr. Jan. 1954, 17p. illus. tables. (Technical rept. no. 9) [AFOSR-TN-54-34] (AF 33(039)23976) AD 27849 Unclassifted

Experiments were performed to verify the exisience of hydrogen superoxide (H_2O_4). Kruglyakova and Emanuel (Doklady Akad. Nauk SSSR, 83: 593, 1952) had reported the formation of H_2O_4 by the dimerization of HO_2 radtcals in the thermal decomposition of aqueous H_2O_2; vartous analyses which were destgned to detect H_2O_4 in tne presence of H_2O_2, however, failed to indicate the presence of the superoxide. An attempt was made to substantiale evtdence reported by Stadnik (Doklady Akad. Nauk SSSR, 87: 445, 1952) for the presence of H_2O_2 in water which absorbs active intermedlates from a hydrogen-oxygen dtffusion flame. Apparatus was built tn which the flame was formed tn close proximity to a moving siream of cold H_2O. The results showed that oxides of N were present tn the absorbing solution, but hydrogen peroxides were absent. Since HNO_2 would destroy any H_2O_2 in the solution, the expertment was inconclusive in determining the abtlty of the apparatus to trap active tntermediates from the hydrogen-oxygen flame. (ASTIA abstract)

PRI. 09:009

Prtnceton U. James Forrestal Research Center, N. J.

COMBUSTION WAVE STABILITY AND FLAMMABILITY LIMITS, by J. B. Rosen. Jan. 1954, 6p. dtagrs. (Technical rept. no. 10) [AFOSR-TN-54-35] (AF 33(038)23976) AD 27850 Unclasstfted

Also published in Jour. Chem. Phys., v. 22: 750-751, Apr. 1954.

A method ts presented whtch ts also used tn deiermintng the region of stabtlity tn the parameter space of a flame-propagating medium wtth stmple kinetics. The meihod involves a stmplifted siabtltiy condition tn which only the ltneartzed 1-dimensional energy equation ts considered along wtth just those ierms tnvolvtng the temperature perturbaiton τ. The resulting eigenvalue problem ts transformed so as to be formally equivalent to the t-dtmensional Schrodinger equation for a parttcle in a potenttal fteld. The resulis of the consequent analysts suggesi that the stabtlity limii has tis phystcal counierpart tn the flammabtlity ltmit, ouiside of which a steady combustion wave no longer propagates.

PRt. 09:010

Prtnceton U. James Forrestal Research Center, N. J.

THE HETEROGENEOUS CARBON MONOXIDE REACTtON ON SILVERt, by D. Garvtn. Feb. 1954 [10]p. tncl. tllus. (Technicat note no. 1t) ([AF]OSR-TN-54-61) (AF 33(038)23976) AD 42798 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 1581, Mar. 20, t954.

Both the efftctent decompositton of ozone by silver (and sitver oxide) and the reductton of sttver oxide by

carbon monoxide are well known. In the course of a study of the thermal reaction between carbon monoxide and ozone in the gas phase, we have observed the production of carbon dioxide on a silver surface which is in contact with a gas stream containing both ozone and carbon monoxide. The results of a limited number of experiments on this heterogeneous reaction are reported here. In addition, the following section contains some remarks on the analytical determination of carbon dioxide in CO - O_3 containing mixtures. (ASTIA abstract)

PRI. 09:011

Princeton U. James Forrestal Research Center, N. J.

STABILIZATION OF ENERGY-RICH MOLECULES. I. ENERGY TRANSFER WITH HYDROGEN, by M. [J.] Boudart and J. T. Dubois. Mau 1954 [32]p. incl. diagrs. tables. (Technical note no. 6) ([AF]OSR-TN-54-81) (AF 33(038)23976) AD 42797 Unclassified

Also published in Jour. Chem. Phys., v. 23: 223-229, Feb. 1955.

The increase in fluorescence yield of β-naphthylamine vapors in the presence of foreign gases provides a new powerful method for studying energy exchange. The effect, discovered by Neporent, is analyzed kinetically and the analogue of the Stern-Volmer equation for this effect is derived. Neporent's data are recalculated in the light of this analysis. Fluorescence stabilization by deuterium and sulfur hexafluoride is studied experimentally following the procedure of Neporent. It is concluded, in particular, that the vibrational and rotational modes of the hydrogen molecules are inactive in the excitation or deexcitation of vibrational energy of complex molecules. (Contractor's abstract)

PRI. 09:012

Princeton U. James Forrestal Research Center, N. J.

COMBUSTION WAVE STABILITY AND FLAMMABILITY LIMITS, II, by J. B. Rosen. Sept. 1954 [29 p. incl. diagrs. table, refs. (Technical note no. 12) ([AF]OSR-TN-54-177) (AF 33(038)23976) AD 45801 Unclassified

The simple model studied in this exploratory investigation has proved useful in two important respects. It has shown that solutions to the steady state flame equations do not necessarily correspond to the stable propagation of a steady state flame, and that the mathematical stability limit corresponds in its general features to experimentally determined flammability limits. (Contractor's abstract)

PRI. 09:013

Princeton U. James Forrestal Research Center, N. J.

THE PRODUCTION OF EXCITED HYDROXYL RADICALS IN THE HYDROGEN ATOM-OZONE REACTION, by J. D. McKinley, Jr., D. Garvin, and M. J. Boudart. Oct. 1954 [13]p. incl. illus. diagr. table, refs. (Technical note no. 15) ([AF]OSR-TN-54-249) (Also bound with its AFOSR-TN-55-164; AD 65496) (AF 33(038)23976) AD 50136 Unclassified

Also published in Proc. Symposium on The Airflow and The Aurorae, Queen's U., Belfast (Ireland) (Sept. 6-7, 1955), N. Y., Pergamon Press, 1955, p. 264-269.

Also published in Jour. Chem. Phys., v. 23: 784-786, May 1955.

Near infrared emission spectrograms of vibrationally excited hydroxyl radicals in the ground state have been obtained upon mixing H atoms and ozone. A recent interpretation of a particular source of the night sky radiation has been verified. A nonequilibrium distribution of energy between the reaction products is indicated. (Contractor's abstract)

PRI. 09:014

Princeton U. James Forrestal Research Center, N. J.

THE VIBRATIONAL SPECTRUM OF METHYL NITRATE, by J. C. D. Brand and T. M. Cawthon. Oct. 1954 [18]p. incl. diagrs. tables, refs. (Technical note no. 14) ([AF]OSR-TN-54-292) (AF 33(038)-23976) AD 50137 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 319-323, Jan. 25, 1955.

The infrared absorption of methyl nitrate in the vapor and liquid phase has been measured in the range 2-15μ and frequencies have been assigned to all the fundamental vibrations except the two torsional modes. The characteristic frequencies of the $-ONO_2$ group are at 1672 (vs), 1287 (s), 854 (s), 759 (m), 657 (m) and 578 (m) cm^{-1}. The heat capacity (C_p = 16.2 cal mol^{-1}) and entropy ($S^o_{298.2}$ = 75.97 e.u.) of methyl nitrate vapor have been calculated assuming free internal rotation. Comparison of the statistical and thermal entropies indicates that the barriers hindering internal rotation are small, and the infrared band contours and Raman depolarization factors are interpreted assuming free rotation about the O-N bond. (Contractor's abstract)

PRI. 09:015

Princeton U. James Forrestal Research Center, N. J.

HIGH TEMPERATURE REACTION KINETICS OF THE SYSTEM: H_2 - HI - I_2, by W. [M.] Graven. Oct. 1954 [28 p. incl. diagrs. tables, refs. (Technical note no. 13) ([AF]OSR-TN-54-293) (AF 33(038)-23976) AD 49985 Unclassified

Also published tn Jour. Amer. Chem. Soc., v. 78: 3297-3300, July 20, 1956.

An tnvestigation at 700°C of the kinetics of the reactions which comprise the equilibrtum

$$2HI = H_2 + I_2$$

has been effected with the use of a flow technique which permitted a reaction time of approximately 0.5 sec. The results are tn accord with bimolecular mechanisms for which the rate constants

$$k_1 = 3.59 \times 10^{12} \exp(-49200/RT)\ 1.\ mole^{-1} sec.^{-1}$$

$$k_2 = 1.23 \times 10^{12} \exp(-4100/RT)\ 1.\ mole^{-1} sec.^{-1}$$

have been calculated for decomposition of hydrogen iodide and combtnation of hydrogen and iodine, respectively. (Contractor's abstract)

PRI. 09:016

Prtnceton U. James Forrestal Research Center, N. J.

KINETICS OF THE THERMAL DECOMPOSITION OF AMMONIUM NITRATE, by T. M. Cawthon and H. Taylor. Nov. 1954 [23] p. incl. diagrs. tables, refs. (Technical note no. 17) ([AF]OSR-TN-54-334) (AF 33(038)23976) AD 50205 Unclassified

The rate of thermal decomposition of ammonium nitrate has been determined as a function of temperature and the amount of ammonium nitrate decomposing. These data are expressed by the equation:

$$dN_2O/dt = k[NH_4NO_3] \text{ in which } k = 5.62 \times 10^{12} \exp$$

$(-39900/RT)\ sec^{-1}$. Kinetics of the decomposition reaction, determined by the dependence of the decomposition rate on the concentration of ammonium nitrate in mixed nitrate melts, are consistent with a mechanism which involves as the rate-controlling step, reaction of ammonia with hydrated nitronium ion to give nitramide. According to this mechanism, the energy of activation for the thermal decomposition of ammonium nitrate is due largely to the endothermicity of the reaction:

$$NH_4^+ + NO_3^- \rightarrow NH_3 + HNO_3.$$

(Contractor's abstract)

PRI. 09:017

Princeton U. James Forrestal Research Center, N. J.

THE THERMAL DECOMPOSITION OF ALIPHATIC AMINE NITRATES, by T. M. Cawthon and H. Taylor. Dec. 1954 [52] p. incl. diagrs. tables, refs. (Technical note no. 18) ([AF]OSR-TN-54-365) (AF 33(038)23976) AD 52430 Unclassified

The rate of methyl ammonium nitrate decomposition ts proporttonal to the amount of methyl ammonium nttrate decomposing, and initial first order rate constants for the formation of nitrogen are expressed by the Arrhenius equation:

$$k = 1.45 \times 10^9 \exp(-30,000/RT)\ sec^{-1}.$$

A mechanism for the decomposition of methyl ammonium nitrate is proposed. This mechanism involves as the slow step, reaction of methyl amine with hydrated nitronium ion to give methyl nitramine, and methyl nitramine is assumed to decompose rapidly to give either nitrous oxide or nitrite ion as one of the products. The rate of nitrogen formation in the thermal decomposition of tertiary butyl ammonium nitrate has been determined as a function of temperature and the amount of tertiary butyl ammonium nitrate decomposing and expressed by the equation:

$$\frac{dN_2}{dt} = 6.4 \times 10^{14} \exp\left(\frac{-43,600}{RT}\right) [C_4H_9NH_3NO_3] \text{ mole sec}^{-1}$$

A mechanism analogous to the methyl ammonium nitrate mechanism is proposed for the thermal decomposition of tertiary butyl ammonium nitrate. A general mechanism which is consistent with the decomposition kinetics and observed volatile products from methyl ammonium nitrate, tertiary butyl ammonium nitrate, iso butyl ammonium nitrate, trifluoro ethyl ammonium nitrate and dimethyl ammonium nitrate, is proposed for the thermal decomposition of primary aliphatic amine nitrates. (Contractor's abstract)

PRI. 09:018

Princeton U. James Forrestal Research Center, N. J.

ISOLATION OF HO_2 FROM THE HYDROGEN-OXYGEN DIFFUSION FLAME, by J. D. McKinley, Jr. July 1954 [1] p. (AF 33(038)23976) Unclassified

Published in Jour. Chem. Phys., v. 22: 1258, July 1954.

A technique is described for the isolation of HO_2 and identification of intermediate species in a hydrogen, oxygen diffusion flame. This research is fully reported in Technical note no. 9, item no. PRI. 09:008.

PRI. 09:019

Princeton U. James Forrestal Research Center, N. J.

VIBRATIONAL RELAXATION TIMES BY THE IMPACT TUBE METHOD. I. EXTENSION OF METHOD TO LONG RELAXATION TIME RANGE. II. INVESTIGATION OF THE OXYGEN-H_2O, OXYGEN-D_2O SYSTEM, by C. S. Tuesday and M. [J.] Boudart. Jan. 1955 [60] p. incl. diagrs. tables, refs. (Technical note no. 7) ([AF]OSR-TN-55-67) (AF 33(038)23976) AD 57918 Unclassified

The theory of the impact tube method is discussed and

the general equations derived. The compressible flow solution for expansion is derived and used to obtain a general solution of the equation. Special cases of the general solution are considered, and the invalidity of the assumption of incompressible nozzle flow is demonstrated. Numerical solutions of the equations are given, and are used in an investigation of the influence of H_2O and D_2O on the vibrational relaxation time of oxygen. The results for the H_2O-oxygen system are found to agree with the results obtained using sonic methods, thus establishing the validity of the treatment. H_2O is shown to be much more effective in transferring vibrational energy from oxygen than D_2O. This is attributed to the near resonance in vibrational levels of oxygen and H_2O which results in resonance vibrational energy exchange. This concept is utilized in a proposed mechanism which satisfactorily explains the experimental results. (Contractor's abstract)

PRI. 09:020

Princeton U. James Forrestal Research Center, N. J.

THE HIGH TEMPERATURE HYDROGEN-BROMINE REACTION, by D. Garvin and M. Plooster. June 27, 1955 [78]p. incl. diagrs. tables, refs. (Technical note no. 16) ([AF]OSR-TN-55-163) (AF 33(038)23976) AD 65495 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 6003-6008, Dec. 5, 1956.

A survey was made of methods of rapid adiabatic compression of gas mixtures. The H-Br reactions at temperatures between 800° and 1000°K were studied by using a modified shock tube technique. A study of the strengths of the shock waves in the modified shock tube system shows that: (1) the shock waves generated produce temperatures higher than those calculated (assuming a reversible adiabatic process); and (2) the terminal pressure of the process was generally greater than 1 atmosphere. In addition, when a high-pressure reservoir has essentially an infinite diameter, the shock waves are stronger than those predicted for a shock tube of uniform cross section at a given ratio of pressures at the diaphragm. The reaction process was studied by measuring photometrically the changes in Br concentration in the compressed, heated gas. Reaction appeared to take place by a near-adiabatic thermal explosion mechanism. From the induction periods of the thermal explosions, it is shown that reaction was slower than would be predicted by the extrapolated rate of the low-temperature reaction, with an apparently lowered activation period. An approximate theoretical treatment of the behavior of the H-Br reaction under nonsteady-state reaction conditions is presented. Satisfactory agreement is found between the experimentally observed induction periods and those calculated on the basis of a nonsteady-state reaction. Exact agreement between theory and experiment is difficult to obtain because: (a) there is some scatter in the experimental data; and (b) the rates of dissociation of Br_2 molecules and the recombination of Br atoms are very uncertain. (ASTIA abstract)

PRI. 09:021

Princeton U. James Forrestal Research Center, N. J.

THE REACTIONS OF ATOMIC HYDROGEN WITH OZONE AND WITH OXYGEN, by J. D. McKinley, Jr. and D. Garvin. May 1955 [20]p. incl. diagrs. tables, refs. (Technical note no. 19) ([AF]OSR-TN-55-164) (Also bound with its AFOSR-TN-54-249; AD 50136) (AF 33(038)23976) AD 65496 Unclassified

Also published in Proc. Symposium on The Airflow and The Aurorae, Queen's U., Belfast (Ireland) (Sept. 6-7, 1955), N. Y., Pergamon Press, 1955, p. 264-269.

Also published in Jour. Amer. Chem. Soc., v. 77: 5802-5805, Nov. 20, 1955.

The reactions of oxygen and ozone with atomic hydrogen at room temperature have been studied in a low pressure flow system, and the products (trapped at liquid nitrogen temperature) have been determined. The yields of water, hydrogen peroxide and "evolved" oxygen under various operating conditions are compatible with the view that product formation occurs primarily by radical recombination reactions in the cold trap. Hydroxyl is the immediate precursor of all water formed (and of a small amount of peroxide) while the fate of perhydroxyl is the formation of hydrogen peroxide (in the cold trap) and either hydroxyl or molecular oxygen in the pretrap phase. (Contractor's abstract)

PRI. 09:022

Princeton U. James Forrestal Research Center, N. J.

A REVIEW OF VIBRATIONAL ENERGY EXCHANGE, by C. S. Tuesday. July 1955, 35p. refs. (Technical note no. 20) ([AF]OSR-TN-55-248) (AF 33(038)-23976) AD 74768 Unclassified

The general methods of measuring vibrational relaxation times (ultrasonic techniques, impact-tube methods, shock-tube methods, and interrupted-radiation techniques) are reviewed. In addition, the more important theoretical treatments of vibrational energy exchange and related experimental results are considered. (Contractor's abstract)

PRI. 09:023

Princeton U. James Forrestal Research Center, N. J.

FLAME PROPAGATION RATES ALONG A NICHROME SURFACE, by A. L. Thomas and R. H. Wilhelm. Sept. 1955, 1v. incl. illus. diagrs. tables, refs. (Technical note no. 22) ([AF]OSR-TN-55-361) (AF 33(038)23976) AD 75394 Unclassified

The rates of flame propagation, along a slot burner, of premixed methane-air flames at gas compositions in the range 10.2 - 14.6% methane have been determined

as a function of surface temperature in the temperature range 25°C - 300°C. The surface was Nichrome V. The slot spacing was 1/16 in. and the average contact time of the gas issuing from the burner with the heated walls of the burner was in the time interval 0.014 to 0.072 sec. The rate of flame propagation increased with surface temperature. The propagation velocity for a 12.4% gas mixture increased from 63 cm/sec at 25°C to 132 cm/sec at 300°C. Two statistical design experiments have indicated that tn the region of turbulent flame propagation, the average rate of propagation ts constant for a given surface temperature, gas flow rate and composition, independent of prepropagation surface conditiontng. No instabilities tn average flame propagation rates were detected. (Contractor's abstract)

PRI. 09:024

Princeton U. James Forrestal Research Center, N. J.

THE TEMPERATURE STABILITY OF THE LAMINAR COMBUSTION WAVE, by J. F. Wehner. July 30, 1955, 13p. (Technical note no. 24) ([AF]OSR-TN-55-426) (AF 33(038)23976) AD 78704 Unclassifted

Also published in Combustion and Flame, v. 1: 339-345, Sept. 1957.

The solution to a simplified form of the linearized time-dependent energy equation of a laminar flame has been considered as an attempt to develop a criterton for the stability of such a flame. This stmplified equation ts always unstable in contrast to some prevtously considered approximations which are always stable. It ts shown that the solution of this simplified equation may be used as a starting point in the solution of the complete ttme-dependent equations as a very strenuous test of the stability of a flame. (Contractor's abstract)

PRI. 09:025

Princeton U. James Forrestal Research Center, N. J.

THE FREE ELECTRON MODEL AND THE FLUORESCENCE OF CATACONDENSED HYDROCARBONS, by B. Stevens. Dec. 1955 [29]p. incl. diagrs. refs. (Technical note no. 25) (AFOSR-TN-56-39) (AF 33-(038)23976) AD 80551 Unclassifted

The effect of vibrattons of the conjugated perimeters of catacondensed hydrocarbons on their π orbital energies and π transition frequencies as given by the free-electron model is discussed. The free electron model gives the π orbital energies and hence π transition frequencies in terms of the length of the conjugated system. Owing to in-plane vibrations of the C-C bonds along the perimeter, this length varies so that the transition frequency depends upon the nuclear configuration at the instant of transition. The most probable configurattons are derived in terms of the vibrational properttes of the perimeter treated as a collection of independently vibrating C-C bonds with the imposition of certain restrictions. Insofar as electronic transitions are determined by the most probable nuclear configurations of the perimeter, term series are obtained for the vibrational structure of absorption and fluorescence spectra of this type of molecule. Following a tentative assignment of the strongest absorption and fluorescence bands of the benzene molecule, these term series are compared with those obtained previously and values obtained for the increase in C-C bond length upon excitation together with the zero-point amplitudes of the C-C bond are of the expected order. Qualitative aspects of the fluorescence phenomenon and associated spectra are discussed tn terms of a 2-dimensional energy diagram, and it ts suggested that the transfer of excess vibrational energy of the excited molecule may be accounted for by a collisionally induced intramolecular process. (Contractor's abstract)

PRI. 09:026

Prtnceton U. James Forrestal Research Center, N. J.

A THEORETICAL DISCUSSION OF THE CONDITIONS NECESSARY FOR CHEMILUMINESCENCE, by J. C. Polanyt. Feb. 1956, 9p. (Technical note no. 21) (AFOSR-TN-56-93) (AF 33(038)23976) AD 82008 Unclassified

Also published in Proc. Symposium on The Airglow and the Aurorae, Queen's U., Belfast (Ireland) (Sept. 6-7, 1955), N. Y., Pergamon Press, 1955, p. 346-350.

The conditions necessary for chemtluminescence are discussed for an atomic reaction $A + BC \rightarrow AB + C$. A method is outltned by which it should be possible to calculate the expected light yield for a reaction of this type. The method consists in the calculatton of the total probability that the reaction will take place with BC extended to $\geq r^*_{BC}$, a critical separation corresponding to a repulsive energy between AB and C $\leq (|\Delta H| - N_0 h\nu)$, where ν is the minimum frequency of the emitted light and ΔH ts the heat of reaction. A preliminary calculation indicates that the method will predtct absolute light yields tn satisfactory agreement with the observed values for the reactions $Na + X\ Hg \rightarrow NaX + Hg$ (X = Cl, Br, I.)

PRI. 09:027

Princeton U. James Forrestal Research Center, N. J.

THE PHOTOLUMINESCENCE AND ASSOCIATED PROCESSES OF COMPLEX ORGANIC MOLECULES IN THE VAPOR PHASE, by B. Stevens. Feb. 1956, 61p. incl. diagrs. tables, refs. (Technical note no. 26) (AFOSR-TN-56-105) (AF 33(038)23976) AD 82019 Unclassifted

Also published in Chem. Rev., v. 57: 439-477, June 1957.

A general photokinetic scheme is constructed for a complex fluorescent molecule in the vapor phase. The 12 processes considered most probable following

PRI. 09:028 - PRI. 09:031

excitation by ultra-violet absorption are discussed with reference to the behavior of those molecules of this class which have been investigated photometrically. The relationship between the intensity of fluorescence emitted by a certain volume of vapor and the measured quantity is treated in some detail since variations in the latter may be caused by factors other than a change in fluorescence yield from which information concerning the rates of the various photokinetic processes is obtained. The rate of first-order fluorescence emission provides the yardstick with which the rate constants of competing processes may be measured, and for some time fluorescence quenching data have been used to determine the relative rates of very fast collisional deactivation processes. More recently similar measurements have been utilized to assess the rate constants of first-order radiationless deactivation of the excited molecule which are found to increase exponentially with the molecular vibrational energy reserve. The inhibition of this process by collisional transfer of excess vibrational energy to inert gas molecules results in fluorescence 'enhancement', the quantitative treatment of which provides an elegant method for obtaining vibrational energy transfer data which reflect the properties of inert gas as well as fluorescent molecules. (Contractor's abstract)

PRI. 09:028

Princeton U. James Forrestal Research Center, N. J.

FIRST-ORDER DECOMPOSITION OF EXCITED ANILINE MOLECULES IN THE VAPOR PHASE, by B. Stevens. Mar. 23, 1956 [1]p. incl. diagr. table. (AFOSR-TN-56-127) (AF 33(038)23976) AD 86004 Unclassified

Also published in Jour. Chem. Phys., v. 24: 1272-1273, June 1956.

In this study concerning aniline excited by radiation of 2950-2500 Å, the following relation was derived, $d = 3.6 \times 10^{13} \exp(-1200/RT_{vib})$, where d is the probability of dissociation. The similarity of this rate equation and that obtained for 2-naphthylamine (I), excited in the region 2804-2537 Å, lends support to the suggestion that dark deactivation in the case of I results from photodecomposition.

PRI. 09:029

Princeton U. James Forrestal Research Center, N. J.

RATE OF THE REACTION: $H + O_3 \rightarrow OH + O_2$. AN ANALYSIS OF A PRODUCT EMITTER FLAME, by D. Garvin and J. D. McKinley, Jr. June 1956, 4p. incl. table, refs. (Technical note no. 28) (AFOSR-TN-56-132) (AF 33(038)23976) AD 86008 Unclassified

Also published in Jour. Chem. Phys., v. 24: 1256, June 1956.

Reaction rate measurements of the reaction $H + O_3 \rightarrow OH + O_2$ was studied by the Polanyi diffusion flame method. Ozone was bled through a narrow nozzle (0.018 cm inside diam) into a low pressure atmosphere of H and H_2. The near IR emission of OH was photographed. The plate exposure was related to the reaction rate by means of an extension of diffusion flame theory to the case where the concentration of an intermediate is determined. Utilizing gas kinetic collision diameters of 2.5, 2.75, 4.5, and 5.0 Å for H, H_2, OH and O_3, respectively, kinetic theory formulas, and averaging procedures, the specific rates for 2 cases, which met the severe photographic and method limitations, were $2.4 \pm 0.3 \times 10^9$ and $2.5 \pm 0.9 \times 10^9$ 1/mol-sec or a collision efficiency of about 1/300. In the case of an alternative interpretation where there is reaction upon every collision, the average life for vibrationally OH* of 8×10^{-5} sec is obtained.

PRI. 09:030

Princeton U. James Forrestal Research Center, N. J.

THE REACTIONS OF TRIFLUOROMETHYL RADICALS WITH HYDROGEN ISOTOPES, by J. C. Polanyi. Mar. 1956 [13]p. incl. diagrs. tables, refs. (Technical note no. 28) (AFOSR-TN-56-147) (AF 33(038)23976) AD 86306 Unclassified

At the present stage of development of the theory of reaction rates, reactions which differ only in the isotopic masses of the reagents are particulary suited to theoretical treatment. Recently measurements have been made of the absolute rates over a range of temperatures for the following rapid reactions: $CF_3 + H_2 \rightarrow CF_3H$, $E = 9.5 \pm 0.7$; $CF_3 + HD \rightarrow CF_3H$, $E = 10.5 \pm 1.5$; $CF_3 + HD \rightarrow CF_3D$, $E = 10.1 \pm 1.5$; and $CF_3 + D_2 \rightarrow CF_3D$, $E = 10.2 \pm 0.7$ kcal mole^{-1}. The experimental results are discussed in detail in terms of collision theory, and the absolute theory of reaction rates. The values for the pre-exponential factors, $A^{400°K}$, predicted by the absolute theory correspond to a 'steric factor' of $\sim 10^{-3}$, which is in agreement with observation. The calculated trend in $A^{400°K}$ values in the series of reactions is only in partial agreement with observation; it is not possible, on the basis of the present experimental data, to say whether this discrepancy arises from a shortcoming in the theoretical treatment or in the experimental method. Theoretical and experimental evidence is adduced for a progressive decline in pre-exponential factor in the series of reactions $H + H_2$, $CH_3 + H_2$, and $CF_3 + H_2$. (Contractor's abstract)

PRI. 09:031

Princeton U. James Forrestal Research Center, N. J.

NEAR INFRARED EMISSION FROM THE H, O_3 REACTION. I. WAVELENGTH MEASUREMENTS OF HYDROXYL VIBRATION-ROTATION BANDS. II. OXYGEN EMISSION BANDS, by T. M. Cawthon and

J. D. McKinley, Jr. Mar. 1956 [12]p. incl. illus. tables, refs. (Technical note no. 30) (AFOSR-TN-56-148) (AF 33(038)23976) AD 86307 Unclassified

Also published in Jour. Chem. Phys., v. 25: 585-586, Sept. 1956.

Wavelength measurements are reported for several rotational lines of 8 vibration bands of OH ($^2\pi$) produced in the low pressure diffusion flame of O_3 in atomic H. Vibrational levels derived from these measurements are compared with the literature values. Attempts to photograph OD bands from the O_3, D atom flame were unsuccessful. Oxygen bands identified as due to the forbidden electronic transition, $^1\sum_g^+ \rightarrow {}^3\sum_g^-$, have been observed in the flames with atomic D and atomic H. (Contractor's abstract)

PRI. 09:032

Princeton U. James Forrestal Research Center, N. J.

THE FLAME ATTACHMENT ZONE OF LAMINAR PREMIXED METHANE-AIR FLAMES, by A. L. Thomas and R. H. Wilhelm. Feb. 1956, 1v. incl. illus. diagrs. tables, refs. (Technical note no. 27) (AFOSR-TN-56-159) (AF 33(038)23976) AD 86319 Unclassified

Research was concerned with the attachment of flames to surfaces. Laminar flames were selected for study to give a frame of reference for work with turbulent flames. Studies were made of the effect on flame properties of the compositional control of the flame attachment zone. A flame model is proposed as a phenomenological interpretation of associated events in laminar flame stabilization at surfaces. Determinations were made of flame blowoff, flashback, and extinction characteristics for laminar CH_4-air systems stabilized in various inert and oxidant atmospheres and stabilized in air with oxidant (inert or combustible) issuing into the zone of flame attachment. Detailed results are presented for (1) premixed, laminar CH_4-air flames; and (2) premixed, turbulent CH_4-air flames. Results showed that small amounts of foreign gas, at less than 1 to 2% of the premixed gas flow, greatly affect and shape the pattern of blowoff stability. The introduction of an auxiliary mass of gas to enrich the local attachment zone was considered an alternate to stabilization with a pilot light which introduces heat into the critical flame base zone. The concept of critical boundary velocity gradient correlated well with blow-off and flashback data which were obtained on rectangular orifices for different orifice widths in atmospheres of air, O, and inert gases (CO_2, He, and N). Turbulent flames were stabilized both at the rim of a tubular burner and on a porous metallic tube which was placed at right angles to the premixed stream to serve as a bluff-object stabilizer.

PRI. 09:033

Princeton U. James Forrestal Research Center, N. J.

THE FLAT FLAME BURNER AND ITS CHARACTERISTICS AS APPLIED TO THEORETICAL STUDIES, by J. W. Jenkins. Sept. 1955, 48p. incl. illus. diagrs. tables, refs. (Technical note no. 23) (AFOSR-TN-56-221) (AF 33(038)23976) AD 88028 Unclassified

The flat flame burner consists of a 1-in. burner tube packed with Cu gauze and closed at one end by a 1/4-in. stainless-steel porous plate with a mean pore size of 5 μ. The burner tube is surrounded by a water jacket with the water inlet at the bottom and the outlet at the top adjacent to the burner surface. A spiral within the jacket directs the water flow around and against the top of the burner tube. Thermistors which are coupled to an ac bridge circuit and calibrated against a Beckmann thermometer are used for measuring inlet and outlet water temperatures. Uniformity of the stream temperatures is obtained by jet mixers positioned upstream in the fluid flow. The water flow, which is measured by a capillary flowmeter, and the temperature rise indicate the heat removed from the flame front through the burner plate. Tests were conducted on 96% technical grade CH_4 and 99% CP propane. Gas flows were measured by rotameters before the gas passed to a mixing chamber; a traveling microscope measured the dead spaces from the base of the luminous flame to the burner surface; and an Eppley thermopile was used for comparative radiation measurements. Results indicated that the flat flame burner can be a useful and reliable tool for flame studies. The principal disadvantages of the burner are the difficulty of insuring a uniform flow and the influence of edge effects. A simple flame-lift method which is proposed for the rapid exploratory determination of the adiabatic flame velocities appears accurate to within 10%. (ASTIA abstract)

PRI. 09:034

Princeton U. James Forrestal Research Center, N. J.

A RELATIONSHIP BETWEEN SOME BOND PROPERTIES OF DIATOMIC MOLECULES AND THE IONIZATION POTENTIALS OF THEIR CONSTITUENT ATOMS, by B. Stevens. [June 1956] [18]p. incl. diagrs. tables, refs. (Technical note no. 34) (AFOSR-TN-56-249) (AF 33(038)23976) AD 88369 Unclassified

In this study, an examination is made of (1) $kr_o^2 2 N(I_A + I_B)$, the empirical relationship between the force constant k, bond length r_o and bond order N of the diatomic molecule AB in its ground state, and the first ionization potentials $I_A + I_B$ of the atoms A and B. This relationship is satisfactory for the hydrogen halides and for stable diatomic molecules. For molecules having totals of 2, 12, and 14 electrons in their valence shells, the expression is modified by introducing 2 constants, a and b, becoming: (2) $k(a+br_o)^2/2 = N(I_A + I_B)$.

PRI. 09:035 - PRI. 10:001

where a = 0.52 and b = 1.2. Expression 1 ts compared with Gordy's expresston, (3) $k = aN(X_A X_B / r_o^2)^{0.75} + b$, where X_A and X_B are the electronegativtties of the bonded atoms, and in most cases $a = 1.07 = 2^{0.75}$. Expresston 1 has the theoretical advantage that the dimenstons on both stdes are equivatent, which ts not the case for Gordy's expresston if X has the dtmenston of energy. Expresston 3, however, has the advantage of much wider apptication, although tt is expected that expression 1 could be applted to any bond if the bonded radicals tonization potentials were known. The latter expression is satisfactory for covalent dtatomtc motecules tn the ground state.

PRI. 09:035

Prtnceton U. James Forrestal Research Center, N. J.

THE REACTIONS OF TRIFLUOROMETHYL RADtCALS WtTH HYDROGEN ISOTOPES, by P. B. Ayscough and J. C. Polanyt. Jan. 24, 1956 [10]p. tnct. dtagrs. tables, refs. (Rept. no. NTC-3985) (tn cooperatton with National Research Counctl of Canada. Dtv. of Pure Chemtstry, Ottawa.) (AF 33(038)23976) AD 119162
Unclasstfted

Also published in Trans. Faraday Soc., v. 52: 961-970, July 1956.

The photolytic decomposttion of hexafluoroacetone has been used to produce trtfluoromethyl radtcats for a study of their reactions wtth hydrogen tsotopes. Activation energtes for the 4 reactions: $CF_3 + H_2 \rightarrow CF_3H$, $CF_3 + HD \rightarrow CF_3H$, $CF_3 + HD \rightarrow CF_3D$ and $CF_3 + D_2 \rightarrow CF_3D$ were found to be, respecttvely, 9.5 ± 0.7, 10.5 ± 1.5, 10.2 ± 1.5 and 10.2 ± 0.7 kcal mole^{-1}. The results are discussed tn detail in terms of the collts ton theory and the absolute theory of reactton rates. Evidence ts adduced for a progresstve decltne in pre-exponential factor down the sertes of reacttons: $H + H_2$, $CH_3 + H_2$, $CF_3 + H_2$. (Contractor's abstract)

PRt. 09:036

Prtnceton U. [James Forrestal Research Center] N. J.

HEAT TtRANSFER tN OSCILtATtNG FLOW, by J. P. Layton. Ftnal rept. July 1, 1953-Sept. 30, 1954. May 15, 1956, [v.] incl. tllus. dtagrs. tables, refs. (Aeronauttcal engineertng rept. no. 266a) (AF 33(038)23976) AD 115834
Unclasstfted

Exploratory research was conducted to determtne the effect of low-amplitude, AF oscillattons tn air, flowtng through a tube, upon the over-all heat transfer from the tube wall to the flowtng medtum. The results of the research tndicated an tncrease tn the rate of heat transfer of approximately 40% above that for steady flow under the conditions provided by the experimental apparatus. Air flowed through a heavy-wall stainless-steel tube located between 2 stagnation chambers. Tube tnlet stagnation-to-outtet static pressure ratios up to 8 and static pressures up to 2000 psta were tnvesttgated. Osctllattons were generated tn the air ftow by tocating a sharp-edged sonic orifice of several stzes at a section near the heat-transfer tube tnlet. Some experiments were conducted wtth an orifice at the tube exit section. An HF response pressure measuring system incorporating a special pressure transducer was emptoyed for recordtng the frequency and amptttude of the osctllations tn the atr flow. The tncrease tn the rate of heat transfer was evaluated from measurements of the stagnation temperatures of the air at the tntet and exit sections of the heat-transfer tube. A selective bibliography of 184 references on heat transfer in oscillating ftow ts appended.

PRI. 09:037

Prtnceton U. James Forrestal Research Center, N. J.

STABILITY OF THE OZONE FLAME PROPAGATION, by J. B. Rosen. [1956] [6]p. tncl. tables. (AF 33-(038)23976)
Unctassifted

Published in Stxth Symposium (International) on Combustton, Yate U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Retnhold, 1957, p. 236-241.

Applicatton ts made of a general theory of lamtnar flame stabtlty prevtously presented (J. B. Rosen, Jour. Chem. Phys., v. 22: 733, 1954) to study the stabtlty of the steady-state ozone flame propagation. The steady-state equattons, as well as the chemical ktnettc and transport coefftctents, are those gtven and solved by Hirschfelder, Curtiss, and Campbell (Jour. Phys. Chem., v. 57: 403, 1953). Some stmplifications tn the steady-state solutton gtven by von Kármán and Penner (Selected Combustion Problems, London, Butterworths' Sctentiftc Pubtications, 1954, p. 5-41) are also utiltzed.

PRt. 10:001

Prtnceton U. James Forrestal Research Center, N. J.

KtNETICS OF FORMATION OF POROUS OR PARTIALLY DETACHED SCALES, by C. E. Btrchenall. July 1954, 7p. (Metallurgy rept. no. 1) ([AF]OSR-TN-54-286) (AF 18(600)967) AD 49866
Unclasstfted

An examtnatton ts made of the variety of kinettc relations which may be found for the oxidation of solid metals accordtng to several systematic procedures. Partticular attention ts gtven to the time sequence tn whtch vartous rate laws may govern the process. The need for more careful correlation of mtcrostructures wtth rate measurements ts emphastzed. The posstble role of plastic deformation is also considered. (Contractor's abstract)

PRI. 10:002

Prtnceton U. James Forrestal Research Center, N. J.

SURFACE ACTIVITY METHODS FOR THE DETERMINATION OF DIFFUSION COEFFICIENTS 1N SOLIDS, by R. H. Condit and C. E. Birchenall. Apr. 1955 [21]p. incl. diagrs. refs. (Metallurgy rept. no. 2) ([AF]OSR-TN-55-159) (AF 18(600)967) AD 63449 Unclasstfied

The surface activity method of determining diffusion coefftctents in solids is examtned wtth emphasis on the proper treatment of the radtation absorption problem under a variety of geometrical conditions whtch may be employed tn diffusion measurements. The theoretical equations have been tested for several geometrtes with the Mn K_{∞} radiation from Fe^{55} sources. (Contractor's abstract)

PRI. 10:003

Prtnceton U. James Forrestal Research Center, N. J.

KINETICS OF FORMATION OF POROUS OR PARTIALLY DETACHED SCALES, by C. E. Birchenall. Jan. 23, 1957 [6]p. tncl. dtagrs. table, refs. (AFOSR-TN-55-461) (AF 18(600)967) AD 115050 Unclassifted

Also published in Jour. Electrochem. Soc., v. t03: 6t9-624, Nov. 1956.

Growth of oxide scales on metals ts often accompanted by the development of porosity tn the oxide or at the metal-oxide interface. These irregularities should affect the kinetics of the reaction and, if ignored, may lead to incorrect conclustons about the mechantsm of the reaction. A number of stmple models tn whtch pores are assumed to grow tn the oxide or at the interface are investtgated, and it is shown that a sequence of ranges governed by dtfferent kinetics might be found in several cases. Recent experiments which seem to contradict Wagner's theory of scale growth are discussed, and an explanation in terms of pore growth is offered. (Contractor's abstract)

PRt. t0:004

Princeton U. James Forrestal Research Center, N. J.

THE REACTIONS OF IRON-NICKEL ALLOYS WITH OXYGEN, by M. J. Brabers, W. J. Heideger, and C. E. Birchenall. Feb. 29, t956, t6p. Incl. illus. tables, refs. (Metallurgy rept. no. 5) (AFOSR-TN-56-t02) (AF 18(600)967) AD 820t5 Unclassified

Also published in Jour. Chim. Phys., v. 53: 810-816 Oct. 1956.

In order to understand the kinetics of the oxidation of Fe-Ni alloys, it is desirable to know the nature of the Fe-Ni-O equtlbrta. Fe-Nt alloys of several compostttons have been partially oxidized and then equilibrated by maintaining them tn a closed system at 1050° or 1095°C for an extended pertod. The products have been examtned microscopically by x-ray diffraction and chemical analysts to determine thetr structure and compostttion. The 3-phase field for alloy-wustite-sptnel has been located approximately, and the sense of some of the 2-phase tie lines has been established. It is posstble to rationalize much of the earlier work on the kinettcs of oxidation of Fe-Ni alloys and to estimate the importance of some sources of error tn the determination of thermodynamic activities by the formation of thin oxtde ftlms in hydrogen-water vapor mtxtures. A summary of latttce constant determtnations are gtven.

PRI. t0:005

Princeton U. James Forrestal Research Center, N. J.

THE GROWTH OF FERROUS SULFIDE ON IRON, by R. A. Meussner and C. E. Btrchenall. May 15, t956 [38]p. tncl. tllus. diagrs. tables, refs. (Metallurgy rept. no. 7) (AFOSR-TN-56-384) (AF 18(600)967) AD 96041 Unclassifted

Also publtshed tn Corrosion, v. t3: 677+, 689+, Oct. t957.

The rate of growth of FeS on Fe in S vapor has been studied between 650 and 900°C and between 10 and 500 mm pressure of S. When dtfferences in condttions are taken tnto account the rates seem to be substantially higher than those found by Hauffe and Rahmel (Zeitschr. Phys. Chem., v. 199: 152, t952). The behavior of inert markers and the sulftdation of eutectic mtxtures of Fe and FeS tndtcate that the Fe ton ts much more mobtle tn FeS than the sulftde ton. Self-dtffuston coefftctents for the Fe tons have been calculated approximately assumtng that Wagner's theory of scale growth (Atom Movements, Amer. Soc. for Metals, Cleveland, 1951) is applicable. It has been noted that markers are often found a considerable distance from their expected location at the metal-sulfide interface. This has attributed to cracking at the interface in some cases and to interference with growth by the markers in other cases. It has been shown that unoxidtzable inclusions slow down the rate of sulfidation. (Contractor's abstract)

PRI. 10:006

Princeton U. James Forrestal Research Center, N. J.

CAVITY FORMATION IN IRON OXIDE, by D. W. Juenker, R. A. Meussner, and C. E. Birchenalt. Aug. 1, t956 [34]p. incl. illus. diagrs. (Metallurgy rept. no. 8) (AFOSR-TN-56-389) (AF 18(600)967) AD 96047 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

PRI. 10:007 - PRI. 11:002

Also published in Corrosion, v. 14: 57-64, Jan. 1958.

Also published in Phys. Rev., v. 99: 657-658, July 15, 1955.

A study is made of the deep oxidation of Fe at high temperatures and in an O_2 atmosphere. Large cavities are always found in specimens whose total oxygen content has been brought to that of "FeO". The scale thickness of such specimens, along with other evidence, implies that "FeO" is plastic in the temperature range in which it is stable, while one or both of the higher oxides is relatively rigid. Evidence is presented which indicates that Fe is transported to its surrounding scale with little or no body diffusion path; the mechanism involved is not identified. An expression, analogous to the parabolic rate law of scaling of plane specimens, is developed for application to cylindrical geometry. (Contractor's abstract)

PRI. 10:007

Princeton U. James Forrestal Research Center, N. J.

PLASTIC FLOW OF IRON OXIDES AND THE OXIDATION OF IRON, by J. D. Mackenzie and C. E. Birchenall. Aug. 31, 1956 [10]p. incl. illus. diagrs. (Metallurgy rept. no. 10) (AFOSR-TN-56-435) (AF 18-(600)967) AD 96518 Unclassified

Also published in Corrosion, v. 13: 783 , 786 , Dec. 1957.

In this study, it is shown that the oxidation of Fe in O_2 is accompanied by the formation of a central box-like cavity, the dimensions of which are identical to those of the original Fe specimen. The decrease in size of this cavity with increasing temperature and its disappearance when the formation of magnetite and hematite is excluded by a controlled oxidizing potential indicates that the plastic properties of the oxides may be an important factor. This is qualitatively confirmed by the measurement of the relative plasticity of the 3 oxides at 800° -1000°C in a specially designed apparatus, which is diagrammed. (Contractor's abstract)

PRI. 10:008

Princeton U. James Forrestal Research Center, N. J.

EFFECT OF NONCOLLIMATED RADIATION ON SURFACE ACTIVITY METHODS FOR THE DETERMINATION OF DIFFUSION COEFFICIENTS IN SOLIDS, by R. H. Condit and C. E. Birchenall. [1956] [4]p. incl. diagrs. (AF 18(600)967) Unclassified

Published in Jour. Metals, v. 8: 1-4, Oct. 1956.

The contributions of radiations arriving at a diffusion specimen surface, including angles other than 90°, have been evaluated for a number of counting geometries. Modifications are proposed for the Steigman, Shockley, and Nix equation for the surface activity method, the Gruzin equation for the residual activity method, and the Gatos and Kurtz equation for autoradiography on an oblique section through the diffusion zone. The theoretical equations for absorption of a divergent beam from a plane source as detected at a point counter have been shown to agree with experimental results for extended counters under not very restricted conditions. MnKα radiation from Fe^{55} was used to obtain a monochromatic source of x-rays. (Contractor's abstract)

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:001

Atlantic Research Corp., Alexandria, Va.

PROPAGATION OF TURBULENT FLAMES, by A. C. Scurlock and J. H. Grover. [1953] [14]p. incl. illus. refs. ([Proj. Squid technical rept. no. ARC-1-P]; technical rept. no. 54) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503 and Nonr-48501) AD 22660 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 645-658.

A theory for propagation of turbulent flames is proposed which differs in many respects from previous concepts. Turbulence is assumed only to wrinkle and extend the flame area. The laminar flame velocity is thus assumed to remain constant and unaffected either by any increase in transport properties or by flame curvature. An initially flat flame surface of infinite extent propagating through a flowing combustible mixture agitated by isotropic turbulence of given scale and intensity is considered. For this system a relation is obtained which expresses the ratio of turbulent flame area to initial area of the flat flame in terms of the mean-square displacement of a flame element from the flame front, $\overline{y^2}$, and the scale. As time passes and the initially flat flame is wrinkled by turbulence, three effects are of importance in determining the area of the wrinkled flame: (a) eddy diffusion associated with turbulence in the unburned gases which tends to increase $\overline{y^2}$; (b) propagation of flame into the unburned gases which tends to reduce $\overline{y^2}$; and (c) shear and eddy diffusion gradients due to the density decrease of the gases upon passage through the flame front which tends to increase $\overline{y^2}$. Consideration is given to these three important effects acting independently and together on flames, and calculated results are compared with existing experimental data.

PRI. 11. 002

Atlantic Research Corp., Alexandria, Va.

EXPERIMENTAL STUDIES ON TURBULENT FLAMES,

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

by A. C. Scurlock and J. H. Grover. [Dec. 1953] [33]p. incl. illus. diagrs. refs. (Proj. Squid) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under [N6ori-10503] and Nonr-48501)
Unclassified

Presented at NATO-AGARD Combustion Colloquium, Cambridge U. (England), Dec. 7-11, 1953.

Published in Selected Combustion Problems, Cambridge U. (England) (Dec. 7-11, 1953), London, Butterworths Scientific Publications, 1954, p. 215-247.

Both turbulent diffusion flames and turbulent flames propagating in homogeneous mixtures are considered. For turbulent diffusion flames, typical experimental results are reviewed which establish that mixing, principally by eddy diffusion, controls the burning process. For both confined and unconfined turbulent flames propagating in homogeneous mixtures, the limited experimental results useful for comparison with theory are reviewed. Demonstrated are: the magnitude of the increase in flame velocity resulting from turbulence, the increase in flame distortion and in turbulent flame velocity with distance downstream from the stabilizer, the characteristic structure of the instantaneous flame front, and for confined flames, the presence of flame-generated turbulence. The experimental results are compared with a theory for the effect of large-scale turbulence, previously developed by the authors, which assumes that turbulence only wrinkles the flame front without changing S_L, and relates S_T/S_L to the dimensionless parameters v'/S_L, ρ_u/ρ_b, and $S_L t/l_2$. Three effects are taken into account in the theory: eddy diffusion, flame propagation, and flame-generated turbulence. Agreement of theory and experiment is acceptable in some instances, but in others the need for further refinement of the theory is evident. Indicated refinements include provision for effects of flame curvature and of flame front instability (when it exists) on S_T, provision for effect of "flame Reynolds number" on percentage conversion of available energy to turbulence, and provision for the effect on S_T of nonisotropy of the flame-generated turbulence. Additional experimental work is necessary to establish the exact nature of these effects. Experimental approaches which should yield useful data are suggested. Consideration of the effect of rate of increase of turbulent flame area in decreasing S_L indicates only a very small reduction even under extreme conditions. The possibility is discussed that at very high, but obtainable, volumetric heat release rates the combustion process may approach that of homogeneous chemical reaction and that under these conditions chemical reaction rate may become controlling. (Contractor's summary)

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:003

Atlantic Research Corp., Alexandria, Va.

PRELIMINARY EVALUATION OF A ROTATING FLAME STABILIZER AS A MEANS OF ACHIEVING HIGHER HEAT-RELEASE RATES PER UNIT OF COMBUSTION-CHAMBER VOLUME, by J. H. Grover, M. G. Kesler, and A. C. Scurlock. Oct. 1956 [23]p. incl. illus. tables. (Proj. Squid technical rept. no. ARC-2-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 108766
Unclassified

Presented at national fall meeting of the Amer. Rocket Soc., Buffalo, N. Y., Sept. 24-26, 1956.

Also published in Jet Propulsion, v. 27: 386-391, Apr. 1957.

Rotation of a cylindrical flame holder with its longitudinal axis normal to the flow of combustible gases about a transverse axis parallel to the flow resulted in the generation of flame front at higher rates than a stationary flame holder. The volumetric heat-release rates were increased, but the rotation tended to reduce the stability limits. For any one tailpipe length, the combustion efficiency increased with increasing rotation rate. This increase tended to be greater the lower the inlet-gas velocity. The power required to overcome the rotational drag was calculated to be usually less than the losses from wall-friction or from the axial drag of the flame holder.

PRI. 11:004

Bureau of Mines, Pittsburgh, Pa.

BURNING-VELOCITY MEASUREMENTS IN A SPHERICAL VESSEL WITH CENTRAL IGNITION, by J. Manton, G. von Elbe, and B. Lewis. [1953] [6]p. incl. tables, refs. [Proj. Squid technical rept. no. BUM-5-P] (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503], NAonr-25-47, and AF 18(600)156) Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 358-363.

The method is reviewed of computing burning velocity from experimental records of pressure rise and flame growth in a spherical vessel with central ignition. This apparatus, experimental procedure, and new experiments that have been performed are described.

PRI. 11:005 - PRI. 11:008

Princeton U. James Forrestal Research Center, N. J (Project SQUID)

PRI. 11:005

Bureau of Mines, Pittsburgh, Pa.

BURNING-VELOCITY MEASUREMENTS ON SLOT BURNERS. COMPARISON WITH CYLINDRICAL BURNER DETERMINATIONS, by J. M. Singer. [1953] [7]p. incl. illus. diagrs. tables, refs. [Proj. Squid technical rept. no. BUM-6-P] (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503], NAonr-25-47, and AF 18(600)156) Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 352-358.

The truncated-cone, Bunsen burner technique of measuring burning velocity is applied to flames of propane-air, methane-air, and ethylene-air mixtures from rectangular burner tubes (slot burners). Analysis of experimental results show the truncated cone method of calculation to give burning velocities for the plane combustion waves thus obtained, which probably correspond closely with true burning velocities. The values show agreement with those obtained by measurements in a spherical vessel with central ignition; they are somewhat lower than those obtained for the curved combustion waves of cylindrical burners due to removal of the effect of combustion-surface curvature of the cylindrical tube.

PRI. 11:006

Bureau of Mines, Pittsburgh, Pa.

THE EXISTENCE AND STABILITY OF SIMPLE, ONE-DIMENSIONAL, STEADY-STATE COMBUSTION WAVES, by J. M. Richardson. [1953] [8]p. refs. [Proj. Squid technical rept. no. BUM-4-P] (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] and NAonr-25-47) Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 182-189.

The existence and stability of one-dimensional, steady-state combustion waves are analyzed for the case of a simplified model of a combustion wave using only one state variable. A simple analytical approximation is devised for the determination of the steady-state solution and its limits of existence. The nonplanar transient problem linearized in deviations from the one-dimensional steady state can be treated by an exact method. It is found that the one-dimensional steady state, when it exists, is always stable.

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:007

Bureau of Mines, Pittsburgh, Pa.

OPEN TURBULENT FLAMES, by B. Karlovitz. [1953] [8]p. incl. illus. diagrs. [Proj. Squid technical rept. no. BUM-9-P] [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47] Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 60-67.

The history of the elucidation of turbulent flame phenomena is reviewed. The understanding of the effects of small and large scale turbulence and the concept of flame generated turbulence are discussed. The phenomena and theory of the stability of turbulent flames are presented together with a discussion of the importance of the concept of a critical boundary velocity gradient.

PRI. 11:008

Bureau of Mines, Pittsburgh, Pa.

THE PROBLEM OF IGNITION, by G. von Elbe. [1953] [8]p. incl. diagrs. table, refs. [Proj. Squid technical rept. no. BUM-8-P] [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47] Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 13-20.

A survey is made of theoretical and experimental studies concerning the formation of a combustion wave by a spark or other local source in an explosive medium. Ignition of an explosive gas mixture by an electric spark is considered, and development discussed of a thermal model which includes an observable quantity, the minimum flame diameter. Use of the concept of excess enthalpy h, accompanying a combustion wave when heat transport by conduction exceeds the opposing flow of enthalpy by interdiffusion of reactants and products, permits an equation for the minimum ignition energy, $H = \pi d^2 h$ where d is the critical flame diameter or quenching distance between electrodes. The excess enthalpy per unit area, h, can be computed from the heat conductivity μ of the mixture, the burning velocity Su, and the flame temperature Tb, by the equation $h \cong (\mu/Su)(Tb - Tu)$ where Tu is the temperature of the fresh gas. Comparison of theoretical and experimental data on minimum ignition energies and quenching distances indicates the theory to be basically correct. Discrepancies are analyzed indicating the value of h

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calculated from the thermal model to be too great in mixtures where transport of enthalpy by diffusion is significant. Research concerning ignition by electrically heated wire, heated spherical pellets, and pilot flames is summarized.

PRI. 11:009

Bureau of Mines, Pittsburgh, Pa.

THE RELATION BETWEEN SAMPLING-TUBE MEASUREMENTS AND CONCENTRATION FLUCTUATIONS IN A TURBULENT GAS JET, by J. M. Richardson, H. C. Howard, Jr., and R. W. Smith, Jr. [1953] [4]p. incl. table. [Proj. Squid technical repl. no. BUM-3-P] (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] and NAonr-25-47) Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 814-817.

A method (Hawthorne et al. Third Symposium on Combustion, Flame and Explosion Phenomena, p. 266-288, 1949), for estimating the concentration (ratio of oxidant-equivalent moles of reacted and unreacted fuel to the total oxidant-equivalent moles of both the fuel and oxidant) fluctuation in a gas jet from the composition of gas removed through a chilled sampling tube, is extended and refined. A redefinition is made of the distribution of concentration in the gas jet, previously assumed to be Gaussian in calculation of the mean square deviation of the concentration from the composition of the withdrawn gas. A more realistic type of distribution function than the Gaussian is utilized in the present treatment.

PRI. 11:010

Bureau of Mines, Pittsburgh, Pa.

STUDIES ON TURBULENT FLAMES. A. FLAME PROPAGATION ACROSS VELOCITY GRADIENTS. B. TURBULENCE MEASUREMENT IN FLAMES, by B. Karlovitz, D. W. Denniston, Jr. and others. [1953] [8]p. incl. illus. diagrs. [Proj. Squid technical rept. no. BUM-7-P] (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503], NAonr-25-47, and AF 18(600)156) Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 613-620.

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Theoretical consideration of the heat flow from the reaction zone of a laminar flame into the unburned explosive mixture shows that in the presence of a velocity gradient the heat flow is spread out over a larger volume of gas, thus decreasing the laminar burning velocity. Exact limits where propagation of the flame would cease cannot be predicted, but the calculated laminar burning velocity is reduced several-fold by the effect of velocity gradient at the experimentally observed limit. Two ionization probe techniques are described for measuring turbulence in or near flames, and experimental results obtained by both methods are given. For regions where the flame front is not too strongly distorted, average flame front fluctuation velocity agrees with the velocity of turbulent fluctuations.

PRI. 11:011

Bureau of Mines, Pittsburgh, Pa.

A TURBULENT FLAME THEORY DERIVED FROM EXPERIMENTS, by B. Karlovitz. [Dec. 1953] [27]p. incl. illus. diagrs. tables, refs. (Proj. Squid) [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under NAonr-25-47 and N6ori-10503] Unclassified

Presented at NATO-AGARD Combustion Colloquium, Cambridge U. (England), Dec. 7-11, 1953.

Published in Selected Combustion Problems, Cambridge U. (England) (Dec. 7-11, 1953), London, Butterworths Scientific Publications, 1954, p. 248-274.

The structure of turbulent flames burning in explosive mixtures is described and illustrated by examples. A theory of turbulent burning velocity is developed, based on this flame structure. The cardinal point of this theory is the calculation of the time interval, during which a small portion of the instantaneous combustion wave has statistical correlation with the random motion of a certain mass of gas. A comparison of measured values of the turbulent burning velocity with the predictions of this theory points to the possibility of turbulence generation by the turbulent flame. The mechanism is described by which the turbulent flame can generate additional turbulence and a theory of this process is developed, which permits the calculation of the intensity of flame-generated turbulence. Turbulence intensities calculated from measured turbulent burning velocity data are in good agreement with turbulence intensities calculated from this theory. For an independent experimental test of both theories the direct measurement of the turbulence intensity in the flame will be necessary. This appears feasible. A relationship is derived between the burning velocity, scale of turbulence, and the thickness of the turbulent flame brush. Measurement of the flame brush thickness by an electronic probe therefore

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gives information about the scale of turbulence in the flame. Further experimental work is required to complete the experimental test of the theory of turbulent flames, and to establish its range of validity. In the discussion of this and a previous paper (Experimental Studies in Turbulent Flames, by A. C. Scurlock and J. H. Grover, see item no. PRI. 11:002) G. H. Markstein considered the interaction of flame with upstream turbulence by means of linearized analysis, and K. Wohl presented supplementary experimental data on burning velocity of methane-air, butane-air, and propane-air mixtures. (Contractor's summary, modified)

PRI. 11:012

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THE SURFACE MIGRATION OF CARBON ON TUNGSTEN, by R. Klein. Jan. 20, 1954 [8] p. incl. diagr. (Proj. Squid technical rept. no. BUM-11-P; rept. no. 1147) ([AF]OSR-TN-54-12) ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ort-10503] and CSO-670-54-9) AD 89980 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1406-1413, Aug. 1954.

The surface migration of carbon on tungsten was observed with the field-emission microscope technique. The carbon source was a carefully outgassed 5-mil diameter graphite filament. The vacuum attained in the system, exclusive of helium, was of the order of 10^{-12} mm Hg. The tungsten point was shadowed with carbon and heated to a given temperature; observations of the emission patterns were made at room temperature at various time intervals. The migration occurs at a measurable rate starting about 850°K. It is characterized by a sharp boundary of a form which clearly shows that the (011) and (121) planes are avoided. An activation energy of 55 ± 7 kcal/mole was calculated for the process by application of the theory of diffusion with a sharp moving boundary. (Contractor's abstract)

PRI. 11:013

Bureau of Mines, Pittsburgh, Pa.

KINETICS OF THE GAS PHASE OXIDATION OF FORMALDEHYDE, by M. D. Scheer. June 1, 1954 [12] p. incl. diagrs. tables, refs. (Proj. Squid technical rept. no. BUM-11-P; rept. no. 1163) ([AF]OSR-TN-54-161) [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ort-10503 and CSO-670-54-9] Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 435-446.

In this study, at the end of each reaction or after any period of reaction, the pressure of the sample was determined rapidly, then mass-spectrometer scanned for CO, CO_2, O, H, HCHO, and peroxides. Evidence is presented for the peroxide-destroying property of Hg vapor. Therefore it is necessary to assume 2 types of stoichiometry, one in which peroxides rapidly are decomposed, forming no HCOOH, and the other in which peroxides decompose less rapidly, forming HCOOH in addition to other compounds. The following mechanism is proposed:

(I) for the main chain:
(1) $HCHO + O_2 \rightarrow HCO + HO_2$ (chain initiating)
(2) $HCO + O_2 \rightarrow HCO_3$ (chain continuing)
(3) $HCO_3 + HCHO \rightarrow HCOOOH + HCO$ (chain continuing)
(4') $HCO_3 + O_2 \rightarrow CO + HO_2 + O_2$ (chain terminating)
(4) $HCO_3 + M \rightarrow CO + HO_2 + M$ (chain terminating)
(5) $HO_2 +$ wall $\rightarrow$ destruction

(II) for the rapid decomposition of HCOOOH:
(6) 2HCOOOH + active surface or Hg vapor $\rightarrow$ $2CO + 2H_2O + O_2$
(7) $2HCOOOH +$ wall $\rightarrow 2CO_2 + 2H_2 + O_2$

(III) for an aged vessel:
(8) $HCOOOH + 2HCHO \rightarrow (CH_2OH)_2\,O_2 + CO$
(9) $(CH_2OH)_2\,O_2 +$ wall $\rightarrow HCOOH + CO_2 + 2H_2$
(6') 2HCOOOH + inactive surface $\rightarrow 2CO + 2H_2O + O_2$
(7') $2HCOOOH +$ wall $\rightarrow 2CO_2 + 2H_2 + 2H_2 + O_2$.

PRI. 11:014

Bureau of Mines, Pittsburgh, Pa.

PHOTODECOMPOSITION OF FORMALDEHYDE, by L. J. Schoen. May 20, 1954, 5p. incl. diagr. tables. refs. (Proj. Squid technical rept. no. BUM-16-P; rept. no. 1160) ([AF]OSR-TN-54-162) ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ort-10503] and CSO-670-54-9) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh, Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 786-790.

An estimate of the limiting energy of dissociation of the C-H band in the formyl radical, HCO, was obtained by the photolysis of formaldehyde in which deuterium was

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used as a tracer for hydrogen atoms. A mechanism is suggested for the photodecomposition from which additional information may be deduced. (Contractor's abstract)

PRI. 11:015

Bureau of Mines [Pittsburgh, Pa.].

THE THERMODYNAMICS OF COMBUSTION GASES: TEMPERATURES OF ACETYLENE-AIR FLAMES, by R. W. Smith, Jr., J. Manton, and S. R. Brinkley, Jr. Feb. 1954, 14p. incl. tables, refs, ([Proj. Squid technical rept. no. BUM-10-R]; rept. no. 5035) ([Sponsored jointly by Office of Naval Research, and [Air Force Office of Scientific Research] under NAonr-25-47 and N6ort-10503) AD 26692 Unclassified

The thermodynamic properties of the products of combustion of acetylene-air flames are presented. The composition at thermodynamic equilibrium of the combustion products are given for temperatures and pressures as follows: T(°K) = 1400-[200]-2800; P(atm) = 0.01, 0.05, 0.10, 0.5, 1.0. The results are presented in table form for various values of fuel-air ratio.

PRI. 11:016

Bureau of Mines, Pittsburgh, Pa.

THE PYROLYSIS OF FORMALDEHYDE, by R. Klein, M. D. Scheer, and L. J. Schoen. Apr. 12, 1955 [3]p. incl. diagr. tables. (Proj. Squid technical rept. no. BUM-19-P; rept. no. 1177) ([AF]OSR-TN-55-456) ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research, under N6ori-10503] and CSO-670-54-9) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 50-52, Jan. 5, 1956.

The pyrolysis of formaldehyde is shown to occur predominantly by a chain reaction. Carbon monoxide and hydrogen are formed in accordance with second-order rate laws. Methyl alcohol results from a homogeneous bimolecular reaction. An unspecified condensation product, amounting to a small fraction of the reacted formaldehyde, is also indicated. The thermal decomposition of mixtures of CH_2O and CD_2O gives H_2, D_2 and HD in proportions such that $P^2_{HD}/P_{H_2}P_{D_2}$ is a constant equal to about 3.6. The pyrolysis of CH_2O and D_2 mixtures shows that the hydrogen atom concentration, although small, exceeds that which would arise from the thermal decomposition of hydrogen atone. (Contractor's abstract)

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PRI. 11:017

Bureau of Mines, Pittsburgh, Pa.

THE OXYGEN INDUCED HYDROGEN-DEUTERIUM EXCHANGE, by R. Klein, M. D. Scheer, and L. J. Schoen. Feb. 3, 1955, 15p. incl. tables. (Proj. Squid technical rept. no. BUM-20-P; rept. no. 1176) [AFOSR-TN-55-457] ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] and CSO-670-54-9) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 47-49, Jan. 5, 1956.

The H_2-D_2 exchange reaction, investigated in detail by A. Farkas and L. Farkas (Nature, v. 132: 894, 1933; Proc. Roy. Soc. (London), v. 152A: 124, 1935), was shown to be homogeneous, gas-phase, and to proceed by a mechanism involving atoms. It is shown in this study that trace amounts of O_2 can increase the velocity of the exchange reaction by several orders of magnitude. In a series of experiments, it was found that: (a) agreement with the Farkas-Farkas rate data could be obtained if O_2-free H_2-D_2 mixtures were reacted in outgassed quartz vessels; (b) the exchange velocities for 1:1 H_2-D_2 mixtures increased in the following order: (1) O_2-free mixture in baked-out quartz vessel; (2) O_2-free mixture in an unbaked quartz vessel; (3) O_2 (3 parts/1000) mixture in baked-out quartz vessel; and (4) O_2 (3 parts/1000) mixture in a quartz vessel previously exposed to H_2O vapor. From observations with different surface-to-volume ratios of the reaction vessel, it was concluded that the mechanism for the O_2-induced exchange involves chain initiation at the wall with chain termination in the gas phase. (Contractor's abstract)

PRI. 11:018

Bureau of Mines, Pittsburgh, Pa.

STABILIZATION AND TEMPERATURE MEASUREMENT OF FLAT COOL FLAMES, by R. J. Forestl. [1955] [8]p. incl. illus. diagrs. table. (Proj. Squid technical rept. no. BUM-18-P) ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] and NAonr-25-47) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 582-589.

A burner of the Powling type (Fuel, v. 28: 25, 1949) was constructed and modified so that low-temperature flame could be stabilized. Preliminary studies were

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carrted out in which requirements for stabilization were observed, temperature measurements through the flame recorded, and several gas samples collected and analyzed. Stabilized cool flames were produced with diethyl ether, n-heptane-air mixtures, and n-hexane-air mixtures. The appearance of these three flames were all similar with a thin lower flame (cool flame) near the burner tip and hotter secondary flame above it. The ether flame could be stabilized without preheating but the hydrocarbon flames required preheating up to ~225°C. A table is given of gas composition at three positions relative to ether-air cool and secondary flames. The first position, just upstream of the cool flame shows little reaction; the second position, between cool and secondary flames, shows evidence of considerable reaction; the third position, above the secondary flame, indicates practically all the reactants consumed. Temperature profiles through the combustion region indicated a rapid rise in temperature through the visible cool flame, followed by a distance relatively constant temperature, then another rapid rise in temperature in the region of the visible secondary flame with a slope not so great as in the cool flame. As mixture becomes leaner the two flames move closer together and finally merge. The effect of preflame temperature increase is to increase the distance between the two flames without changing the temperatures of the cool and secondary flames.

PRI. 11:019

Bureau of Mines, Pittsburgh, Pa.

BURNING VELOCITIES BY THE BUNSEN BURNER METHOD. I. HYDROCARBON-OXYGEN MIXTURES AT ONE ATMOSPHERE. II. HYDROCARBON-AIR MIXTURES AT SUBATMOSPHERIC PRESSURES, by J. M. Singer, J. Grumer, and E. B. Cook. July 1955, 21p. illus. refs. (Proj. Squid technical rept. no. BUM-13-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47) AD 64155 Unclassified

Also published in Proc. Gas Dynamics Symposium, Northwestern U., Evanston, Ill. (Aug. 22-24, 1955), 1956, p. 139-150.

The Bunsen-burner technique of measuring burning velocity was applied to the following fast burning mixtures: methane-oxygen, ethane-oxygen, and propane-oxygen at atmospheric pressure. Hydrocarbon-air mixtures of methane-air, propane-air and ethylene-air were investigated by the same technique at subatmospheric pressure. The potentialities of the Bunsen-burner method were re-examined; the disadvantages inherent in all burner methods are discussed.

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PRI. 11:020

Bureau of Mines, Pittsburgh, Pa.

STUDY OF PRESSURE DEPENDENCE OF BURNING VELOCITY BY THE SPHERICAL VESSEL METHOD, by J. Manton and L. B. Milliken. July 1955, 11p. illus. refs. (Proj. Squid technical rept. no. BUM-12-P; rept. no. 1186) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47) AD 64154 Unclassified

Also published in Proc. Gas Dynamics Symposium, Northwestern U., Evanston, Ill. (Aug. 22-24, 1955), 1956, p. 151-157.

Burning-velocity measurements over the pressure range from 1.5 to 1/25 atm showed that pressure dependence is variable and apparently a function of burning velocity. Burning velocities below 50 cm/sec varied inversely with pressure. In the 50- to 100-cm/sec range, burning velocity was almost constant with pressure; from 100 cm/sec upward, burning velocity increased with pressure. Observations indicated that all burning velocities must approach a constant value at very low pressures.

PRI. 11:021

Bureau of Mines, Pittsburgh, Pa.

SIGNIFICANCE OF QUENCHING BY PORTS IN BURNING-VELOCITY MEASUREMENTS BY BUNSEN-BURNER METHODS, by J. M. Singer, J. Grumer, and E. B. Cook. Mar. 1956, 3p. illus. (Proj. Squid technical rept. no. BUM-14-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47) AD 89152 Unclassified

Also published in Jet Propulsion, v. 26: 989, Nov. 1956.

An experiment was initiated pertaining to the role of flame port diameters in burning velocity measurements by burner methods. Two photographs are presented of a 0.8 stoichiometric CH_3-air flame stabilized by a 1.0-cm-diam coil of 1-mm-od stainless steel tubing, with and without water-cooling; the coil was hot in the latter instance. Both photographs are practically identical, showing the absence of major quenching by the port over most of the flame. A similar experiment with stoichiometric CH_3-air flames resulted in an increase in flame height of about 4 to 5% when the glowing hot coil was water-cooled. The small increment in burning velocity, indicated by the change in flame height, may be the result of preheating of unburned gas by the glowing hot coil. Another mechanism, possibly that of flame cooling by the ambient atmosphere, should be considered to explain low burning velocities obtained on small port burners.

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PRI. 11:022

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FLAME PROPAGATION IN CYLINDRICAL TUBES NEAR THE QUENCHING LIMIT, by J. M. Singer and G. von Elbe. Aug. 1956 [12]p. incl. illus. table, refs. (Proj. Squid technical rept. no. BUM-15-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and NAonr-25-47) AD 104496 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-25, 1956), N. Y., Reinhold, 1957, pp. 127-130.

Linear flame speeds at near-quenching limits were obtained for CH_4 air mixtures to test Lewis-von Elbe theory that the axial burning velocity and the linear flame speed at quenching are about equal to the standard burning velocity. Uniform flame movement in downward propagation was obtained within a few centimeters after ignition. Nonsymmetrical tilting of the flame front increased the instability and caused lower linear flame speeds and burning velocities. The dead-space distances increased sharply for lean and rich mixtures. The data confirmed the prediction of Lewis and von Elbe.

PRI. 11:023

California Inst. of Tech., Pasadena.

THERMAL CONDUCTIVITY OF FLUIDS. NITROGEN DIOXIDE IN THE LIQUID PHASE, by G. N. Richter and B. H. Sage. July 1956 [27]p. incl. illus. tables, refs. (Proj. Squid technical rept. no. CIT-1-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 104498 Unclassified

The thermal conductivity of nitrogen dioxide was measured between 40° and 160°F and at pressures to 5000 psi. Equipment of spherical configuration was constructed for the measurements. The results are presented in graphical and tabular form. Measurements of electrical energy addition, temperature differences, and thermal losses indicated a probable error in the reported values of thermal conductivity of 0.0015 Btu/hr-ft-°F.

PRI. 11:024

California U. Inst. of Engineering Research, Berkeley.

PRANDTL NUMBER DETERMINATION BY MEANS OF RECOVERY FACTOR MEASUREMENTS, by R. A. Seban, S. Scesa, and A. Levy. Sept. 1954, 35p. incl. illus. tables. (Proj. Squid technical rept. no. UCB-1-R) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 46387 Unclassified

A cylindrical probe was used to measure the difference between stagnation and wall temperatures. Recovery factors were obtained for the laminar boundary layer flow of air, N, He, and He-N mixtures in the 100° to 600°F range. The Prandtl number was inferred from the recovery factor results in which the square of the measured recovery factor was within 3% of the available values of the Prandtl number for air and N and within 1% when corrected for theoretically evaluated errors; these are magnitudes of uncertainty comparable to that on the individual properties for which the Prandtl number is evaluated. The less decisive results obtained with He and He-N mixtures indicated the available Prandtl number values for He may be too high.

PRI. 11:025

California U. [Inst. of Engineering Research] Berkeley.

SUPPLEMENTARY INFORMATION ON PRANDTL NUMBER DETERMINATION BY MEANS OF RECOVERY FACTOR MEASUREMENTS, by R. A. Seban and A. Levy. Nov. 1955, 4p. illus. (Proj. Squid technical rept. no. UCB-2-R) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 75713 Unclassified

Additional measurements made with air in the 500 to 700°F range indicate that magnitude of the square of the apparent recovery factor remains the same to 675°F. The source of the error in the platinum probes is unresolved, but it appears to be associated with the presence of oxygen in the gas, since the anomalous behavior was not experienced when operating with nitrogen at temperatures up to 625°F. Results of measurements with Bakelite probes were about the same as the results previously obtained with platinum probes for air and helium in the 100 to 200°F range.

PRI. 11:026

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

SHORT TIME HIGH TEMPERATURE BENDING FATIGUE PROPERTIES OF SHEET MATERIALS, by F. J. Gillig. Sept. 8, 1949, 29p. incl. illus. tables, refs. (Proj. Squid technical memo. no. CAL-30-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ort-11901 and [N6ort-10503]) AD 123217 Unclassified

Qualitative short-time high-temperature fatigue studies were made for three heat resistant alloys. The

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complexity of the mechanism of high temperature fatigue failure was established. The investigation brought out the limitations of the constant deflection type fatigue machine for high temperature work. A number of proolems are proposed for further investigation.

PRI. 11:027

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

DEVELOPMENT OF HIGH TEMPERATURE METALLOSCOPE, by E. H. Kinelski. Sept. 19, 1949, 22p. incl. illus. refs. (Proj. Squid technical memo. no. CAL-31-[M]) (Sponsored jointly by [Office of Naval Research and Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U13502; ATI-86539 Unclassified

A high-temperature metalloscope was designed and built which satisfactorily took photo and cinemicrographs of 24S-T Al microstructure up to 1000°F under a maximum vacuum of 4×10^{-5}mm of Hg. Ternary eutectic melting was photographed at 935°F in 24S-T Al. Preliminary attempts to secure photomicrographs of heat SAE-4130 steel and 70-30 cartridge brass were unsuccessful due to an oxide formation which obliterated the microstructure.

PRI. 11:028

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

AN EVALUATION OF THE POTENTIAL MERITS OF DUCTED PULSEJETS, by G. Rudinger. Oct. 1949, 40p. incl. diagrs. (Proj. Squid technical memo. no. CAL-32-[M]; rept. no. DD-420-A-31) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U11310; ATI-78578 Unclassified

A ducted pulsejet is a conventional pulsejet completely submerged in a surrounding duct, thus permitting operation at flight velocities which are so high that a pulsejet alone would not function. An analysis of such a power plant is presented in which the nonsteady phenomena are replaced by "effective" steady state conditions, and certain other simplifying assumptions are introduced. An analysis of the ramjet based on similar assumptions is also carried out. It is concluded that the ducted pulsejet should have a definite field of application in the subsonic range of flight velocities and possibly even up to low supersonic velocities, but any final decision on the best power plant for a specific application will also depend on additional considerations not treated here; i.e., drag or relative importance of engine size vs fuel consumption.

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PRI. 11:029

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

LINEARIZED SOLUTION OF NONSTEADY FLOWS THROUGH DUCTS, by W. Squire and T. R. Goodman. Mar. 1950, 38p. incl. illus. (Proj. Squid technical memo. no. CAL-33-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U11181; AD 201062 Unclassified

Part I: An attempt was made to determine the wave phenomena resulting from a duct of slowly varying cross section by linearizing the Langrangian equation of motion. The duct was placed in a subsonic air stream; the velocity at the exit was controlled and given as a function of time. A solution for the first order equations was obtained for a straight duct. The solution of a numerical example was compared with those obtained by the method of characteristics and by the linearization of the Eulerian equations. Part II: A linear solution of the periodically pulsating flow inside a tube of constant cross-sectional area was attempted. The tube was submerged in a flowing gas so that its axis was parallel to the flow. Higher-order solutions were derived for the velocity- and pressure-forcing function of the differential equations and the boundary conditions. A general solution is given for the first-order terms.

PRI. 11:030

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

FORCED SHOCK OSCILLATIONS IN DIFFUSERS, by J. G. Logan, Jr. Apr. 1950, 9p. illus. diagrs. (Proj. Squid technical memo. no. CAL-12-[M]; rept. no. DD-420-A-32) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U16842; ATI-96025 Unclassified

An experimental technique for the study of shock motion in diffusers under the influence of downstream pressure oscillations is described. The results of preliminary experiments indicate that the maximum pressure amplitude of these disturbances that will permit the shock to be retained in a diffuser is approximately a linear function of diffuser length and frequency. These experimental results are compared with those predicted theoretically by Kantrowitz.

PRI. 11:031

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

FLAME PROPAGATION STUDIES, by G. H. Markstein. [1950] [7]p. [Proj. Squid technical rept. no. CAL-51-P] (Sponsored jointly by Office of Naval Research

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

and Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503])
Unclassified

Published in Durham Res. Rev., v. 1: 8-14, May 1950.

A general discussion of flame propagation is presented. Particular emphasis is placed on the mutual interaction of flame propagation and flow disturbances. Experiments performed at the Cornell Aeronautical Lab. concerning investigations of flame structure are described. (Contractor's abstract)

PRI. 11:032

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

PERFORMANCE OF SINGLE-FLOW JET ENGINES, by J. V. Foa. May 1, 1950 [98]p. incl. diagrs. tables, refs. ([Proj. Squid technical rept. no. CAL-46-P-R]; technical rept. no. 20) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503])
U13611, ATI-91033 Unclassified

A generalized method is presented analyzing the performance of existing or conceivable power plants of the single-flow type of jet engine. The method is based on the description of the modes of compression, heating, and expansion of the working fluid in terms of parameters that can be varied continuously over their respective ranges of practical significance. The thrust and specific impulse of single-flow jet engines are then derived as functions of such parameters. This method yields a direct comparison of the performance of existing engines, together with an indication of the extent to which they may be improved.

PRI. 11:033

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A RECORD OF CONFERENCE, SPONSORED BY THE MATERIALS PANEL OF PROJECT SQUID IN WASHINGTON, D. C. ON MAY 24, 1950 ON FATIGUE OF METALS AT HIGH TEMPERATURES, comp. by H. J. Yearian, ed. by P. K. Porter. May 24, 1950, 178p. incl. illus. diagrs. refs. ([Proj. Squid technical rept. no. CAL-60-R; technical rept. no 21) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U13983; ATI-92366 Unclassified

The following papers are included: Past Work on the Fatigue of Metals in the High Temperature Field, by T. J. Dolan; Current Theories of Fatigue, by A. M. Freudenthal; Elevated Temperature Fatigue Testing at Air Materiel Command, by F. B. Fuller; High Temperature Fatigue Program of the Bureau of Aeronautics, by N. E. Promisel and E. L. Olcott; Strain Rate Aspects of Fatigue Testing, by N. J. Grant; Effect of Notches and Shot Peening on High Temperature Fatigue Properties, by W. E. Jones and G. B. Wilkes; High Temperature Fatigue Program at C.A.L., by L. W. Smith; Creep and Rupture Properties of Temperature Resistant Materials under Unidirectional and Reversed Fatigue Stress, by B. J. Lazan; and Some High Temperature Tensile-Fatigue Data On Gas Turbine Alloys, by W. F. Simmons and H. C. Cross.

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:034

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THE STRUCTURE OF FLAMES BURNING IN TUBES. PART I. FLAME STRUCTURE IN SLOW BURNING MIXTURES OF HYDROCARBONS, AIR AND NITROGEN, by G. H. Markstein. Oct. 1, 1950, 22p. illus. diagrs. refs. ([Proj. Squid technical rept. no. CAL-53-P-R]; technical rept. no. 24) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503])
U16841; ATI-99035 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 18: 199-209, Mar. 1951.

The structure of flames burning in tubes has been studied. Slow-burning flames in rich mixtures of higher hydrocarbons, air and nitrogen were found to assume a cellular structure in the absence of turbulence in the approach stream. Lean mixtures gave smooth disc-shape flames, the transition from cellular to noncellular flames taking place at stoichiometric composition. Addition of hydrogen caused appearance of cell structure in lean mixtures of all hydrocarbons. For fuel concentrations between 1.2 and 1.4 times stoichiometric, the average cell diameter d of n-butane-air-nitrogen flames remained constant at atmospheric pressure. In the range of 1/3 to 1 atmosphere, it varied according to the expression $d \cdot p^{3/4} = \text{Const.}$ Within the same range of fuel concentrations and at atmospheric pressure, average cell size for various hydrocarbons and fuel molecular weight M were related by $d \cdot M^{1/3} = \text{Const.}$ Preliminary work on flame structure in fast-burning mixtures indicated a close connection between cellular flame structure and vibratory flame motion. Theoretical interpretations of the observed phenomena are discussed. (Contractor's abstract)

PRI. 11:035

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

SINGLE FLOW JET ENGINES - A GENERALIZED TREATMENT, by J. V. Foa. May 15, 1951 [12]p. incl. diagrs. refs. ([Supplement to Proj. Squid technical rept. no. CAL-46-P-R]; technical rept. no. 20)

PRI. 11:036 - PRI. 11:040

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

(Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20731; ATI-200937
Unclassified

Also published in Jour. Amer. Rocket Soc., v. 21: 115-126, Sept. 1951.

Generalized performance equations are obtained for single flow air breathing jet engines from entropy considerations. The analysis is simplified by the use of convenient parameters in the description of the modes of compression, combustion, and expansion. The generalized equations are applied to a few cases of current interest, for the purpose of illustration.

PRI. 11:036

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

INTERACTION OF FLOW PULSATIONS AND FLAME PROPAGATIONS, by G. H. Markstein. [1951] [2]p. [Proj. Squid technical memo. no. CAL-37-M-P] (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20884; ATI-112519
Unclassified

Also published in Jour. Aeronaut. Sciences, v. 18: 428-429, June 1951.

Some qualitative preliminary results are presented in connection with studies of flame propagating from the open to closed end of straight tubes containing premixed combustible gas. Pressure oscillations accompanied by cellular flame structures were observed. The first-order perturbation theory of flame front stability is generalized to include the case of vibratory flame motion.

PRI. 11:037

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A NEW FORM OF HEAT ENGINE UTILIZING PRESSURE WAVES (Unclassified title), by A. Hertzberg and J. G. Logan, Jr. Aug. 15, 1951, 12p. illus. diagrs. refs. (Proj. Squid technical memo. no. CAL-35-[M]; rept. no. DD-420-A-35) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) C0996; ATI-123992 Confidential

PRI. 11:038

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

CYCLIC LOADING EFFECTS ON THE CREEP PROPERTIES OF SHEET MATERIALS, by F. J. Gillig and

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

G. J. Guarnieri. Sept. 28, 1951, 22p. illus. diagrs. refs. (Proj. Squid technical memo. no. CAL-38-[M]; rept. no. DD-420-A-38) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20707; ATI-128995 Unclassified

An investigation was made to determine the effects of cyclic loading on the high temperature creep deformation rate of metals, particularly as related to conditions encountered in jet propulsion engines. Armco iron and commercial high purity aluminum were used to establish generalizations concerning the following variables: (a) amplitude of cyclic load between 0 and 50% of the mean stress; (b) temperature (cold working and annealing ranges); and (c) frequency of load variation from 1.5 to 4,200 c/min. The data show that the superposition of a cycles load upon a static tensile load in a creep test on Armco iron will not necessarily cause deformation to proceed at an increased rate provided the frequency is high enough for the conditions of stress and temperature which prevail. Only a limited amount of data was obtained for the aluminum prior to termination of the project.

PRI. 11:039

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

LIMITING HIGH TEMPERATURE CREEP AND RUPTURE STRESSES OF SHEET ALLOYS FOR JET APPLICATIONS, by G. J. Guarnieri and J. Salvaggi. Sept. 28, 1951, 8p. diagrs. tables, refs. (Proj. Squid technical memo no. CAL-39-[M]; rept. no. DD-420-A-39) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20276; ATI-122296
Unclassified

High temperature creep and fracture stresses have been determined for 24 alloys in sheet form over the range of service temperatures and times of interest to designers of jet aircraft parts. Tests of several hundred hrs were conducted on austenitic stainless steels and Inconel X between 1200° to 1800°F; cobalt base alloys between 1500° to 1800°F; low-alloy ferritic steels between 800° and 1200°F; and 24S-T3 alclad aluminum, and FS-1H magnesium. While the data presented were obtained from a single heat for each material, they provide a design basis for efficient utilization of sheet alloys in high temperature service. (Contractor's abstract)

PRI. 11:040

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

SPECTROSCOPIC STUDY OF COMBUSTION, by G. H. Rothgery and J. T. Grey. Summary rept. Sept. 28,

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

1951, 13p. diagrs. (Proj. Squid technical memo. no. CAL-34-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20729; ATI-130556 Unclassified

A study of combustion phenomena at low pressure has been made through a spectrographic examination of stable flames. A range of burner pressures and oxygen-fuel ratio has been investigated. The relative intensity of the OH, CH, and C_2 bands has been studied as a function of the combustion parameters, burner pressure, mass flow, oxygen-fuel ratio, and partial pressure of fuel. A correlation between the variations found for the relative intensity of these bands as a function of pressure and a previously suggested mechanism of formation of CH radicals has been noted.

PRI. 11:041

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

ON THE PERFORMANCE ANALYSIS OF THE DUCTED PULSEJET, by G. Rudinger. Oct. 1951, 32p. diagrs. tables. (Proj. Squid technical memo. no. CAL-36-[M-P]; rept. no. DD-420-A-36) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20277; ATI-122295 Unclassified

Chapter III of this memorandum, The Magnitude of the Flow Pulsations in the Shroud of a Ducted Pulse Jet was presented at the First National Congress of Applied Mechanics, Chicago, Ill., June 1951.

Ducting of a pulsejet is a means to keep the engine operating at flight Mach numbers at which unducted conventional engines would not operate. It also allows the primary engine to take advantage of the possible ram precompression which is not utilized in the case of conventional pulsejets. Since no methods are available to analyze in detail the periodic flow phenomena that occur in engines of this type, some approximate method of performance calculation is required. Depending on the shroud configuration, mixing of the pulsejet exhaust with the remaining shroud flow may or may not take place. In the latter case, methods of analysis developed for single-flow engines may be applied; while in the former, only the equivalent steady flow approximation appears to be feasible at the present time. Estimates are derived for the magnitude of the flow pulsations in the shroud; and on the basis of this, a discussion of the equivalent steady flow approximation is presented. Unfortunately, it is found that only a rough estimate of the potential engine performance can be made. However, from the performance computed for various conditions, it is possible to draw conclusions about the merits of various configurations. (Contractor's abstract)

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:042

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

SUMMARY REPORT ON VALVELESS PULSEJET INVESTIGATION, by J. G. Logan, Jr. Oct. 1951, 19p. diagrs. refs. (Proj. Squid technical memo. no. CAL-42-[M-P]; rept. no. DD-420-A-37) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U20275; ATI-122297 Unclassified

Summary published in Durham Res. Rev., v. 2: 5-10, Dec. 1951.

The investigations conducted at Cornell Aeronautical Lab. with valveless pulsejet engines from Oct. 1948 to Sept. 1951 and the whirling arm tests of 6-in. valveless pulsejets conducted at the Chesapeake Bay Annex of the Naval Research Lab. between Jan. 1951 and Sept. 1951 are described.

PRI. 11:043

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

NONSTEADY FLOW IN STRAIGHT DUCTS, by C. Ferrari, tr. by R. H. Cramer. Nov. 1951, 40p. incl. diagrs. (Proj. Squid technical memo. no. CAL-43-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) U22417; ATI-152538 Unclassified

Presented at the International Union of Appl. and Theoretical Mech. Colloquium on Nonlinear Vibrations, Sept. 18-22, 1951 on the Ile de Porquerolles.

The nonsteady, isentropic flow of a liquid or gas in a straight duct with deformable sides is investigated by the method of characteristics. A closed-form solution in parametric form is derived by replacing the thermodynamic equation of state with a fictitious equation by applying a similarity principle which enables transfer between the unknown-real and the known-fictitious system. The result is applied to the analysis of the fuel inlet system of a diesel engine. A generalization of the equation of motion is included for the case where the changes of state are not isentropic.

PRI. 11:044

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

STUDY OF FLOW OSCILLATIONS IN RAMJETS (Unclassified title), by G. H. Markstein. Termination rept. Nov. 1951, 38p. incl. diagrs. refs. (Proj. Squid technical memo. no. CAL-41-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) C7711; ATI-143593 Confidential

PRI. II:045 - PRI. II:050

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. II:045

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

NON-ISOTROPIC PROPAGATION OF COMBUSTION WAVES, by G. H. Markstein. [Apr. 14, 1952] [2]p. [Proj. Squid technical rept. no. CAL-54-P] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-II90I and [N6ori-10503] U24559; ATI-170653 Unclassified

Also published in Jour. Chem. Phys., v. 20: 1050-1052, June 1952.

A reply is made to a criticism of the author's treatment of combustion wave instability.

PRI. II:046

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THE INFLUENCE OF WALL MATERIAL ON COMBUSTION, by P. E. Erbe, J. T. Grey, and J. L. Beal. Summary rept. Sept. 1952, 15p. illus. tables. (Proj. Squid technical memo. no. CAL-40-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-II90I and [N6ori-10503]) AD 7159 Unclassified

The possible catalytic effect of various wall materials and surface conditions of premixed fuel and air has been investigated in heavily insulated tubes of small internal diameter. In comparison with Inconel, various metals and their respective oxides exhibited no apprectable difference. Silica, however, exhibited a positive effect. No significant effect could be traced to the internal surface condition of the tube.

PRI. II:047

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THREE-DIMENSIONAL LIQUID ANALOG FOR THE DETERMINATION OF TEMPERATURE DISTRIBUTION, by G. A. Sterbutzel and J. L. Beal. Oct. 1952, 22p. illus. (Proj. Squid technical memo. no. CAL-44-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-II90t and [N6ori-10503]) AD 11618 Unclassified

The development and use of a three-dimensional liquid analog for the determination of steady state temperature patterns in a structure are described. The particular analog model was used to investigate temperatures in a rocket motor whose wall was cooled by a liquid flowing in ducts surrounding the combustion chamber. (Contractor's abstract)

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. II:048

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THRUST AND DRAG, by R. C. Weatherston. [1952] [2]p. [Proj. Squid technical rept. no. CAL-55-P] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) Unclassified

Published in Jour. Amer. Rocket Soc., v. 22: 343-344, Nov.-Dec. 1952.

In a letter to the editor, an attempt is made to arrive at a standard and realistic definition of the available thrust of a jet engine.

PRI. II:049

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

CELLULAR FLAME STRUCTURE AND VIBRATORY FLAME MOVEMENT IN N-BUTANE-METHANE MIXTURES, by G. H. Markstein and L. M. Somers. [1953] [9]p. incl. illus. [Proj. Squid technical rept. no. CAL-52-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 22742 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Witkins, 1953, p. 527-535.

Cellular structure and vibratory flame movement studies with mixtures of n-butane and methane showed a shift of the transition from smooth flames to fully developed cell structure to richer mixtures than for a single higher hydrocarbon. Only oscillations of the fundamental organ-pipe frequency occurred in a 2-ft tube, and the maximum amplitudes of these oscillations were significantly larger in mixtures that burned with cellular flame structure than others. In a 4-ft tube, excitation of the fundamental frequency was preceded by the first harmonic for mixture burning with cellular flame structure. The amplitudes of these oscillations showed no correlation with cell structure.

PRI. II:050

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

INSTABILITY PHENOMENA IN COMBUSTION WAVES, by G. H. Markstein. [1953] [16]p. incl. illus. table, refs. [Proj. Squid technical rept. no. CAL-57-P; technical rept. no. 55] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 22743 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 44-59.

Theory and experiment on stability in combustion waves are reviewed. Reference is made to cellular and polyhedral flames and to pressure and flow oscillations associated with combustion.

PRI. 11:051

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A SLOT BURNER METHOD FOR STUDYING COMBUSTION WAVE INSTABILITY, by G. H. Markstein and L. M. Somers. Mar. 2, 1953 [1] p. incl. illus. [Proj. Squid technical memo. no. CAL-45-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-11901 and [N6ori-10503]) AD 25131 Unclassified

Also published in Jour. Chem. Phys., v. 21: 941, May 1953.

A discussion of the methods of quantitative study of combustion wave instability is presented. A slot burner setup is described which eliminates the shortcomings of the tube technique without accepting all the drawbacks of polyhedral flame studies.

PRI. 11:052

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

INTERACTION OF A PLANE FLAME FRONT WITH A PLANE SINUSOIDAL SHEAR WAVE, by G. H. Markstein. May 6, 1953, 2p. incl. illus. ([Proj. Squid technical rept. no. CAL-56-P]; technical rept. no. 53) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 60047 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 581-582, Aug. 1953.

The problem of the normal intersection of a shear wave and a combustion wave is treated. Results are presented in terms of the amplitudes of velocity perturbations and flame front deflection relative to that of the upstream shear flow.

PRI. 11:053

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

THE USE OF THE SHOCK TUBE FOR STUDYING CHEMICAL KINETICS (Abstract), by A. Hertzberg and

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

W. Squire. [1953] [2]p. (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 469-470, July 15, 1953.

A modified shock tube is described for studing the kinetics of chemical reactions with a characteristic time on the order of 10^{-3} sec at high temperatures. The reactant sample is heated by a strong shock wave and then cooled rapidly by an expansion wave to freeze the reaction. Calculations show that extremely high temperatures and cooling rates can be obtained under closely controlled conditions. (Contractor's abstract)

PRI. 11:054

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

ON THE REFLECTION OF SHOCK WAVES FROM AN OPEN END OF A DUCT, by G. Rudinger. Aug. 1954, 34p. illus. refs. (Proj. Squid technical rept. no. CAL-61-P) (Sponsored jointly by Office of Naval Research, [Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 52851 Unclassified

Presented in part at Second Canadian Symposium on Aerodynamics, Toronto, Ont., Feb. 25-26, 1954.

Also published in Jour. Appl. Phys., v. 26: 981-993, Aug. 1955.

The readjustment of the mean exit pressure to its steady-flow equilibrium level, following the arrival of a shock wave at an open end of a duct, has been investigated. For a cylindrical duct in which the gas is initially at rest, a solution based on acoustic theory was obtained in the form of a Fourier integral. The nature of this solution was established as a series of damped harmonic oscillations superposed on an exponential pressure decay. The actual pressure decay curve was obtained by numerical integrations. The same problem was attacked experimentally using a shock tube of 3.23 in i.d. From pressure records taken some distance from the open end, the "effective" exit pressure was derived. It was found that the exit pressure deviates appreciably from its steady-flow equilibrium value during a time in which a sound wave could travel about three duct diameters. Satisfactory agreement between theory and experiment was observed for shock pressure ratios up to about 1.9 (in air) although, near this limit, significant deviations due to wall friction were observed toward the end of the pressure decay region. For still stronger shocks, the influence of the decay time on the phenomena inside the duct becomes unimportant while friction effects

PRI. 11:055 - PRI. 11:057

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dominate. The possible significance of the log in the establishment of steady-flow boundary conditions in practical applications is discussed, in particular, for cases where the acceleration of the gas by the reflected expansion wave may be of importance. (Contractor's abstract)

PRf. 11:055

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

ON THE STABILITY OF A PLANE FLAME FRONT IN OSCILLATING FLOW, by G. H. Markstein and W. Squire. Nov. 5, 1954 [9]p. incl. illus. refs. [Proj. Squid technical rept. no. CAL-66-P] (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 83852 Unclassified

Also published in Jour. Acoust. Soc. Amer., v. 27: 416-424, May 1955.

Recent experimental studies revealed a close connection between spontaneous excitation of organ-pipe oscillations by flames propagating in tubes and flame front instability characterized by cellular structure. On the basis of these observations a dominant mechanism of vibratory flame movement is proposed, consisting of the following two steps: (1) as a consequence of acceleration instability, the oscillation of the gas column alternatingly distorts and flattens the flame front, thus creating the observed vibration-induced cell structure; and (2) the distortions of the flame front cause in turn periodic changes of flame surface area and therefore of burning rate. Spontaneous oscillations are excited if the phase relation between burning rate vibration and pressure oscillation is favorable. In this paper only the first step is analyzed. The linearized treatment yields stability limits in terms of dimensionless parameters representing amplitude and frequency of gas column oscillation and wavelength of flame front distortion. The properties of the flame front entering into the analysis are the ratio of densities of unburned and burned gases, the burning velocity of the plane flame front, and a characteristic length that determines its stability in the absence of oscillations. Results in qualitative agreement with experimental observations are derived. (Contractor's abstract)

PRI. 11:056

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

INTERACTION BETWEEN PRESSURE WAVES AND FLAME FRONTS, by G. H. Markstein and D. Schwartz. Feb. 1955, 6p. illus. (Proj. Squid technical rept. no. CAL-62-M) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 53841 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Also published in Jet Propulsion, v. 25: 174-176, Oct. 1955.

A shock tube method was developed for studying the effects of pressure-wave disturbances on flame propagation. Preliminary results of the interaction phenomenon were obtained with oscillographic records of the pressure transients and schlieren high-speed motion pictures. A pressure record obtained with air in a combustion chamber was compared with a pressure record obtained while burning a stoichiometric butane-air mixture in the chamber. A sequence of frames are shown from a schlieren motion picture of flame front-pressure wave interactions in a stoichiometric butane-air mixture.

PRf. 11:057

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A NEW SHOCK TUBE TECHNIQUE FOR THE STUDY OF HIGH TEMPERATURE GAS PHASE REACTIONS, by H. S. Glick, W. Squire, and A. Hertzberg. Apr 1955, 33p. incl. illus. tables, refs. (Proj. Squid technical rept. no. CAL-63-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 58832 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 393-402.

A large evacuated tank, separated from the high-pressure section by a second diaphragm, was added to a shock tube for the study of high-temperature chemical kinetics. A sample of reactant gas in the shock tube is subjected to a controlled high-temperature pulse with real gas temperatures up to several thousand degrees Kelvin and cooling rates in excess of 10^3 °K/msec. Quantitative data can be obtained on the equilibrium state of the reacted gas and the kinetics of the approach to equilibrium. The gas sample in the shock is heated and compressed by the incident and reacted shock waves. After the passage of the shock waves through the reacting gas, the gas remains heated and at rest until the rapid cooling by the tank generated expansion wave occurs. The amplitude of the temperature pulse is determined by the pressure and speed of the sound ratios of the high- and low-pressure gases. The pulse duration is controlled by the length of the shock tube and by the time delay between the breaking of the diaphragms. Helium was used as the driver gas. By using an auxiliary shock tube and variable length ducts to power diaphragm-piercing needles, a satisfactory method was devised for breaking the second diaphragm after the rupture of the first diaphragm within a delay accuracy of 100 μsec. Preliminary experiments were performed on the reaction $1/2\ N_2 + 1/2\ O_2 \rightleftarrows NO$. From 2500° to 3000°K, concentrations

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of NO which approached equilibrium values were found. An estimate of the reaction rate was made by assuming a bimolecular mechanism from the data obtained below 2500°K. A least-square fit of the specific reaction-rate constant data gave an activation energy of 40 kcal/mol.

PRI. 11:058

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

CELLULAR SLOT BURNER FLAMES, by G. H. Markstein and D. Schwartz. June 1955, 28p. illus. refs. (Proj. Squid technical rept. no. CAL-64-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 62883 Unclassified

Also published in Proc. Gas Dynamics Symposium, Northwestern U., Evanston, Ill. (Aug. 22-24, 1955), 1956, p. 83-94.

A slot burner method for investigating cellular flame structure was developed. Steady flames consisting of a single row of cells separated by straight and parallel ridges were obtained on the burner over fairly wide ranges of combustible mixtures composition and flow rate. Rich butane-air mixtures were employed in this study. Streak camera records of nonsteady cellular flames were obtained. Within the range of equivalence ratios between 1.25 and 1.45, minimum cell width remained almost constant, with an indication of a shallow minimum of 0.31 cm at an equivalence ratio of 1.36; for richer mixtures, the cell width increased up to 0.060 cm for an equivalence ratio of 1.75.

PRI. 11:059

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

IMPROVED WAVE DIAGRAM PROCEDURE FOR SHOCK REFLECTION FROM AN OPEN END OF A DUCT, by G. Rudinger. June 1955, 6p. illus. (Proj. Squid technical rept. no. CAL-65-P) (Sponsored jointly by Office of Naval Research, Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 64152 Unclassified

Also published in Jour. Appl. Phys., v. 27: 1339-1341, Nov. 1955.

The recently derived improved boundary conditions for the reflection of weak shock waves from an open end of a duct can be well approximated by a centered expansion wave if the center of the latter is located on the leading characteristic of the reflected wave and at some distance, e, outside the duct. An empirical formula,

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$e/D = (0.90 + \frac{0.677}{(p_1/p_0)-1})(\gamma + 1.08) - 3.8$, was derived, where D is the duct diameter, p_1/p_0 the shock pressure ratio, and γ the specific heat ratio. This result allows application of the improved boundary conditions without losing the convenience of the customarily used wave-diagram procedure. (Contractor's abstract)

PRI. 11:060

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A FLOW INSTABILITY FOLLOWING SHOCK REFLECTION FROM A FLARED END OF A DUCT, by G. Rudinger and L. M. Somers. Sept. 1955, 10p. incl. illus. (Proj. Squid technical rept. no. CAL-67-M) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 70001 Unclassified

Also published in Jet Propulsion, v. 25: 541-544, Oct. 1955.

Studies indicated that violent pressure oscillations may occur in a duct following the reflection of a shock wave from a flared end. These oscillations could be qualitatively explained by alternate periods of separation and reattachment of the flow in the flare. This view is supported by high-speed schlieren motion pictures of the flow just outside the exit of the flare. The pictures show that a number of vortices are emitted from the duct when pressure oscillations appear. The instability occurs only when the flow becomes supersonic in part of the flare.

PRI. 11:061

Cornell Aeronautical Lab., Buffalo, N. Y.

REFLECTION OF PRESSURE WAVES FROM AN OPEN END OF A DUCT (Abstract), by G. Rudinger. [1955] [1]p. [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under [N6ort-10503])
Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Sertes II, v. 1: 15, Jan. 30, 1956.

When pressure waves in a duct reach an open end, a three-dimensional wave pattern is established in the vicinity of the exit. These waves tend to adjust the exit pressure to the level it would have if the flow

PRI. 11:062 - PRI. 11:065

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remained steady but further arriving waves continually modify the adjusiment process. The instantaneous exit boundary conditons which determine the reflected waves depend therefore on the history of the flow. In the analysis of a nonsteady-flow problem by means of a wave diagram, this difficulty is customarily circumvented by the assumption that the exit pressure adjusts instantaneously to its steady-flow level. In the present investigation, the response of the exit pressure to an arbitrary incident wave was derived from the response to an incident shock wave by means of a Duhamel integral. A general wave diagram procedure is described which corrects the boundary conditions at any instant for the effects of the flow history. The correction is found to be small but may occasionally be significant. (Contractor's abstract)

PRI. 11:062

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

BOUNDARY CONDITIONS IN NONSTEADY FLOW, by G. Rudinger. Aug. 1956 [14] p. incl. illus. refs. (Proj. Squid technical rept. no. CAL-69-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 104981 Unclassified

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 3: 152-164, 1957.

Boundary conditions are surveyed which are encountered in a wave-diagram analysis of problems that involve quasi-one-dimensional nonsteady flow in a duct. Boundary conditions for open ends are presented which were derived by means of the acoustic theory discussed by Rudinger (Jour. Appl. Phys., v. 26: 981, 1955) to account for the effect of the flow history. The actuat flow conditions in the reflected wave lag behind those which are computed on the basis of the steady-flow boundary conditions. This lag is of the order of $3D/a_o$ after the reflection of a shock wave, where D represents the duct diameter and is the speed of sound of the initially quiet gas.

PRI. 11:063

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

A SHOCK TUBE STUDY OF FLAMES FRONT-PRESSURE WAVE INTERACTION, by G. H. Markstein. Aug. 1956, 1v. incl. illus. refs. (Proj. Squid technical rept. no. CAL-68-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 104497 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 387-398.

The interaction of initially laminar stoichiometric butane-air flames with shock waves of several pressure ratios was investigated. Schlieren spark photographs and streak records showed that reflection and transmission of the incident shock wave from the side of the unburned gas initially occurred according to theoretical expectation. Pressure transients near the bottom and top of the combustion chamber, and of flame radiation, were recorded. The radiation transients showed gradual increases during and after wave interaction and yielded maxima which depended on the shock-pressure ratio. The absence of abrupt changes of radiation during passage of the shock waves through the flame indicated that the radiation may be regarded as a rough measure of instantaneous burning rate.

PRI. 11:064

Cornell Aeronautical Lab., Inc., Buffalo, N. Y.

FLOW DISTURBANCES INDUCED NEAR A SLIGHTLY WAVY CONTACT SURFACE, OR FLAME FRONT, TRAVERSED BY A SHOCK WAVE, by G. H. Markstein. Oct. 1956, 4p. (Proj. Squid technical rept. no. CAL-70-P) ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research] under N6ori-10503) AD 108765 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 24: 238-239, Mar. 1957.

The effects of shock waves on flame structure are analyzed in an attempt to determine the modifications required in the instability concept of Taylor (Proc. Roy. Soc. London A, v. 201: 192, 1950). The analysis is simplified by computing the effect of a constant acceleration of a very short duration τ and of such magnitude that the equation $\tau = U$ is satisfied. This simplification is equivalent to neglecting compressibility effects or regarding the speed of sound as infinite. The analysis shows that for a sufficiently large initial distortion, the disturbance velocities may be of the same order of magnitude as the velocity U.

PRI. 11:065

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

FLAME STABILITY OF LIQUID-VAPOR OXYGEN MIXTURES, by J. A. Browning and M. L. Thorpe. Feb. 11, 1952, 45p. incl. diagrs. tables, refs. (Proj. Squid technical memo. no. DART-1 [M.]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under Nonr-43801 and [N6ori-10503.]) U24106; ATI-167375 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

The flame stability curves for a variety of liquid fuels burned in oxygen have been determined under varying conditions of stream temperature, flame tube diameter, and flame tube length-to-diameter ratio. Insufficient heat has been added to vaporize the fuel completely; thus, both the liquid and vapor states of the fuel are present in the mixtures. Results show a marked similarity between these flames and their gaseous fuel counterparts, except at low stream temperatures and high fuel concentrations, when a large portion of the fuel remains in the liquid phase. Benzene-oxygen flames appear to have favorable non-oxidizing qualities inherent in acetylene flames, and have the ability to produce strong fusion welds in steel. (Contractor's abstract)

PRI. 11:066

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

BASIC FLAME STUDIES AND THEIR RELATIONSHIP TO WELDING EQUIPMENT, by J. A. Browning and M. L. Thorpe. Oct. 1952, 4p. incl. illus. (Proj. Squid technical memo. no. DART-3-[P]) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503 and [Nonr-43801]) Unclassified

Also published in Welding Jour. Res., Suppl., Oct. 1952.

From an analysis of the known principles of flame stabilization remedies are suggested that might eliminate continued burning of a fuel-air mixture after flashback has taken place in a welding torch. The use of benzene for welding and a test apparatus designed for a study of the simplest elements of a welding flame are briefly described. (Contractor's abstract)

PRI. 11:067

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

FLAME STABILITY OF LIQUID-VAPOR AIR MIXTURES, by J. A. Browning and M. L. Thorpe. Oct. 2, 1952, 15p. illus. (Proj. Squid technical memo. no. DART-2-[M]) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-10503) AD 5517 Unclassified

The flame stability diagrams for mixtures with air of normal-heptane, iso-octane, and benzene burned in the open atmosphere above Bunsen tubes have been determined under varying conditions of stream temperature and tube diameter. Results are nearly identical to those obtained for gaseous fuels except at low temperatures and high fuel concentrations when a portion of the fuel remains in the liquid phase. The use of a short outer tube enclosing the base of an air-fuel flame serves as an efficient stabilizing device. Flow velocities through the Bunsen tube can be increased to very high values without danger of overheating the stabilization device. (Contractor's abstract)

PRI. 11:068

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

LATERAL BLOWOFF OF A BUNSEN FLAME, by M. L. Thorpe and J. A. Browning. Apr. 26, 1954, 3p. incl. illus. [Proj. Squid technical rept. no. DART-5-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 62825 Unclassified

Also published in Indus. Engineering Chem., v. 46: 2203-2205, Oct. 1954.

Blowoff limits for Bunsen flames burning within a secondary stream of atmospheric air have been studied. Results obtained between certain limits of fuel-air ratio and secondary stream velocity show that high Bunsen tube stream velocities can maintain a stable flame. The presence of the Bunsen tube creates eddies within the secondary stream. Thus, this tube acts as a flame holder. (Contractor's abstract)

PRI. 11:069

Dartmouth Coll. [Thayer School of Engineering] Hanover, N. H.

EFFECT OF FUEL DROPLETS ON FLAME STABILITY, FLAME VELOCITY, AND INFLAMMABILITY LIMITS, by J. A. Browning and W. G. Krall. Sept. 1954, 9p. incl. illus. refs. (Proj. Squid technical rept. no. DART-4-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 53842 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 159-163.

The flame velocities, inflammability limits, and stability limits of mixtures of kerosene mist in air have been measured. The mist is composed of droplets of sub-micron diameter formed by the rapid condensation of the fuel vapor in cold air. The maximum laminar flame velocity and the lean limit of inflammability for the mist are equivalent to values obtained for a gaseous fuel counterpart. However, the rich limit is considerably higher than for the vapor, and the stability limits are wider. (Contractor's abstract)

PRI. 11:070 - PRI. 11:073

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PRI. 11:070

Dartmouth Coll. Thayer School of Engineering, Hanover, N. H.

THE EFFECT OF PARTICLE SIZE ON THE COMBUSTION OF UNIFORM SUSPENSIONS, by J. A. Browning, T. L. Tyler, and W. G. Krall. Sept. 1955, 16p. refs. (Proj. Squid technical rept. no. DART-6-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 70871 Unclassified

Also published in Indus. Engineering Chem., v. 49: 142-147, Jan. 1957.

The lean limit of inflammability and the maximum pressure rise of nearly monodisperse clouds of Armowax particles in air have been determined. The maximum pressure reached during the constant volume combustion of suspensions composed of particles ranging from 10μ to 90μ is inversely proportional to particle size. A maximum air fuel ratio of 58:1 for the lean limit of inflammability is obtained for suspensions of 60μ particles. Larger and smaller particles have lean limits of lower air-fuel ratio with values of 25:1 for both 10μ and 90μ sizes. No rich limit is evident within the range of mixture strengths tested. (Contractor's abstract)

PRI. 11:071

Delaware U., Newark.

THE DETERMINATION OF THE TEMPERATURE OF NON-LUMINOUS FLAMES BY RADIATION IN THE NEAR INFRARED, by L. Bernath, H. N. Powell and others. [1950] 14p. tables. ([Proj. Squid technical rept. no. DEL-1-P]; technical rept. no. 32) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N8onr-74001 and [N6ori-10503]) U16749; ATI-148970 Unclassified

Also published in Proc. Conference of the Inst. Mech. Engineers and the Amer. Soc. Mech. Engineers, London (England), Sept. 11-13, 1951.

Abstract published in Appl. Mech. Rev., v. 5: 138-139, Mar. 1952.

A 2-wavelength method is described in which the temperature is obtained from the ratio of 2 peak intensities of the near infrared H_2O-band system after the ratio of their emissivities has been established as a function of temperature. The method appears applicable to any combustion process where H_2O vapor is produced. The absolute accuracy of the temperatures obtained was approximately ± 20°C. A comparison of experimental and calculated temperatures indicated that the former did not exceed the adiabatic flame temperature; flame-point temperature of 3.33% butane was 86° below the adiabatic. The temperature of the burning zones of several lean and rich butane-air flames was measured as a function of distance from the zone. There was strong evidence of the thermal nature of infrared radiation; this was the case up to 0.2 mm from the burning zone where chemiluminiscent radiation was emitted in the visible and ultraviolet part of the spectrum.

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:072

Delaware U., Newark.

THE BURNING VELOCITY OF TURBULENT FLAMES, by K. Wohl, L. Shore and others. [1952] [16]p. incl. illus. tables, refs. ([Proj. Squid technical rept. no. DEL-2-P]; technical rept. no. 50) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N8onr-74001 and [N6ori-10503]) AD 22775 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 620-635.

Suggestions are made concerning the theory of turbulent flames by modification of the standard equations of turbulent burning velocity. The effect of approach stream turbulence involves amplification mechanisms, one of which may be called induction of flame created turbulence. Another effect is the tendency of the laminar flame front to become unstable with increasing fuel concentration for higher hydrocarbons. Experiments with flames burning from flameholders in ducts show that turbulent burning of this type of flame requires a high stream velocity, but not necessarily any approach stream turbulence.

PRI. 11:073

Delaware U., Newark.

QUENCHING, FLASH BACK, BLOW-OFF-THEORY AND EXPERIMENT, by K. Wohl. [1953] [22]p. incl. illus. tables, refs. ([Proj. Squid technical rept. DEL-3-P]; technical rept. no. 51) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N8onr-74001 and N6ori-10503) AD 22376 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 68-89.

Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID)

In a survey of theoretical and experimental data regarding the phenomena of quenching, flashback, and blowoff, existing theory and experiments are reviewed. A dtscusston of the relationship between quenchtng distance and dead space is presented. The limitations of the velocity gradient at the tube wall as the suitable parameter whtch is to be tnterpreted by theory ts discussed wtth respect to the explanation of flashback and blowoff phenomena. (Contractor's abstract)

PRI. 11:074

Delaware U., Newark.

USE OF SPECTROSCOPY IN ELUCIDATING REACTION MECHANISMS, by A. G. Gaydon. [Dec. 1953] [12]p. tncl. refs. (Proj. Squid) [Sponsored jointly by Offtce of Naval Research, Air Force Office of Scientiftc Research, and Offtce of Ordnance Research under N6ort-10503] Unclassified

Presented at NATO-AGARD Combustion Colioquium, Cambridge U. (England), Dec. 7-11, 1953.

Published in Selected Combustion Problems, Cambrtdge U. (England) (Dec. 7-11, 1953), London, Butterworths Scientific Publications, 1954, p. 132-143.

The need for quantitative rather than qualitative spectroscopic work is stressed, and the difficulties in making experimental observations and in interpreting the results are discussed in relation to emission and absorption spectra. Recent experimental developments — low pressure flames, atomic flames, use of deuterium as tracer, flash photolysis and absorption spectroscopy of flat diffusion flames — are discussed. The information to be dertved from electronic, vibrational and translational tntensity anomalies and also from predissociations and continuous spectra are examtned. The mechanism of formation of C_2, CH, OH, and HCO radtcals tn organic flames ts reviewed. Spectroscopic evidence on the nature and meaning of activatton energy tn relation to flame propagaiton ts dtscussed. It is suggested thai observations of flame spectra could be interpreted as due to breakdown of the hydrocarbons etc. rather than to the formation of partial oxidation products. (Contractor's summary)

PRI. 11:075

Delaware U., Newark.

BURNING VELOCITY OF UNCONFINED TURBULENT FLAMES, by K. Wohl and L. Shore. [Mar. 5, 1954] [11]p. tncl. illus. tables, refs. [Proj. Squid technical rept no. DEL-5-P] (Sponsored jointly by [Office of Naval Research, Air Force Office of Scientiftc Research, and Office of Ordnance Research, under N6ori-10503) AD 68123 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Also published in Indus. Engineering Chem., v. 47: 825-834, Apr. 1955.

Theories of turbulent burning velocity are reviewed. The theory of Scurlock and Grover is discussed and tt is shown that the scale of turbulence affects the turbulent burning velocity only as long as the steady state ts not reached. An approximate verston of the ftnal differential equation for the turbulent burning velocity is given, which can be integrated tn closed form. The equations following from this theory are compared with the equation given by Karlovitz, Denniston, and Wells and a modified version of tt. The average turbulent burning velocity of butane-air and methane-air flames burning from tubes in air at ordinary pressure was measured from the area of maximum luminosity, which ts shown by chemical analysis to coincide with the one at which the oxygen concentration of the combustible mixture has dropped to 50%. Intensity of approach stream turbulence has been varied independently of velocity with the help of screens. The result for methane flames roughly agree with the predtctions of Karlovtiz, Denniston, and Wells for "passive" flame fronts. The burning velocity of rich butane flames ts much larger than predtcted; that of lean butane flames ts much smaller. These effects are explained on the basis of the difference between the diffusivities of butane and oxygen. With increasing tube diameter average turbulent burning velocity increases strongly because the flame front distortions traveling down the flame front have an increasing opportunity to grow. The peculiar shape of experimental curves confirms qualitatively Scurlock and Grover's theory of turbulence-generating flames. The measured average turbulent burning velocity and the average base diameter of flame front distortions are not affected by the scale of approach turbulence within the experimental range. (Contractor's abstract)

PRI. 11:076

Delaware U., Newark.

SPECTROPHOTOMETRIC TRAVERSES THROUGH FLAMES FRONTS, by K. Wohl and F. Welty. Sept. 1954, 18p. illus. (Project Squid technical rept. no. DEL-1-P) (Sponsored jotnly by Office of Naval Research, [Air Force] Office of Scientiftc Research, and Office of Ordnance Research under N6ori-10503) AD 53843 Unclassified

Also published in Ftfth Sympostum (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Retnhold, 1955, p. 746-753.

A spectrophotomeirtc study was made of the structure of the burning and post-combustion zones of butane-air flames at 1 atm. A flat flame front was created which was viewed edgewise by the spectroscope, and the light emission of a gas element was followed along its path.

PRI. 11:077 - PRI. 11:079

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Measurements tn the near IR ytelded the temperature proftle, and measurements tn the vistble and UV gave tnformation on the rise and decay of the radtation of flame radicals.

PRI. 11:077

Delaware U., Newark.

ON THE STRUCTURE OF TURBULENT FLAMES, by K. Woht, H. von Rosenberg and others. June 1956, 15p. tllus. tables, refs. (Proj. Squid technical rept. no. DEL-6-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 95376 Unclasstfied

Also published in Stxth Sympostum (International) on Combustion, Yale U., New Haven, Conn. (Aug 19-24, 1956), N. Y., Reinhold, 1957, p. 333-340.

A comparative study was made between the progress of the chemical combustion process in several turbulent flames and the local luminosity of the flames as obtained by a densitometric evaluation of direct photographs. Studies of enclosed flames at atmospheric pressure involved the burning of various homogeneous propane-air mixtures in a horizontal duct. Analysis showed that, generally, slight combustion occurs in the schlieren front, most of the gas breaks through the front unburned or tncompletely burned. The quenchtng of the combustion reactton by cooling in the sampltng probe was independent of sampltng velocity. The relattonship between lumtnostty and progress of combustion was tested with open butane-air burning from a cooled tube through which N was flowing at 1 in./sec. The points of maximum luminosity in the flame axis were 5.3 mm below the points of 50% O consumption; the points of maximum luminosity in 2 flame cross sectlons at lower heights were 0.6 mm closer to the axis than the points of 50% O consumption. Results favored a model of flame front burning rather than a continuously distrtbuted reaction. An expertment was conducted wtth butane-air flames burning at 0.2 atm in a vertical cooled lube from a central stoichtometrtc H-O pilot flame. Data were used to make a comparison between the points of maxtmum luminostty and 50% consumption of reactable O in a hortzontal cross section, and between the outer points of 20% of maxtmum luminostty and those of 10% O consumption in a horizontal cross section. Results are presented for a stoichiometric flame at average cold stream velocities of 32 and 68 fps and turbulence levels of 0.6 and 7%.

PRI. 11:078

Experiment, Inc., Richmond, Va.

EFFECT OF INITIAL TEMPERATURE ON MINIMUM

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

SPARK IGNITION ENERGY, by I. R. Ktng and H. F. Calcote. May 1955 [6]p. tncl. tllus. table. (Proj. Squid technical rept. no. EXP-2-M) (Sponsored jotntly by Office of Naval Research, [Atr Force] Office of Sctentiftc Research, and Offtce of Ordnance Research under N6ori-10503) AD 62244 Unctassifted

Also published in Jour. Chem. Phys., v. 23: 2444-2445, Dec. 1955.

Data are presented concerntng the effect of the initial fuel-atr temperature on ignitton energy between -50° and 250°C for several hydrocarbons, propylene oxide, hydrogen, and carbon disulfide. Provision was made for controlling the temperature of the ignition bomb by circulating either cooling or heating liquids from a constant-temperature bath through cotls embedded tn the bomb watls. The graph of the mtnimum spark-ignition energy vs equtvalence ratio shows that the equivalence ratio at which the minimum in the ignition-energy curve occurs moves toward leaner mixture and extends over a broader range of equivalence ratios as the initial temperature is increased. An equivalent shift in the maximum burning-velocity curve with increasing initial temperature was also observed. The minimum spark-ignition energy for stoichiometric mixtures with air of a number of fuels is summarized at 0°, 25°, and 100°C. The logarithm of the ignition energy was inversely proportional to the temperature except in the range -30° to -50°C where for some fuels a rapid increase in energy was observed with a reduction in tnitial temperature.

PRt. 11:079

Experiment, Inc., Richmond, Va.

STUDIES OF IONIZATION IN FLAMES BY MEANS OF LANGMUIR PROBES, by H. F. Calcote and I. R. Kttg. May 1955 [37]p. tncl. tllus. refs. (Proj. Squtd technical rept. no. EXP-1-P) (Sponsored jotntly by Offtce of Naval Research, [Air Force] Office of Scienttfic Research, and Office of Ordnance Research under N6ori-10503) AD 62243 Unclasstfied

Alsc published in Ftfth Sympostum (International) on Combustton, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 423-434.

The use of the Langmuir probe in studying ionization tn flames is described with typtcal results and an interpretation of some of the experimental evidence to prove that ionization in the combustion zone is not due to contaminants. The arguments for this conclusion are: (1) flames of some fuels do not contain ions. Were contaminants responsible, all flames would be expected to have ions present; (2) flames at low temperatures have high ion concentrations such tha. it would require one mole-percent sodium impurity in the input gas to account for the observed concentration;

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(3) ionization is concentrated in a very thin region comparable in the thickness to the reaction zone; and (4) results at different pressures cannot be correlated by assuming thermal ionization of contaminants. (Contractor's abstract)

PRI. 11:080

Experiment, Inc., Richmond, Va.

EFFECT OF PROBE SIZE ON ION CONCENTRATION MEASUREMENTS IN FLAMES, by I. R. King and H. F. Calcote. June 1955 [5]p. incl. tables. (Proj. Squid technical rept. no. EXP-3-M) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 64153 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2203-2204, Nov. 1955.

It has been pointed out that when known concentrations of salts were introduced into a flame, the measured ion concentration was lower than the theoretical value by a factor of 200 to 400(H. F. Calcote and I. R. King, Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), 1955, p. 423-434). This lack of agreement was attributed to the cooling effect of the probe. A more detailed study of positive-ion concentration, N_+, has indicated, however, that the size of the measuring probe greatly influences ion-concentration values, the larger the probe, the lower the measured values of ion concentration. As a result, a correction, N_+ (corrected) = $(r/l)N_+$ (expertmental), where r = radius of the probe and l = mean flight path, has been introduced. The results of calculations seem to show that the discrepancy in ion-concentration values is caused by probe size and not by gas cooling, and that the correction r/l is reasonable.

PRI. 11:081

Johns Hopkins U., Baltimore, Md.

INFLUENCE OF RESOLVING POWER ON MEASUREMENT OF CORRELATIONS AND SPECTRA OF RANDOM FIELDS, by M. S. Uberoi and L. S. G. Kovasznay. Jan. 1951. 34p. incl. illus. tables. (Proj. Squid technical rept. no. JHU-1-R.; technical rept. no. 30) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research, under N6onr-24320 and N6ori-10503]) AT1-130376 Unclassified

Functional relations are derived between the true correlations and spectra of a random field and those measured with a probe of finite resolving power. The case of a probe having zero resolving power in one direction (e.g., infinitely long hot wire) is examined; and it is shown that, in the case of homogeneous random fields, the true correlations and spectra can be recovered from the corresponding measured quantities. These relations are applied to turbulence measurements by hot wire anemometers and optical methods. Explicit calculations of hot wire length effect are made for some simple velocity and temperature spectra.

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PRI. 11:082

Johns Hopkins U., Baltimore, Md.

LAURENT SCHWARTZ'S THEORY OF "DISTRIBUTIONS" AND SOME OF ITS APPLICATIONS (FOURIER TRANSFORMATION), summarized by G. B. Mélèse. Sept. 1951, 106p. refs. ([Proj. Squid technical rept. no. JHU-2-R]; technical rept. no. 41) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6onr-24320 and [N6ori-10503]) AD 5903 Unclassified

This paper abstracts essentially the practical results of Laurent Schwartz's theory of "distribution" from his two books published in French (Théorie des Distributions, vol. 1-2, Hermann and Cie, Paris, 1950). It is written for applied mathematicians and theoretical physical scientists. The notion of "function" is first generalized to "measure" (Dirac delta function). With the new notion of distribution, justifications are given for many (previously heuristic) manipulations of discontinuities encountered in the solutions of partial differential equations.

PRI. 11:083

Johns Hopkins U., Baltimore, Md.

EXPERIMENTAL INVESTIGATION OF OPTICAL METHODS FOR MEASURING TURBULENCE, by L. S. G. Kovasznay and P. C. Clarken. Jan. 1, 1952, 85p. incl. illus. refs. ([Proj. Squid technical rept. no. JHU-3-R]; technical rept. no. 42) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-10503) AD 2352 Unclassified

Optical methods for measuring statistical properties of turbulent density fluctuations were explored. The analysis of shadow pictures of turbulent regions in the wake of special "grid projectiles" can yield the micro-scale of turbulent density fluctuations of the right order of magnitude. An experimental comparison between optical methods and hot-wire anemometer measurements was performed in a flow field in which both types of measurements were feasible. An electrically heated grid placed in a small jet provided a flow having sufficiently intense temperature, and therefore density fluctuations. The density fluctuations were measured by the shadow method and from the shadow correlation

PRI. 11:084 - PRI. 11:087

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the microscale of density fluctuations was computed. From time record interferometer fringe fluctuations the power spectrum of the density fluctuations was determined. Hot-wire measurements of the power spectrum of the temperature fluctuations gave a comparison. The experiments proved that the optical methods are practicable in a certain domain of the variables but are not superior to the hot-wire anemometer where the latter is applicable. (Contractor's summary)

PRI. 11:084

Johns Hopkins U., Baltimore, Md.

TURBULENCE IN SUPERSONIC FLOW, by L. S. G. Kovasznay. Jan. 1953 [19]p. incl. illus. refs. (Proj. Squid technical repl. no. JHU-4-P) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 26882 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 20: 657-675, Oct. 1953.

First-order perturbation theory indicates that the Navier-Stokes equations for a compressible, viscous, and heat-conductive gas can have three distinctly different types of disturbance fields, obeying three independent differential equations. These three "modes" of disturbance fields are: vorticity mode, entropy mode, and sound-wave mode. The modes are independent when the intensities of the fluctuations are small, but they interact at larger intensities when linearization is not permissible. The principal tool for measuring the fluctuating fields is the hot-wire anemometer adapted for supersonic flow. In a supersonic flow the hot-wire anemometer responds to two variables: mass flow fluctuations and stagnation temperature fluctuations. Each of the above three modes contributes to both of these variables. By taking fluctuation measurements at different wire temperatures, the relative sensitivity to the flow parameters varies and a "fluctuation diagram" can be obtained. The character of the fluctuation diagram differs for each mode, and even coexisting modes can be separately determined by analyzing the fluctuation diagram under certain restrictive conditions. Hot-wire measurements were obtained in various supersonic flows. Pure temperature spottiness (entropy mode) and pure sound-wave fields were explored. Detailed measurements were taken in a turbulent supersonic boundary layer. With the aid of the fluctuation diagram, the intensity of temperature spottiness (entropy mode) and of turbulent velocity fluctuations (vorticity mode) was measured across the layer. Energy spectrum and probability density measurements gave clues concerning the character of the fluctuations. (Contractor's summary)

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PRI. 11:085

Johns Hopkins U., Baltimore, Md.

EDDY TURBULENCE AND RANDOM SOUND IN A COMPRESSIBLE FLUID, by M. S. Uberoi. Feb. 10, 1953 [4]p. (Proj. Squid technical rept. no. JHU-5-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 26881 Unclassified

Also published in Proc. Cambridge Philos. Soc. (England), v. 49: 731-734, Oct. 1953.

An analysis is presented which shows that for a given velocity correlation based on a statistical average, any turbulence field can be decomposed into two uncorrelated parts. One part corresponds to eddy turbulence and the other to random sound.

PRI. 11:086

Johns Hopkins U., Baltimore, Md.

ANALYSIS OF TURBULENT DENSITY FLUCTUATIONS BY THE SHADOW METHOD, by M. S. Uberoi and L. S. G. Kovasznay. Jan. 18, 1954 [6]p. incl. illus. refs. [Proj. Squid technical repl. no. JHU-7-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 103804 Unclassified

Also published in Jour. Appl. Phys., v. 26: 19-24, Jan. 1955.

Shadow pictures of turbulent flow regions give a particular kind of information about the three-dimensional density field. If homogeneity and isotropy of the fluctuation field can be assumed, the statistical properties of the picture uniquely determine the correlation function or power spectrum of the three dimensional turbulent density field. Shadow pictures obtained in the wake of a supersonic projectile were analyzed in this manner and encouraging results were obtained. In order to check the validity of the method, the density fluctuations in a heated jet were measured both by the shadow method and by the more conventional hot-wire technique.

PRI. 11:087

Johns Hopkins U., Baltimore, Md

ON AXISYMMETRIC TURBULENCE, by G. B. Melese. June 1954, 112p. refs. (Proj. Squid technical rept. no. JHU-6-R) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research,

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

and Office of Ordnance Research under N6ori-10503 and NOrd-8036) AD 46388 Unclassified

The kinetic problem of axisymmetric turbulence is considered. Properties of directly measurable 2-point correlations caused by incompressibility, homogeneity, and axisymmetry are derived for first-, second-, and third-order correlation tensors. Equations are derived for correlation as a function of triple correlations in the dynamics of axisymmetric turbulence. A solution is given for double velocity correlations in the asymptotic state for small Reynolds numbers. Fourier transforms of the correlations are introduced, and the energy and the 1-dimensional spectrums are defined. Results are obtained for small and large wave numbers, and the spectrum is obtained in the case of small Reynolds numbers.

PRI. 11:088

Johns Hopkins U., Baltimore, Md.

AN EXPERIMENTAL STUDY OF SHOCK WAVE TURBULENCE INTERACTION (Abstract), by L. S. G. Kovasznay. [1955] [2]p. [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] Unclassifted

Presented at meeting of the Amer. Phys. Soc., Old Point Comfort and Langley Aeronautical Lab., Va., Nov. 22-24, 1954.

Published in Phys. Rev., v. 98: 1141-1142, May 15, 1955.

Small perturbation theory indicates that fluctuations in a compressible, viscous, heat-conductive medium have three distinct "modes"; vorticity mode (turbulence); pressure mode (sound waves); entropy mode (temperature spottiness). As long as each of these fields is weak, there is no interaction between them within the fluid away from solid boundaries. When one or more of the three modes is intense, nonlinear interaction takes place and energy is converted from one mode into another. Weak turbulence passing through a stationary strong shock wave has been treated theoretically by Ribner. A simple experiment was carried out by the author in a supersonic wind tunnel. An axisymmetric turbulent wake was produced by a cylindrical body and a wedge created a strong oblique shock wave. The resulting flow field was explored by a hot-wire anemometer and the detailed fluctuation fields have been studied in the light of existing theories. (Contractor's abstract)

PRI. 11:089

Johns Hopkins U., Baltimore, Md.

INTERACTION OF A SHOCK-WAVE AND TURBULENCE, by L. S. G. Kovasznay. June 1955 [16]p. incl. illus. (Proj. Squid technical rept. no. JHU-8-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 62882 Unclassified

Presented at meeting of the Heat Transfer and Fluid Mechanics Inst., Los Angeles, Calif., June 1955.

An attempt was made to demonstrate experimentally the interaction between the random fluctuation field and a strong shock wave. An axisymmetric wake is passed through an oblique shock produced by a wedge. Hot-wire anemometer survey of the turbulent fluctuations were made to explore the different modes. A comparison was made of the fluctuation in the wake before and after the passage through the shock, and sound waves emanating from the interaction zone were located.

PRI. 11:090

Johns Hopkins U., Baltimore, Md.

ON AN INITIAL VALUE PROBLEM OF AN UNBOUNDED INCOMPRESSIBLE VISCOUS FLOW, by T.-S. Chow. Nov. 1955, 25p. illus. (Proj. Squid technical rept. no. JHU-9-T-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 75711 Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 5: 263-276, 1956.

An attempt was made to analyze the interaction of the various Fourier components with each other which occur as a result of the nonlinearity of the Navier-Stokes equation when applied to the problem of unbounded incompressible viscous flow. An investigation is made of the subsequent development of the motion of an unbounded viscous incompressible fluid when initially its motion is described by 2 spatially periodic waves. The solution to this problem is carried out by successive approximation, and the existence of the solution is proved. The velocity and pressure fields are first expressed in a Fourier representation, and the Navier-Stokes and continuity equations are then transformed into equations for the Fourier components.

PRI. 11:091

Johns Hopkins U., Baltimore, Md.

MAXIMUM PRODUCTION OF VORTICITY IN ISOTROPIC TURBULENCE, by R. Betchov. Mar. 1956 [15 p. refs. (Proj. Squid technical rept. no. JHU 10-P)] (Sponsored jointly by Office of Naval Research,

PRI. 11:092 - PRI. 11:094

Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID)

Atr Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 86635 Unclassified

Also published in Proc. Ninth Internationat Congress of Appt. Mech., Brussels (Betgium) (Sept. 5-13, 1956), 1957, v. 3: 405-413.

Given the foltowing quantities: x_t, the Cartesian coordtnates; u_t, the velocttty vector; $u_{ij} = \frac{\partial u_i}{\partial x_j}$; $u_{ij} = s_{ij} + r_{ij}$, where s_{ij} ts the symmetric rate of strain tensor and r_{tj} ts the antisymmetric vorticity tensor; and a, b, and c the eigenvalues of s_{ij}.

With $\langle\ \rangle$ indicating the averaged (time or ensemble average) quantity, the following modtfted inequatity is proven:

$$\pm\langle abc\rangle \leq \frac{1}{3\sqrt{3}} \langle a^2 + b^2 + c^2\rangle^{1/2} \langle a^4 + b^4 + c^4\rangle^{1/2}$$

Relations, conditions, and conclusions are developed for these parameters.

PRI. 11:092

Johns Hopkins U., Baltimore, Md.

THE INFLUENCE OF FINITE OBSERVATION INTERVAL ON THE MEASUREMENT OF TURBULENT DIFFUSION PARAMETERS, by O. Ogura. Mar. 1956 [20]p. refs. (Proj. Squid technical rept. no. JHU-11-P) (Sponsored jointly by Office of Naval Research, Atr Force Offtce of Scientific Research, and Office of Ordnance Research under N6ort-10503) AD 89154 Unclassifted

The correlation functions obtained from truncated samples are expressed tn terms of the sampling length and correlation functions of the basic random vartables. The application of the results to diffusion phenomena tn a turbulent flow ts discussed. The tnvestigation brings out the influence of confintng oneself to finite observatton tntervals on the average rate of disperston of particles from a point source. It is also shown that the turbulent level is of importance in determing the relationship between the Eulerian and Lagrangian time intervals of observation. (Contractor's abstract)

PRI. 11:093

Johns Hopkins U., Baltimore, Md.

ON THE INTERACTION OF WEAK DISTURBANCES AND A PLANE SHOCK OF ARBITRARY STRENGTH IN A PERFECT GAS, by C.-T. Chang. May 1956, 19p. illus. refs. (Proj. Squid technical rept. no. JHU-12-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of

Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID)

Ordnance Research under N6ort-10503) AD 95262 Unclassified

The tnftuence was studted of weak dtsturbances upstream of the shock on the flow field downstream of the shock. The basic flow pattern was taken as the one corresponding to a uniform supersonic stream past a 2-dimensional wedge. The unperturbed shock was considered to be a semi-inftnite ptane with ϵ as the upstream shock angle and β as the downstream shock angle. The upstream disturbance can be any one of 3 modes (entropy, vorticity, and sound) occurring separately or simultaneously. The dtscusston is confttned to an entropy disturbance of the step function type. The boundary equations and the governing equations which describe the flow fietd downstream of the shock are presented. The problem can be formulated conveniently in terms of the theory of conical flow. A governing equation for the perturbed pressure is derived which is shown to be hyperbolic or elliptic according to the range of one of tts variables. The method of characteristics ts used in considering the hyperbolic region. In the elliptic region, the governtng equation for the perturbed pressure is reduced to a Laptace equation by the Tschaplygin transformation; the problem is reformulated in a complex plane by using the method of conformat mapping.

PRI. 11:094

Johns Hopkins U., Baltimore, Md.

ON THE INTERACTION OF WEAK UPSTREAM DISTURBANCE WITH AN INFINITELY-EXTENDED PLANE SHOCK OF ARBITRARY STRENGTH, by C.-T. Chang. May 1956, 26p. illus. (Proj. Squtd technical rept. no. JHU-13-P) (Sponsored jotntly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ort-10503) AD 95263 Unclassifted

The tnteraction between an upstream disturbance and a plane shock of inftnite extent were investigated. The interaction is analyzed by splitting the velocity field into (1) an irrotational part associated with a scalar potential and (2) a rotational part assoctated with a vector potential. The boundary conditions at the shock are formulated. The dependence on the original properties of the shock ts shown explicitly in terms of its strength and its inclination with respect to the downstream main flow. A boundary-value problem is formulated from the governing equation for the scalar potential. A parameter related to the inclination of the upstream disturbance is defined as an effective Mach number M_e of the problem; when $M_e > 1$, the governing equation for the scalar potential is reducible to a simple wave equation. When $M_e < 1$, the governing equation is reducible to a Laplace equation. An illustrative example is given of the interaction of a plane normal

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shock with a sinusoidal entropy wave. The amplitudes of the shock displacement and of the downstream waves are plotted as functions of the inclination of the upstream disturbance at a given shock strength. The amplitudes are finite at the critical inclination of the upstream disturbance.

PRI. 11:095

Johns Hopkins U., Baltimore, Md.

INTERACTION OF A PLANE SHOCK AND OBLIQUE PLANE DISTURBANCES WITH SPECIAL REFERENCE TO ENTROPY WAVES, by C. [-T.] Chang. [Oct. 26, 1956] [8]p. incl. diagrs. refs. (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) Unclassified

Published in Jour. Aeronaut. Sciences, v. 24: 675-682, Sept. 1957.

The problem of the interaction between a plane entropy wave of arbitrary orientation and a plane oblique shock of infinite extent is investigated. As a result of the interaction, it is found that, in the perturbed flow field downstream of the shock, three kinds of disturbances are present — namely, an entropy mode, a vorticity mode, and a sound mode. The nature of the sound wave generated depends on the orienlation of the upstream disturbance. Within certain orientations of the upstream disturbance, the sound waves generated downstream attenuate. Beyond these orientations, the sound waves generated have constant amplitudes. When the downstream sound waves are not attenuated, there is no phase shift in the entropy disiurbance across the shock; when the downstream sound waves are attenuated, a phase shift occurs in the entropy disturbance across the shock. An illustrative example is given for the interaction between a plane normal shock and a sinusoidal entropy wave. At a given shock strength the amplitudes of the shock displacement and the downstream disturbances generated are plotted as functions of the orientation of the upstream disturbance. (Contractor's abstract)

PRI. 11:096

Johns Hopkins U., Baltimore, Md.

RESOLUTION OF THE PHOTOGRAPHIC PLATE AND INFORMATION THEORY, by L. S. G. Kovasznay and Y. K. Pien. Nov. 1956 [27 p. incl. illus. (Proj. Squid technical rept. no. JHU-14-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 113181 Unclassified

An attempt is made to estimate the limit of the amount

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of information carried by a photographic plate. Three cases of sampling are distinguished: poini sampling, sampling of a large area, and an intermediate sampling area. In the first case, the photodensitometer samples an area much smaller than the area of the average grain in the emulsion. The computations indicate that the total amount of information in this case is jusi proportional to the number of independent samples which in turn depend on the grain structure. For the case where the sampling is large compared to the grain area, the average transparency approaches closer and closer to the value of the ideal transparency. If the grain number is introduced as a parameter, the transparency is an exponential function of the number of grains. Computations show that the amount of information per sample increases as the logarithm of the area. For the case where the sampling area is neither very large nor very small compared to the grain area, both the grain shape and the statistical distribution of the grains is involved. Crude approximations are made for this case.

PRI. 11:097

Massachusetts Inst. of Tech., Cambridge.

HEAT CONDUCTIVITY, VISCOSITY, SPECIFIC HEAT AND PRANDTL NUMBERS FOR THIRTEEN GASES, by F. G. Keyes. Apr. 1, 1952, 33p. incl. diagrs. tables, refs. ([Proj. Squid technical rept. no. MIT-2-R]; technical rept. no. 37) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07855 and [N6ori-10503]) U24100; ATI-167173 Unclassified

The experimental effort under the present contract is especially directed to obtaining measurements of heat conductivity at temperatures above the upper range of reported data. No measurements to temperatures approaching 1000°C are given in this report. However the execution of the design equipment is proceeding satisfactorily, and the necessary exiensive thermometric investigation will presently be in operation. The results of several years of conductivity measurements for a number of gases are brought together in this report in the form of tables for thirteen gases, computed from formulations which include all available information. Data for the first temperature range in the case of the mixture N_2-CO_2 are also given. Viscosities and specific heats are also included in the tables, all for zero pressure. (Contractor's abstract)

PRI. 11:098

Massachusetts Inst. of Tech., Cambridge

THERMAL CONDUCTIVITIES FOR SEVERAL GASES WITH A DESCRIPTION OF NEW MEANS FOR OBTAINING DATA AT LOW TEMPERATURES AND

PRI. 11:099 - PRI. 11:102

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

ABOVE 500°C, by F. G. Keyes. Oct. 1, 1952, 34p. incl. illus. tables. (Proj. Squid technical memo. no. MIT-1-M) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N5ori-07855 and [N6ori-10503]) AD 5117 Unclassified

Thermal conductivities were measured for argon, hydrogen, nitrous oxide, methane, and ammonia between 50° and 350°C; the effect of pressure on thermal transport appeared to depend on the intermolecular field of the molecules. An apparatus was completed for the low-temperature measurement of gases and liquids. Values of dE/dt were determined for a copper-constantan thermocouple between 175° and 30°C, where E is the emf. A platinum-10% rhodium thermocouple was calibrated for equipment designed for the 500° to 900°C range.

PRI. 11:099

Massachusetts Inst. of Tech., Cambridge.

HETEROGENEOUS COMBUSTION OF GASES IN A VORTEX SYSTEM, by H. C. Hottel and R. A. Person. [1953] [8]p. incl. illus. diagrs. [Proj. Squid technical rept. no. MIT-4-P] [Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under N5ori-07855 and N6ori-10503] Unclassified

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams &Wilkins, 1953, p. 781-788

A study of combustion in a simple type of three-dimensional vortex system which might produce significant recirculation for mixing in a regular pattern as opposed to the random turbulence in conventional high output combustion chambers is described. Cold flow investigations were utilized to determine the nature of the vortex flow. Hot flow tests were used in a comparison of the vortex system with other high output combustors in terms of heat release per unit volume, combustion efficiency, and pressure group.

PRI. 11:100

Massachusetts Inst. of Tech., Cambridge.

SOME PROPERTIES OF ROD-STABILIZED FLAMES OF HOMOGENEOUS GAS MIXTURES, by G. C. Williams and C. W. Shipman. [1953] [10]p. incl. illus. diagrs. table, refs. [Proj. Squid technical rept. no. MIT-3-P] (Sponsored jointly by Bureau of Ordnance under NOrd-9661, Office of Naval Research under [N5ori-07851, and [Air Force] Office of Scientific Research under N6ori-10503]) Unclassified

Princton U. James Forrestal Research Center, N. J. (Project SQUID)

Published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 733-742.

A study is made of the flow patterns about transverse cylinders (0.1 to 0.5-in. diam) holding flames in an atmospheric stream of propane-air mixtures flowing through a 1-in. by 3-in. rectangular duct. From measurements of wall pressure and pressure distribution about the cylinder circumference, analysis of the gases sampled in the immediate wake of the flameholder, and observations by still and high speed motion picture schlieren photography, conclusions are presented regarding processes involved in the stabilization and blowoff of flames anchored on bluff objects.

PRI. 11:101

Massachusetts Inst. of Tech., Cambridge.

THERMAL CONDUCTIVITY OF GASES, by F. G. Keyes. July 1954 [8]p. incl. illus. tables, refs. (Proj. Squid technical rept. no. MIT-5-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 46155 Unclassified

Also published in Trans. Amer. Soc. Mech. Engineers, v. 76: 809-816, July 1954.

This paper is a continuation of earlier reported work in connection with two of the fundamental properties required for understanding and designing heat transfer equipment. New measurements of heat conductivity are presented along with values for viscosity obtained by correlation of all available data found in the literature. The simplest substance from the point of view of theory is the monatomic gas. The results of a study of the five rare gases are included. (Contractor's abstract)

PRI. 11:102

Massachusetts Inst. of Tech., Cambridge.

COMBUSTION OF DROPLETS OF HEAVY LIQUID FUELS, by H. C. Hottel, G. C. Williams, and H. C. Simpson. Mar. 1955, 58p. illus. refs. (Proj. Squid technical rept. no. MIT-6-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 58833 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh, Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 101-129.

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Droplet burning was studied by projecting a stream of uniform droplets up into an electric furnace and allowing the droplets to follow their trajectories inside the furnace and out through the bottom of the furnace. The experiments showed that the combustion of pure hydrocarbon droplets takes place in two stages, preheat and vaporization. In the preheat region, heat is supplied by radiation for the furnace walls and by conduction from the hot ambtent gases. In the vaporization region, the major heat source in single-droplet burning is the flame envelope surrounding the droplet. Heat is transferred to the droplet surface by conduction against the vaporizing fuel.

PRI. 11:103

Massachusetts Inst. of Tech., Cambridge.

EFFECT OF GAS TEMPERATURE GRADIENTS ON RADIANT HEAT TRANSFER, by E. S. Cohen. July 1955, 6p. illus. (Proj. Squid technical rept. no. MIT-7-T) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 67773 Unclassified

An tnvestigation to develop a technique for calculating radiant heat transmisston in enclosures is summarized which makes allowance for temperature nonuniformtties in the gas mass. The technique tnvolves the evaluation of the emission from either a gas zone or a surface zone and the radiant tnterchange between any 2 of these zones while taking into account the absorption along every beam from one zone to another and the partial diffuse reflection of every beam at every surface. The gas zones are taken as cubes or as shapes capable of being built of cubes, and the surface zones are taken as squares or shapes capable of betng built from squares. A numertcal example was worked out for the case of a highly idealtzed furnace to illustrate the salient points in the use of the method. The technique is considered capable of providing more detailed information on the radiant tnterchange within the enclosure than was previously possible. The chief weaknesses of the method are (1) the use of finite sized zones which are assumed to be tsothermal, (2) the assumption of uniform absorption and emission properties of the gas, and (3) the assumption that detailed knowledge of the combustion and mixing pattern is available.

PRI. 11:104

Massachusetts Inst. of Tech., Cambridge.

BOUNDARY LAYER EFFECTS ON BLUFF-BODY FLAME STABILIZERS, by P. T. Woo. Sept. 1955, 11p. illus. (Proj. Squid technical rept. no. MIT-8-T) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Ordnance Research under N6ori-10503) AD 70002 Unclassified

Experimental work is summarized on a study of the effect of boundary layer thickness on (a) flame stability corresponding to vartous rates of boundary layer withdrawal, and (b) molecular diffusion and wake gas composition. The studies suggest that boundary layer removal produces the following effects in the wake of bluff-body flame stabilizers: (a) the combustion reaction propagating into the free vortex layer is chilled by the cold gases in a thinned vortex layer; (b) the recirculation rate of hot combustion products into the tmmediate wake is reduced because of the narrowing of the wake; and (c) the difference in compcsition between the tmmediate wake and the approach stream tncreases.

PRI. 11:105

Massachusetts Inst. of Tech., Cambridge.

THERMAL CONDUCTIVITY OF GASES, by F. G. Keyes. [1955] [2]p. incl. tables. [Proj. Squid technical rept. no. MIT-9-P] (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 107457 Unclassified

Also published in Trans. Amer. Soc. Mech. Engineers, v. 77: 1395-1396, Nov. 1955.

A paper presented before the Heat Transfer Dtv. at the 1953 Annual meeting (item no. PRI. 11:101) contains a description of the below-ice point temperature apparatus for measuring thermal conductivities of gases and liquids, and a few results for neon were reported. During the past year low-temperature measurements have been made on the remainder of the rare gases (argon, krypton, xenon, nitrogen, oxygen, carbon dtoxide and methane). Reliable results from thermal-conductivity measurements now appear to be forthcoming with the high-temperature apparatus to temperatures of 1380° F.

PRI. 11:106

Massachusetts Inst. of Tech., Cambridge.

BOUNDARY LAYER EFFECTS ON STABILITY CHARACTERISTICS OF BLUFF-BODY FLAME-HOLDERS, by G. C. Williams, P. T. Woo, and C. W. Shipman. June 1956, 24p. illus. refs. (Proj. Squid technical rept. no. MIT-10-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 95264 Unclassified

Also published in Sixth Symposium (International) on

PRI. 11:107 - PRI. 11:109

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 427-438.

Atmospheric streams of propane vapor in air were studied to determine the effect of removal of the boundary layer from flame holders on the limits of stable operation and on the atomic composition of the burning gases in the immediate wake of the flame holder. A square-cross-section combustion chamber was used which was 3.17 in. wide and 10 in. long. The flameholders were located 2 in. from the inlet. A plenum chamber and nozzle just upstream from the combustion chamber were fed a homogeneous stream of propane and air; flow was directed into the combustion chamber at a low turbulence level with a flat velocity profile. Boundary-layer removal was effected by slots which were cut close to the isothermal-flow separation point on the stabilizers. Chemical analysis of gas samples from the immediate wake showed that the atomic composition of the gases was often significantly different from that of the approach stream; the difference decreased with increasing approach-stream velocity. Boundary-layer removal increased the difference in atomic composition the increase reached a maximum at intermediate Reynolds numbers. The effect of removal on the stability limits was a function of the feed mixture and velocity. Removal curtailed the fuel-lean limit in all cases; the effect decreased with increasing velocity of the approach stream. Removal extended the fuel-rich limits at low velocities, produced no change at intermediate velocities, and curtailed the limits at high velocities. Results are explained in terms of molecular diffusion across the laminar free vortex layers which bound the recirculation zone in the wake of the stabilizer.

PRI. 11:107

Massachusetts Inst. of Tech., Cambridge.

COMBUSTION STUDIES IN A STIRRED REACTOR, by H. C. Hottel, G. C. Williams, and M. L. Baker. June 1956 [25]p. incl. illus. tables. (Proj. Squid technical rept. no. MIT-11-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 96255 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 398-411.

An adaptation of the spherical reactor of Longwell and Weiss (Ind. Eng. Chem., v. 47: 1634-1637, 1955) was used in comparing the combustion rates of 2 fuel mixtures: (1) 57.7% propane, 31.1% CO_2, and 11.3% O; and (2) 57.7% Me_2CO, 26.8% H_2O, and 15.5% ethylene mixtures. Each entering premixture of fuel and air was mixed as thoroughly as feasible with its combustion products. Results are tabulated of analysis of gas samples which where withdrawn from the reactor zone. The behavior of a completely stirred adiabatic reactor

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was analyzed to delineate the effects of activation energy, collision factor, inlet temperature, and reaction scheme.

PRI. 11:108

Massachusetts Inst. of Tech., Cambridge.

FLAME STABILIZATION IN VOLATILE FUEL SPRAYS, by H. C. Hottel, C. P. Marion, and W. P. Jensen. June 1956 [40]p. incl. illus. tables, refs. (Proj. Squid technical rept. no. MIT-12-P) (Sponsored jointly by Bureau of Ordnance under NOrd-9661, Office of Naval Research and [Air Force Office of Scientific Research under N6ori-10503]) AD 97586 Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 451-464.

Stability-limit measurements of 4 fuels showed that higher blowoff velocities were attainable with larger drops sizes, increased preparation time, and more volatile fuels. At low velocity, lean limits were reached when heat transferred to the rod exceeded requirements and when the rod became too hot (vapor bound) to collect fuel. At high velocity, lean limits with the less volatile fuels occurred with wet flameholders and were extended to leaner mixtures by increased fuel volatility. Rich limits with a dry stabilizer were made richer by a decreased drop size but were reached at lower fuel rates than when the rod was wet. Rich limits with a wetted stabilizer were extended by a decreased drop size, increased preparation time, and decreased fuel volatility.

PRI. 11:109

Massachusetts Inst. of Tech., Cambridge, Mass.

FLAME STABILIZATION IN A BOUNDARY LAYER, by H. C. Hottel, T.-Y. Toong, and J. J. Martin. Oct. 1956 [14]p. incl. illus. (Proj. Squid technical rept. no. MIT-13-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 108767 Unclassified

Presented at Fall meeting of the Amer. Rocket Soc., Buffalo, N. Y., Sept. 24-26, 1956.

Also published in Jet Propulsion, v. 27: 28-30, Jan. 1957.

The theory of flame stabilization is studied for a lean propane-air flame in the boundary layer along a water-cooled slender rod with its longitudinal axis lying at the center line of a large pyrex duct. The boundary

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velocity-gradient, calculated at the stable flame positions by assuming a Blasius velocity profile in the boundary layer, is correlated with the propane-air ratio. The resulting curve is also compared with curves obtained as flashback and blowoff limits for a Bunsen flame.

PRI. 11:110

Michigan U., Ann Arbor.

MEASUREMENTS ON GASEOUS DETONATION WAVES, by J. A. Nicholls, R. B. Morrison, and R. E. Cullen. [1955] 15p. incl. illus. tables. [Proj. Squid technical rept. no. MICH-2-P] [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503] AD 52144 Unclassified

Also published in Second ONR Symposium on Detonation, Washington, D. C., Feb. 9-11, 1955, p. 148-162.

An analysis of one-dimensional steady detonation waves is presented which emphasizes the dynamic properties of velocity and heat release. The analysis shows that two types of detonation are possible: the Chapman-Jouget type and the strong detonation. A comparison of heat release as a function of detonation Mach number is made between the simplified theory presented and the results of shock tube experiments. The experimental data correlate reasonably well with the theory, although the slope of the experimental curve differs from that of the theory. A number of spark schlieren photographs are presented which indicate the initiation of the steady detonation, the interaction of the wave with a wedge, and the possibility of a spinning detonation.

PRI. 11:111

Michigan U., Ann Arbor.

ON THE CLASSIFICATION OF NORMAL DETONATION WAVES, by T. C. Adamson, Jr. and R. B. Morrison. June 1955, 6p. (Proj. Squid technical rept. no. MICH-1-M) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 62881 Unclassified

Also published in Jet Propulsion, v. 25: 400, 403, Aug. 1955.

A classification of normal detonation waves is proposed which involves the definition of a heat-release function F that depends upon the incoming velocity and temperature and the heat release by the unburned mixture per unit mass. A Chapman-Jouguet detonation wave corresponds to $F = 1$; $1 < F < 2$ corresponds to a strong detonation wave; and $F = 2$ corresponds to a shock wave.

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PRI. 11:112

Michigan U., Ann Arbor.

ON THE INTERACTION OF A CHAPMAN-JOUGUET DETONATION WAVE WITH A WEDGE, by R. S. B. Ong. June 1956, 73p. incl. illus. tables, refs. (Proj. Squid technical rept. no. MICH-3-T) [Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research and Office of Ordnance Research under N6ori-10503] AD 97587 Unclassified

A method is given for determining the critical angle which separates the region of Mach reflection from that of regular reflection for an impinging Chapman-Jouquet detonation wave of a certain known strength. This angle is determined by finding the limit of the real solutions of the equation for the deflection condition in the problem of regular reflection. The configuration of the reflected shock wave in the case of a Chapman-Jouquet detonation wave impinging on a wedge is approximated by assuming a cylindrical reflected shock wave as a zeroth-order solution. Schlieren photographs were made of both the regular and Mach reflection phenomenon, and numerical calculations were made to determine the zeroth-order circular reflected shock wave for an incident detonation wave of the same strength as that used in the experimental work. The configuration of the actual reflected shock wave is computed and constructed from the resulting theoretical analysis of the Mach reflection problem, and the theoretically constructed reflected wave is compared with that traced from the schlieren photographs.

PRI. 11:113

New York U., N. Y.

A DIFFRACTION GRATING INTERFEROMETER, by R. [J.] Kraushaar. [1950] [2]p. incl. illus. diagr. [Proj. Squid technical rept. no. NYU-24-P] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) Unclassified

Published in Jour. Opt. Soc. Amer., v. 40: 480-481, July 1950.

A compact new kind of interferometer is described which can produce much larger fields of view than the conventional Mach-Zehnder interferometer. The instrument is an outgrowth of the Ronchi-schlieren apparatus, and involves only reflections of light beams in the essential portions of the apparatus.

PRI. 11:114 - PRI. 11:117

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PRI. 11. 114

New York U., N. Y.

HEAT CONDUCTION IN SIMPLE METALS, by M. L. Storm. Jan. 12, 1951 [12]p. incl. diagrs. tables, refs. ([Proj. Squid technical repl. no. NYU-22-P]; technical rept. no. 31) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U20746; ATI-126033 Unclassified

Also published in Jour. Appl. Phys., v. 22: 940-951, July 1951.

The partial differential equation of heat conduction is a nonlinear equation when the temperature dependence of the thermal parameters (i.e., the thermal conductivity, K, the product of the density, and the specific heat constant pressure S) is taken into account. It is shown that a mathematical condition for the transformation to linear form of the one-dimensional, nonlinear, partial differential equation of heat conduction is the constancy of $1/(KS)\,[(d/dt)\log(S/K)]^{1/2}$. This discovery is the motivation for an investigation of the relations between the thermal parameters of simple metals on the basis of the theory of solids and available experimental data. It is found that KS is essentially constant, its variation with temperatures being much less than that of either K or S considered separately. It is also shown, as a result, that the condition for the afore-mentioned transformation is valid for simple metals. Application of the transformed equation to the solution of problems in heat conduction is considered. (Contractor's abstract)

PRI. 11:115

New York U., N. Y.

A HIGH SPEED STEREOSCOPIC SCHLIEREN SYSTEM, by J. H. Heil. Feb. 1951 [3]p. incl. illus. diagrs. (Proj. Squid technical memo. no. NYU-8-[P]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U20887; ATI-112789 Unclassified

Also published in Jour. Soc. Motion Picture and Television Engineers, v. 56: 214-218, Feb. 1951.

A stereoscope schlieren system is described. A 16-mm Fastax camera is used to photograph 10-in. sections of a 4 x 4-in. flame tube at 9000 frames/sec. A polarizing projection system is used. The depth effect is observed with burning gases provided sufficient detail is available in the image. (Contractor's abstract)

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PRI. 11:116

New York U., N. Y.

ISOTOPE EFFECT IN HYDROCARBON FLAME SPECTRA, by G. M. Murphy and L. [J.] Schoen. Mar. 1951 [1]p. incl. diagr. (Proj. Squid technical memo. no. NYU-9-[P]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U20886; ATI-112790 Unclassified

Also published in Jour. Chem. Phys., v. 19: 380-381, Mar. 1951.

The spectra of the low pressure flame of atomic oxygen and deuterated acetylene (C_2D_2) were photographed in the first and second orders of a Jarrell-Ash three-meter grating photograph. Comparison with the spectra of a normal acetylene flame recorded under similar conditions leads to an isotopic displacement in those bands caused by hydrogen-containing molecules from which it is theoretically possible to obtain information concerning the identity and structure of the emitter.

PRI. 11:117

New York U., N. Y.

THE EFFECT OF RAPID HEATING ON THE SPECIFIC HEAT CURVE OF LOW CARBON STEEL AT THE PHASE TRANSFORMATION POINTS, by A. M. Nathan. Mar. 13, 1951, 9p. illus. diagrs. (Proj. Squid technical memo. no. NYU-6-[M]-P) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U20017; ATI-125305 Unclassified

Also published in Jour. Appl. Phys., v. 22: 234-235, Feb. 1951.

A dynamic method of measuring the specific heat curves of metals under conditions of rapidly increasing temperature (1000°C) is described and some results obtained with it are given. The method is used for a preliminary study of the specific heat curves of low carbon steel at the phase transformation points. The specimen employed is standard SAE-1040 steel containing 0.40% carbon, 0.60% manganese, annealed at 950°C. It is heated by high amperage DC currents from a storage battery source, while enclosed in an evacuated chamber. During the heating run, the temperature of the steel and the power input are continuously recorded. Temperature is measured by a fine wire (.002 inches) thermocouple, platinum-platinum 13% rhodium, spot welded to the specimen rod at its center. Power input is obtained by measuring the heating current and the voltage drop across the central 15 cm portion of the rod. These quantities are recorded

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by photographing the face of a cathode ray tube which displays them. Results obtained indicate that the peak of specific heat which normally occurs at the A, allotropic phase transformation point under equilibrium conditions is greatly affected by rapid heating, while the specific heat anomaly at the Curie point is not affected by the rate of heating. (Contractor's abstract)

PRI. 11:118

New York U., N. Y.

THE MEASUREMENT OF INSTANTANEOUS EXHAUST TEMPERATURES OF LIQUID FUEL ROCKETS (Unclassified title), by J. H. Hett and J. B. Gilstein. Apr. 1951, 19p. incl. illus. diagrs. (Proj. Squid technical memo. no. NYU-7-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) C6574; ATI-114141 Confidential

PRI. 11:119

New York U., N. Y.

THE AZOMETHANE-INDUCED OXIDATION OF PROPANE, by M. D. Scheer and H. A. Taylor. July 3, 1951 [5]p. incl. diagrs. tables, refs. [Proj. Squid technical rept. no. NYU-25-P; technical rept. no. 40] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U25000; ATI-165377 Unclassified

Also published in Jour. Chem. Phys., v. 30: 653-657, Apr. 1952.

The effect of methyl radicals from the photolysis of azomethane on propane-oxygen mixtures in pyrex vessels has been shown to include a slow oxidation in the temperature range 35° to 200°C and cool flames at 250°C. Azomethane decomposed thermally induces cool flames in propane-oxygen mixtures at 255° and 270°C, temperatures below those at which cool flames occur in the system propane-oxygen alone. A rapid photo-oxidation has been observed in a quartz vessel in the temperature range 230° to 250°C. (Contractor's abstract)

PRI. 11:120

New York U., N. Y.

VIBRATIONAL STRUCTURE OF HYDROCARBON FLAME BANDS, by G. M. Murphy and L. [J.] Schoen. July 13, 1951 [1]p. incl. table. (Proj. Squid technical rept. no. NYU-23-P; technical rept. no. 33) (Sponsored jointly by Office of Naval Research and [Air Force

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Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) ATI-131280 Unclassified

Also published in Jour. Chem. Phys., v. 19: 1214-1215, Sept. 1951.

A vibrational analysis of the hydrocarbon flame band system based on two active modes of vibration in the wavelength region 2500 to 4000 Å is presented.

PRI. 11:121

New York U., N. Y.

THE EFFECTS OF CAVITY RESONATORS COUPLED TO PULSE JET ENGINE COMBUSTION CHAMBERS, by J. Lemelson. Aug. 3, 1951, 6p. diagrs. (Proj. Squid technical memo. no. NYU-13-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U24957; ATI-177043 Unclassified

Tubes of various diameters and lengths were attached to the combustion chamber of a Dynajet engine. Thrust and fuel flow were measured for various configurations. It is shown that both thrust and fuel flow are markedly affected by the phase relation between the gas flow in the pulsejet engine and that in the tube. A suggestion is made to use a resonant cavity with ram air. (Contractor's abstract)

PRI. 11:122

New York U., N. Y.

MANOMETERS IN PULSATING SYSTEMS, by R. J. Kraushaar. Aug. 22, 1951, 14p. illus. diagrs. tables. (Proj. Squid technical memo. no. NYU-14-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U24959; ATI-177042 Unclassified

A series of experiments are described to check the practicality of measuring average pressures in pulsating systems with a connecting tube. Several diameter tubes and typical tube materials were used. It was noted: (1) "average" pressure showed considerable variation with the length of tube; (2) there is a periodic variation related to the frequency of oscillation of the primary system; (3) the tube material affects the magnitude of the peaks; (4) that the tube diameter affects the magnitude of the peaks; (5) that the aperture size will show a gating effect; and (6) that the use of a light valve will permit the reading of maximum or minimum pressure depending upon its directionality regardless of tube length. (Contractor's abstract)

PRI. 11:123 - PRI. 11:127

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PRI. 11:123

New York U., N. Y.

THE THERMISTOR AS A FLOWMETER, by R. W. King, Jr. Oct. 2, 1951, 5p. diagrs. (Proj. Squid technical memo. no. NYU-10-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U24958; ATI-177046 Unclassified

Early circuit designs measured only fluctuations in flow rate. Later developments employ a feedback bridge circuit using a dc amplifier to maintain the thermistor at a constant temperature. The calibration becomes independent of the gain, being largely determined by the constant in the feedback bridge. Ambient temperature effects in the liquid have been reduced by using a second thermistor in the bridge circuit which measures only the temperature. Experiments were confined to low flow rates (2 gal/hr).

PRI. 11:124

New York U., N. Y.

REPORT ON FULL SCALE PULSE JET TESTING, by J. H. Hett. Nov. 7, 1951, 15p. illus. diagrs. refs. (Proj. Squid technical memo. no. NYU-12-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U24956; ATI-177044 Unclassified

A P.J. 31 pulsejet engine was mounted on a trailer and fired statically. An instrument trailer was built having 16 channels for information on cathode-ray tubes which were viewed by four drum cameras. Tests were made of the flame flow pattern in the engine using windows and a strip camera, and simultaneous determinations were made of valve position. To measure instantaneous pressures and instantaneous flame temperatures, special instruments were developed and mounted on the P.J. 31. Experiments were also made with instantaneous liquid flowmeters employing thermistors. Other experiments were performed with pulsating manometer systems. The project ended before simultaneous measures of all parameters could be obtained. (Contractor's abstract)

PRI. 11:125

New York U., N. Y.

FINAL REPORT ON THE NEW YORK UNIVERSITY PRESSURE GAUGE, by R. W. King, Jr. Dec. 10, 1951, 20p. illus. diagrs. tables, refs. (Proj. Squid technical memo. no. NYU-11-[M]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) U24705; ATI-177045 Unclassified

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Various experiments with the NYU type condenser gauge are described. The thermal perturbation of the sensing diaphragm as a function of diaphragm shape, concave or convex, is investigated. Diaphragms laminated with copper thermosetting plastics showed much improvement. A new circuit was devised which uses the connecting cable as a low impedance coupling between a resonant circuit at the gauge and a resonant circuit as the receiver. Phase changes in the receiver are measured with 6 BN-6 tubes. The system operates well in gas turbines, but additional cooling is desirable in rockets. (Contractor's abstract)

PRI. 11:126

New York U. Coll. of Engineering, N. Y.

INDICATED INSTANTANEOUS TEMPERATURES OF LIQUID ROCKET EXHAUSTS AND COMBUSTION CHAMBERS, by J. H. Hett and J. B. Gilstein. [1955] [9]p. incl. illus. diagrs. tables. (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-1102 and [N6ori-10503]) Unclassified

Published in Jet Propulsion, v. 25: 119-127, Mar. 1955.

A modified two-path method was used to measure instantaneous temperatures of the exhaust and combustion chamber flames of 1500-lb-thrust alcohol-oxygen rockets. Spectral studies of the flames indicated divergence from thermal equilibrium in both combustion chamber and exhaust. Nevertheless the indicated temperatures obtained agreed closely in the exhaust flames with average temperatures obtained by the method of Kuribaum, but were lower than average temperatures obtained by the sodium line reversal method. The measured temperatures in the combustion chamber and the exhaust were lower than the theoretical temperatures. (Contractor's abstract)

PRI. 11:127

Northwestern U. Technological Inst., Evanston, Ill.

SQUID CONFERENCE ON ATOMIZATION, SPRAYS, AND DROPLETS HELD AT NORTHWESTERN TECHNOLOGICAL INSTITUTE, SEPTEMBER 24-25, 1953. Dec. 1, 1954 [100]p. (Proj. Squid technical rept. no. NTI-1-C) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of [illegible]ance Research under N6ori-10503) AD 50186 Unclassified

A summary is presented of the proceedings of the conference. The following four papers are presented in

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their entirety: Characteristics of Sprays and Droplets, by J. M. Pilcher, Battelle Memorial Inst.; Drop-Size Distributions and Their Averages, by R. E. Thomas, Battelle Memorial Inst.; Review of Mass Energy Transfer Between Liquid Droplets and Surrounding Gases, by C. C. Graves and D. W. Bahr, National Advisory Committee for Aeronautics; and Injection in Afterburning Turbojets, by D. G. Samaras, Wright Patterson Air Force Base. Abstracts are given, or references are made to, the following 13 papers: Review of Experiments and Empirical Correlations Relating to the Production of Sprays, by W. R. Marshall, Jr., Wisconsin U.; Review of Theoretical and Mathematical Analyses of the Performance of Atomizing Nozzles, by R. Lasier and M. Doumas, General Foods Corp.; Fuel Spray Spreading and Evaporation in a Flowing Air Stream, by D. W. Bahr, National Advisory Committee for Aeronautics; Review of Instrumentation and Methods of Experimental Study, by J. L. York, Michigan U.; An Apparatus for Suspending Small Droplets of Liquid in Space, by J. A. Boll, Michigan U.; Measurement of Dry Bulb Temperature in Mists, by E. W. Comings, Purdue U.; Gas Absorption and Aerosol Collection in a Venturi Atomizer, by H. F. Johnstone, R. B. Feild, and N. C. Tassler, Illinois U.; Fuel Injection Problems in Turbojets, by H. A. Fremont, General Electric Co.; Fuel Injection Problems in Ramjets, by J. P. Longwell, Standard Oil Development Corp.; Application of Spray Technology to Liquid Propellant Rockets, by C. C. Miesse, Aerojet-General Corp.; Vaporization of Fuel Droplets in a Diesel Engine, by P. S. Meyers, O. A. Uyehara and M. M. El Wakil, Wisconsin U.; Fuel Injection Problems in Otto Cycle Engines, by W. E. Meyers, Pennsylvania State Coll.; and Chemical Engineering Applications, by A. F. Johnstone, W. R. Marshall, J. L. York, E. W. Comings and G. G. Lamb.

PRI. 11:128

Northwestern U. Technological Inst., Evanston, Ill.

A NEW TECHNIQUE FOR DROP-SIZE DISTRIBUTION DETERMINATIONS, by A. P. R. Choudbury and W. F. Stevens. Aug. 1955, 8p. illus. (Proj. Squid technical rept. no. NTI-2-M) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research and Office of Ordnance Research under N6ori-10503) AD 67774 Unclassified

Accurate knowledge of the drop-size distribution of liquid sprays is necessary in order to evaluate various atomization devices. This drop-size distribution is usually obtained by a procedure involving sampling of the spray, followed by actual counting of the various drop sizes in the spray sample. Such a procedure is extremely time-consuming and may be subject to sampling errors. This paper describes a new method which greatly simplifies the process of determining such a drop-size distribution. The new procedure involves the capture and instantaneous freezing of the entire spray in a bath of liquid nitrogen, followed by screening of the resulting solid spheres into sized fractions. The screening is carried on a set of standard test screens, inside a walk-in cold room kept at -60°F. After the individual fractions are obtained, each is transferred to a small beaker, placed in a desiccator, and allowed to warm up and melt. The weight of each fraction is accurately determined, on an analytical balance, after which the data are combined to give the complete drop-size distribution. The procedure is described in detail, and both advantages and disadvantages of the method are pointed out. Typical drop-size distribution curves obtained by the method are included. (Contractor's abstract)

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COMPOSITION CHANGE IN BINARY COMPONENT SPRAY VAPORIZATION AT ATMOSPHERIC PRESSURE, by J. F. Culverwell, P. W. Grounds, Jr. and others. Mar. 1956, 14p. illus. tables, refs. (Proj. Squid technical rept. no. NTI-3-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 90702 Unclassified

The behavior of the o-dichlorobenzene-tetrachloroethylene system was studied in air at 400° to 1000°F. Variables studied for their effect on the composition change-vaporization relationship were air temperature; feed composition, temperature and pressure; and distance from the nozzle. Measurements were made with a spray composed of drops with diameters in the 20- to 400-μ range. Equations are presented which describe mathematically the vaporization process, with the assumption of liquid diffusion control. Calculations agreed with the experimental data obtained for the first 5 in. of nozzle-to-tray travel. Beyond 5 in., the deviation was considerable. The behavior studies indicated that the change of residual spray composition with vaporization is a function of initial composition, chamber air temperature, and nozzle characteristics for a particular binary component spray. Feed pressure and temperature, and nozzle-to-tray distance locate the position on the vaporization-composition curve but do not affect its shape. Calculated results for the binary system which is based on the assumption of liquid diffusion control of mass transfer indicated that the smaller droplets slowed down, increased in temperature, changed in composition, and decreased in radius more rapidly than the larger drops.

PRI. 11:130

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SIZE DISTRIBUTION OF DROPLETS FROM GROOVED-

PRI. 11:131 - PRI. 11:133

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

CORE CENTRIFUGAL PRESSURE NOZZLES, by A. P. R. Choudbury, G. G. Lamb, and W. F. Stevens. May 1956 [24]p. incl. illus. tables. (Proj. Squid technical rept. no. NTI-4-P) (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 93806 Unclassified

A successful correlation is presented for drop-size distribution data obtained by a unique technique (item no. PRI. 11:128) which appeared exceptionally reproducible. The drop size distribution data for 13 systems having a wide range of fluid properties best fit the square-root-normal distribution. For this distribution the square root of the random variable, the droplet diameter, plotted against the distribution function, cumulative mass percentage over the stated size, an arithmetic probability paper, results in a straight line.

The most probable size ($X_{50}^{1/2}$) and the selected second point ($X_{15.87}^{1/2}$), where standard deviation equals $X_{15.87}^{1/2} - X_{50}^{1/2}$, were determined for each run by graphical integration of a plot of cumulative fraction over the stated size as the square root of the average screen aperture on rectangular coordinates. Then, the values were correlated in terms of fluid properties and nozzle characteristics. The entire correlation may be expressed as $X_{50}^{1/2} = mN_{Re}^2 + I$, where $m = f(N_{Re}\ I/2) =$ the slope of plot $EX^{1/2}$ (or $X_{15.87}^{1/2}$) vs N_{Re}^2 and I = intercept of the plot of $EX^{1/2}$ (or $X_{15.87}^{1/2}$) vs N_{Re}^2. Limitations of the correlation are caused by deviations at the extreme values of Reynolds and Ohnesarge numbers and the necessity of using the hydraulic diameter which is sometimes difficult to evaluate because of a lack of knowledge of the air core dimensions.

PRI. 11:131

Polytechnic Inst. of Brooklyn, N. Y.

HEAT TRANSFER IN A LAMINAR COMPRESSIBLE BOUNDARY LAYER ON A POROUS FLAT PLATE WITH VARIABLE FLUID INJECTION, by S. W. Yuan and N. Ness. Sept. 1, 1950, 9p. diagrs. ([Proj. Squid] technical memo. no. PIB-15-[M.]) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research, under N6ori-9802 and [N6ori-10503.]) U16034; ATI-96625 Unclassified

A theoretical investigation of the heat transfer in a laminar compressible boundary layer on a partially porous flat plate with variable fluid injection (trapezoidal and bilinear types) is made. The method of iteration and graphical integration is used to obtain the solution of the boundary layer equation. The relation between wall temperature and the rate of coolant injection is calculated for 3 different injection profiles (trapezoidal, bilinear, and uniform). The results indicate that for equal quantities of coolant injected, the variable injection cases are slightly more efficient than is the uniform injection case. (Contractor's abstract)

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PRI. 11:132

Polytechnic Inst. of Brooklyn, N. Y.

AN EXPERIMENTAL INVESTIGATION OF THE ISOTHERMAL LAMINAR BOUNDARY LAYER ON A POROUS FLAT PLATE, by P. A. Libby, L. Kaufman, and R. P. Harrington. Apr. 19, 1951 [8]p. incl. illus. diagrs. refs. ([Proj. Squid] technical memo. no. PIB-16-M-P) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-9802 and [N6ori-10503]) U23016 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 19: 127-134, Feb. 1952.

The transition Reynolds numbers and velocity profiles of the laminar isothermal boundary layer on a porous flat plate with suction or injection have been measured and compared with the laminar boundary layer analyses that have been carried out in the past several years. The results indicate that porous plates closely approximating the mathematical or ideal porous plates can be realized and that the theoretical velocity profiles are in good agreement with experiment.

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ON HEAT TRANSFER OVER A SWEAT-COOLED SURFACE IN LAMINAR COMPRESSIBLE FLOW WITH A PRESSURE GRADIENT, by M. Morduchow. Nov. 15, 1951 [8]p. incl. illus. refs. [Proj. Squid technical rept. no. PIB-21-P; technical rept. no. 44.] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 9091 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 19: 705-712, Oct. 1952.

A simple expression is derived for the normal injection velocity distribution theoretically required to maintain a given uniform temperature along a porous surface in the laminar-boundary layer region of a compressible flow with a given velocity distribution outside of the boundary layer. This expression is valid for any given free-stream Mach number but is

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valid based on a Prandtl number of unity and on the assumption that the viscosity coefficient varies linearly with the temperature. By using the Dorodnitsyn type of transformation the variation of fluid properties even in the case of zero Mach number is taken into account. This study is of practical interest in connection with the sweat cooling of turbine blades and of airfoil surfaces in high-speed flow. The method of analysis consists of applying the Kármán-Pohlhausen method to both the momentum and energy boundary-layer equations and of using an additional heat balance equation, involving the coolant temperature. A closed-form approximate solution of the equations is then derived. Numerical examples for flow in the immediate vicinity of a stagnation point and for a typical type of flow over a turbine blade are given. (Contractor's summary)

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ON THE TEMPERATURE DISTRIBUTION ALONG A SEMI-INFINITE SWEAT-COOLED PLATE, by N. Ness. Nov. 15, 1951 [9] p. incl. illus. ([Proj. Squid technical rept. no. PIB-22-P]; technical rept. no. 45) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 9092 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 19: 760-768, Nov. 1952.

A theoretical investigation of the temperature distribution along a semi-infinite porous flat plate under the condition of uniform injection from the bottom of the plate is made. A heat-balance differential equation of the second order, including a term containing the physical parameters of the plate, is derived and is employed in conjunction with the well-known Prandtl boundary-layer equations of continuity, momentum, and energy for a solution of the problem. The temperature distribution along the plate is obtained for the respective cases of thermal conductivity not equal to, and equal to, zero. Results show that the inclusion of the thermal conductivity term in the heat-balance equation eliminates the infinite temperature gradient at the leading edge. Other results when thermal conductivity is considered are: (a) the boundary conditions at the leading edge — i.e., the ratio of wall to free-stream temperature and the axial temperature gradient there may be chosen arbitrarily but are related mathematically to each other; (b) the ratio of thermal to velocity boundary-layer thickness is less than unity at the leading edge for Prandtl numbers greater than 0.35 and is equal to unity at an infinite distance downstream; and (c) at an infinite distance downstream, the wall temperature approaches the coolant temperature.

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A PROVISIONAL ANALYSIS OF TURBULENT BOUNDARY LAYERS WITH INJECTION, by J. H. Clarke, H. R. Menkes, and P. A. Libby. May 12, 1954 [6] p. incl. illus. tables. [Proj. Squid technical rept. no. PIB-26-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 82574 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 255-260, Apr. 1955.

Prandtl's analysis of the incompressible turbulent boundary layer over a flat plate is extended in this report to include the effect of uniform, transverse fluid injection. The nondimensional parameters characterizing such a flow are deduced by dimensional reasoning. Velocity profile is generated by considering the flow over a plane wall; this distribution reduces to the universal log law when the mass transfer is zero. The expression also serves to relate the local skin friction to the boundary-layer thickness. When these relationships are used in conjunction with the von Kármán integral, the problem becomes mathematically specified. Since only a limited amount of experimental data is available, it is necessary to assign to certain parameters that arise in the velocity profile the constant values they have for no mass transfer. When more measurements are completed, it may be possible to adjust these parameters as or if required. The results give the variation skin-friction coefficient with the injection ratio and the Reynolds number based on streamwise coordinate. The agreement between these results and the experimental data available is found to be satisfactory. The significant reductions in skin friction, and therefore in heat transfer, to be realized with small rates of injection are indicated. (Contractor's abstract)

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A METHOD FOR ANALYZING THE HEAT INSULATING PROPERTIES OF THE LAMINAR COMPRESSIBLE BOUNDARY LAYER, by P. A. Libby and A. Pallone. [1954] [10] p. illus. [Proj. Squid technical rept. no. PIB-24-P] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-10503) Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 825-834, Dec. 1954.

A method for investigating the insulating properties of a laminar compressible boundary layer on a two-dimensional surface with zero heat transfer is presented. The Kármán integral method extended to both

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the momentum and energy partial dtfferential equations of the boundary layer has been used. Thus the velocity and stagnation enthalpy proftles have both been taken as sixth degree polynomials. The two resulttng tntegral dtfferential equations are then solved for two unknown functions of the dtstance along the wall. These two functions are related to the boundary layer thickness and to the wall temperature. Initial condttions correspondtng to a gtven tnitial wall temperature and an tnitial boundary layer thicknoss are prescrtbed. Exact closed-form solutions for the case of zero axial pressure gradtent are obtatned. For flows wtth stgnlftcant pressure gradtents, numertcal solutions are requtred tn general. Several numertcal examples of practtcal tnterest are presented.

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LAMINAR PIPE FLOW WITH INJECTION AND SUCTION THROUGH A POROUS WALL, by S. W. Yuan and A. B. Ftnkelstetn. Mar. 1955 [23] p. tncl. tllus. (Project Squtd technical rept. no. PIB-25-P) (Sponsored jotntly by Offtce of Naval Research, [Atr Force] Office of Sctentiftc Research, and Offtce of Ordnance Research under N6ort-10503) AD 58831 Unclasstfted

Published in Trans. Amer. Soc. Mech. Engtneers, v. 78: 719-724, May 1956.

The effect of injection and suctton at the wall of the two-dtmenstonal steady-state lamtnar flow of a flutd tn porous-wall ptpe has been tnvestigated tn detatl by the solution of Navter-Stokes equations tn cyltndrtcal coordtnates. An exact solutton of the dynamtc equations, reduced to a thtrd-order nonltnear dtfferenttal equatton wtth approprtate boundary conditions, ts obtained. A perturbatton method was used to solve the latter equation for both small and large flows through the porous wall. The velocity components are expressed as functions of the ratio of velocttv through the porous wall to the maximum axial velocttv at the ptpe entrance, the coordinates of the ptpe, and the physical properties of the flutd. The results show that the effect of tnjectton at the porous wall of the ptpe ts to tncrease the frtctton coefftctent at the wall. For an tnjectton ratto $Q/W = 0.01$ ($500 \leq R_e \leq 2500$) the frtctton coefftctent at the wall is tncreased by 70-85% over the zero tnjectton case (Potseutlle case). (Contractor's abstract)

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HEAT TRANSFER OF A LAMINAR PIPE FLOW WITH COOLANT INJECTION, by S. W. Yuan and A. B. Ftnkelstetn. Mar. 1956 [13] p. tncl. dtagrs. (Project Squtd technical rept. no. PIB-27-P) (Sponsored jotntly by Offtce of Naval Research, Atr Force Office of Sctentiftc Research, and Offtce of Ordnance Research under N6ort-10503) AD 89153 Unclassifted

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The effect of coolant tnjectton at the wall on the temperature dtstrtbution of the lamtnar flow of a fluid in a porous wall ptpe has been investigated. The temperature dtstrtbutions tn the ptpe for vartous fluid tnjections are obtained by solvtng the energy equation. The results are expressed tn terms of Nusselt number as function of the Péclet number, the dtmenstons of the pipe and the coolant flow. The relatlcn between the wall temperature and the rate of coolant tnjection ts also calculated. The results also show that the heat transfer coefftctent at the wall decreases wtth an tncrease of the rate of coolant tnjection, whereas tt was prevtously found that the frtctlon coefftctent at the wall tncreases wtth an tncrease of flutd tnjection. Thus the analogue between the heat transfer and momentum transfer does not exist tn porous wall cooltng of ptpe flow. (Contractor's abstract)

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ON LAMINAR FLOW THROUGH A CHANNEL OR TUBE WITH POROUS WALLS. APPLICATION OF METHOD OF AVERAGES, PART I, by M. Morduchow. June 1956, 12p. incl. tllus. tables. FURTHER INVESTIGATION OF LAMINAR FLOW IN CHANNELS WITH POROUS WALLS, PART II, by S. W. Yuan. June 1956, 3p. tncl. illus. table. (Proj. Squtd technical rept. no. PIB-28-P, pts. 1-2) (Sponsored jotntly by Offtce of Naval Research, Atr Force Offtce of Sctentiftc Research, and Office of Ordnance Research under N6ort-10503) AD 98477 Unclasstfied

Part I also published in Quart. Appl. Math., v. 14: 361-368, Jan. 1957.

Part II also published in Jour. Appl. Phys., v. 27: 267-269, Mar. 1956.

Part I - An approximate closed-form solutton ts gtven for flow through a channel and through a ctrcular tube wtth porous walls which ts valid for the entire range of normal flutd tnjectton velocttles from zero to tndefinitely large. The soluttons reduce exactly to the small perturbation soluttons for small values of the tnjectton velocttv. Part II - The problem of two-dtmenstonal steady-state lamtnar flow in channels wtth porous walls has been extended to the case of moderate to high suctton or tnjectton at the walls. An exact solutton of the Navter-Stokes equations, reduced to a third-order nonltnear differential equatton wtth approprtate boundary condttions, ts obtatned. The velocity components, the pressure, and the coefftctent of wall lrtctton are expressed as functtons of velocity through the porous walls, the average axtal velocity of Potseutlle's flow,

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the coordinates and dimensions of the channel, and the physical properties of the fluid. (Contractor's abstract)

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TRANSPIRATION COOLING IN THE TURBULENT FLOW THROUGH A POROUS-WALL PIPE, by S. W. Yuan and L. S. Galowin. July 1956 [17]p. incl. illus. (Proj. Squid technical rept. no. PIB-30-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 102725 Unclassified

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956), v. 2: 331-340, 1957.

Data show the effect of coolant injection on the velocity and temperature distributions of fully developed turbulent flow in a circular pipe. The data were obtained from a 5-in.-diameter 20-in.-long, porous-wall stainless steel pipe. The Reynolds numbers ranged from 10^5 to 3 x 10^5; the mass flow ratios were 0.0, 0.0058, and 0.0103. Comparison of the theoretical curve with the experimental velocity-distribution data showed close agreement. Agreement between theory and experiment for temperature-distribution data was better for low coolant injection rates. Based on the Prandtl mixing-length theory, the velocity and temperature distributions were obtained from the Reynolds equations and the eddy heat transfer equation, respectively. A significant reduction occurred in the heat transfer to the wall with low rates of coolant injection.

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HEAT INSULATING PROPERTIES OF THE LAMINAR COMPRESSIBLE BOUNDARY LAYER (Abstract), by P. A. Libby. July 1952, tp. [Proj. Squid technical rept. no. PIB-23-P] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-t0503) Unclassified

Presented at Eighth International Congress of Theoretical and Applied Mechanics, Istanbul (Turkey), Aug. 20-28, 1952.

Published in Jet Propulsion, v. 26: 663, Aug. t956.

Results of a theoretical investigation of the insulating properties of a laminar compressible boundary layer are given. The Kármán-Pohlhausen integral method extended to both the momentum and energy partial differential equations are then solved for two unknown functions of the distance along the wall. These two functions are related to the boundary layer thickness and to the wall temperature. Initial conditions corresponding to a given initial wall temperature and an initial boundary layer thickness are prescribed. Exact, closed-form solutions for the case of zero axial pressure gradient are obtained. For the case with axial pressure gradient, approximate numerical solutions for the interesting case of an accelerating pressure gradient have been obtained. Circumstances under which the laminar compressible boundary layer may insulate a surface from high energy gases are discussed.

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FUNDAMENTAL PROBLEMS IN ROCKET RESEARCH, by M. Summerfield. [1950] [15]p. incl. illus. refs. [Proj. Squid technical rept. no. PR-26-P-R] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) Unclassified

Published in Jour. Amer. Rocket Soc., No. 81: 79-98, June 1950.

Various problems that have arisen in connection with recent advances of rocket technology are discussed, and indications of directions in which solutions might be found are presented. The topics discussed are concerned with combustion, heat transfer, transport properties, and flow through exhaust nozzles. A comprehensive bibliography is presented.

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THE EFFECT OF TRACES OF OXYGEN ON THE REACTION OF ALUMINUM BOROHYDRIDE WITH ETHYLENE, by R. S. Brokaw. June 15, 1950, 7p. diagrs. tables. (Proj. Squid technical memo. no. PR-15-M-[P]; technical paper no. 48) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-t0503) U10824; ATI-83861 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 72: 5263-5366, Nov. 1950.

The effect of traces of oxygen on the reaction between aluminum borohydride and ethylene has been studied. It is found that the reaction is accelerated by oxygen and inhibited by a reaction product and by increased surface area. An equation which qualitatively describes the experimental results is given, and a possible

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mechanism is proposed. A few experiments on the induced combustion of ethylene with aluminum borohydride and with boron triethyl have been performed. (Contractor's abstract)

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KINETICS OF THE THERMAL DECOMPOSITION OF DIBORANE, WITH A REVIEW OF STRUCTURE DATA, by R. P. Clarke. July 1, 1950, 22p. diagrs. tables, refs. (Proj. Squid technical memo. no. PR-16-M; technical paper no. 49) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) U12171; ATI-98545 Unclassified

A study has been made of the rate of decomposition of diborane in a static system from 85° to 163°C, employing starting pressures up to 160 mm hg. The overall effect is that of chain-reaction polymerization of B_2H_6 to $(BH)_x$. Evidence is given for an initial 3/2-order step. A mechanism is proposed which includes back-reactions involving the respective partial pressures of hydrogen, diborane, and the volatile intermediates. (Contractor's abstract)

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Princeton U., N. J.

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE MIXING OF A SUPERSONIC STREAM WITH AN INDUCED SECONDARY STREAM AS APPLIED TO DUCTED PROPULSIVE DEVICES, by H. L. Pool and J. V. Charyk. Sept. 1950, 61p. illus. diagrs. tables, appendices. (Proj. Squid technical rept. no. [PR-42-R]; technical rept no. 25) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) ATI-101133 Unclassified

Test results an certain aspects of ejector performances are reported including effects of such factors as primary to secondary jet area ratio, location of actuating jet, under and over expansion of supersonic jet nozzle, etc. Some typical test data are also included for the case where chemical reaction occurs between the two fluid streams. Pressure and temperature distributions along the duct are included. An appendix treats the problem of constant area or constant pressure mixing according to the usual one-dimensional fashion. Appropriate selection of parameters permits of a solution in very simple form. (Contractor's abstract)

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Princeton U., N. J.

A THEORY OF UNSTABLE COMBUSTION IN LIQUID PROPELLANT ROCKET SYSTEMS, by M. Summerfield. Apr. 1951, 16p. incl. illus. (Proj. Squid technical rept. no. [PR-43-R-P]; technical rept. no. 26) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) ATI-114348 Unclassified

Also published in Jour. Amer. Rocket Soc., v. 21: 108-114, Sept. 1951.

On the basis of an hypothesis that low frequency oscillations ("Chugging") sometimes observed in liquid propellant rocket engines are the result of oscillatory propellant flow induced by a combustion time lag, conditions for the suppression of such oscillations are derived. It is found that stability can be achieved by increases in the length of feed line, the velocity of the propellant in the feed line, the ratio of feed pressure to chamber pressure, and the ratio of chamber volume to nozzle area. Equations are given for the frequencies of oscillations. Examination of the equation for stability indicates that self-igniting propellant combinations are likely to be more stable than non-self-igniting systems.

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A THEORETICAL AND EQPERIMENTAL INVESTIGATION OF THE FEASIBILITY OF THE INTERMITTENT RAMJET ENGINE. PART I. THEORETICAL INVESTIGATION, by A. Kahane. PART II. EXPERIMENTAL INVESTIGATION, by A. Kahane, A. A. Marino and others. Aug. I, 1951, 172p. incl. illus. diagrs. tables, refs. ([Proj. Squid technical rept. no. PR-45-R]; technical rept. no. 35) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) U24371; ATI-197742 Unclassified

Theoretical and experimental investigations of the possibilities of an intermittent ramjet engine were made. Theoretical studies were made of several possible modes of intermittent combustion, gas dynamic cycle of the engine, and problem of diffuser and nozzle design. Performance theory of intermittent jet engines was developed, and specific impulse calculations of the intermittent ramjet were made for possible modes of combustion. Experimental investigations of the intermittent combustion process in a flowing gas in a constant area tube were made. Synchronized high speed motion picture and transient pressure studies were used to determine the mode of the combustion process occurring. Transient pressure rise measurements

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were made over a range of combustion chamber Mach numbers and fuel flows. Performance tests of subsonic configuration at 0.5 Mach number were also made. (Contractor's abstract)

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THERMODYNAMIC AND TRANSPORT PROPERTIES OF LIQUIDS, PROBLEM I. THERMAL CONDUCTIVITIES OF LIQUIDS, by E. F. Johnson, Jr. and W. J. Sheffy. Final rept. Oct. 1, 1951, 6p. (Proj. Squid technical memo. no. PR-17-M) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) U21040; ATI-131270 Unclassified

The measurement of thermal conductivities and diffusivities in pure liquids and liquid mixtures over extensive pressure and temperature ranges is considered. On the basis of experimental work and a survey of the literature, a comparison is made between disk-type apparatus and a heterogeneous apparatus of concentric metal cylinders for measuring thermal diffusivities in steady- and unsteady-state operation.

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THE DESIGN, CONSTRUCTION, AND OPERATION OF THE PRINCETON 4 BY 8 INCH VARIABLE-DENSITY SUPERSONIC TUNNEL, by S. M. Bogdonoff. Oct. 22, 1951, 39p. incl. illus. diagrs. ([Proj. Squid technical rept. no. PR-44-R]; technical rept. no. 34) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) ATI-139932 Unclassified

The design, construction, and operation of the Princeton 4- by 8-in. variable density supersonic wind tunnel are described in some detail. The tunnel has been designed for a range of Mach numbers from 1.5 to 5.0 and has operated in a Reynolds number range from less than 1×10^3 up to 60×10^6. Model mounting and tunnel starting problems are discussed and the present research program now under way is outlined. (Contractor's abstract)

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Princeton U., N. J.

EXPERIMENTAL STUDIES OF ENERGY RELEASE RATES IN ROCKET MOTOR COMBUSTION CHAMBERS, by J. V. Charyk and G. B. Matthews. Final rept. Mar. 1952, 61p. incl. illus. tables. (Proj. Squid technical rept. no. PR-76-R) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) AD 147698 Unclassified

By measuring axial pressure distributions in tubular rocket motors and applying this data to the one-dimensional equations of motion, heat release parameters were calculated for the combustion of gaseous methane and oxygen at pressures above atmospheric. The results were interpreted to give a minimum resistence time and hence a minimum L* (the ratio of combustion-chamber volume to throat area) for the process.

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A PERFORMANCE STUDY OF THE RAM ROCKET POWER PLANT AND RELATED PROBLEMS (Unclassified title), by J. V. Charyk and G. S. Sutherland. Mar. 15, 1952, 144p. incl. illus. tables, refs. (Technical rept. no. 36) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) AD 5081 Confidential

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Princeton U., N. J.

THE THERMAL OXIDATION OF HYDRAZINE VAPOUR, by W. I. H. Winning. May 21, 1952 [6]p. incl. illus. tables. (Proj. Squid technical rept. no. PR-49-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 42987 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 926-931, Mar. 20, 1954.

The thermal gas phase reaction between hydrazine and oxygen shows none of the chain characteristics of, e.g., the hydrocarbon series. It is predominantly surface reaction, the activation energy of which, below 100°C, was found to be 6430 cal/mole. On comparison with the absolute reaction rate expression for a bimolecular surface reaction, unrelated by the products, and in which neither reactant is strongly adsorbed, very good agreement is obtained between the experimental and the theoretical rate value. (Contractor's abstract)

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PRELIMINARY INVESTIGATION OF THE RAM ROCKET

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AS A POWER PLANT FOR A LONG-RANGE GUIDED MISSILE (Unclassified title), by G. S. Sutherland. July 1, 1952, 39p. illus. refs. ([Proj. Squid] technical memo. no. PR-19) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) AD 1248 Confidential

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KINETICS OF THE NON-CATALYTIC OXIDATION OF AMMONIA: STATIC EXPERIMENTS IN AN EMPTY UNCOATED SILICA VESSEL, by E. R. Stephens and R. N. Pease. [1952] [3]p. illus. [Proj. Squid technical rept. no. PR-36-P] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) Unclassified

Published in Jour. Amer. Chem. Soc., v. 74: 3480-3482, July 20, 1952.

A study of the oxidation of ammonia in an uncoated silica reaction vessel indicates that the rate increases in passing from ammonia rich to ammonia lean mixtures. On the rich side, rates are roughly proportional to the product of ammonia and oxygen concentrations, whereas on the lean side the square of the oxygen concentration seems to be involved. The activation energy approximates 45,000 cal in both regions.

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Princeton U., N. J.

CURRENT THEORETICAL CONCEPTS OF STEADY STATE FLAME PROPAGATION, by M. W. Evans. [1952] 93p. incl. illus. tables, refs. ([Proj. Squid technical rept. no. PR-37-P-R]; technical rept. no. 27) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) ATI-131269; AD 16728 Unclassified

Also published in Chem. Rev., v. 51: 363-429, Dec. 1952.

Current theoretical concepts of steady-state flame propagation are discussed. General notations used in all theories are given at the beginning of the report. The details of the discussion cover: the basic equations of fluid dynamics and the generalizations and simplifications required for their use in theories of one-dimensional, steady-state, nonviscous flame propagation; simplifying assumptions used to effect a solution of the equations for one-dimensional steady-state nonviscous flame propagation; the physical structure of the one-dimensional steady-state flame, flame velocity measurements; and classification of theories of steady-state flame propagation.

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BURNING VELOCITIES OF METHANE WITH NITROGEN-OXYGEN, ARGON-OXYGEN, AND HELIUM-OXYGEN MIXTURES, by W. H. Clingman, R. S. Brokaw, and R. N. Pease. [1953] [4]p. incl. illus. tables, refs. [Proj. Squid technical rept. no. PR-47-P] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 45923 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 310-313.

Burning velocities at one atmosphere and 25°C have been determined for methane in nitrogen-oxygen, argon-oxygen, and helium-oxygen mixtures. Results are correlated with values calculated by means of the Tanford-Pease theory. Experimental burning velocity ratios for the nitrogen-argon-helium case at 10% methane are 0.43:1:1.417. Calculated values are 0.359:1:1.296. A modified Tanford-Pease theory gives 0.373:1:1.392.

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THE MIXING AND BURNING OF TWO CONCENTRIC FLUID STREAMS, by J. V. Charyk, I. Glassman, and R. R. John. [1953] [8]p. incl. illus. tables. [Proj. Squid technical rept. no. PR-39-P; technical rept. no. 49] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 22741 Unclassified

Also published in Fourth Symposium (International) on Combustion, Mass. Inst. of Tech., Cambridge (Sept. 1-5, 1952), Baltimore, Williams & Wilkins, 1953, p. 886-893.

Report includes an experimental verification of the use of the one-dimensional equations of mixing and burning in the theoretical performance calculations for a liquid oxygen-gasoline-air ducted rocket. Methods are presented for predicting empirically the longitudinal static pressure distribution in the ducted rocket burner and thus the burner length as a function of R and R* for the liquid oxygen-gasoline system. These results are generalized, making it possible to predict empirically the static pressure distributions along the burner duct for a wide range of ram-rocket operating conditions, including other propellants and different flight conditions.

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Princeton U., N. J.

THE EFFECT OF WATER ON THE BURNING VELOCITIES OF CYANOGEN-OXYGEN-ARGON MIXTURES, by R. S. Brokaw and R. N. Pease. [1953] [4]p. [Proj. Squid technical rept. no. PR-38-P; technical rept. no. 48] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10503) Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 1454-1457, Mar. 20, 1953.

Burning velocities have been determined for cyanogen-oxygen-argon mixtures containing varying amounts of moisture. The effect of water is explainable on the basis of the Tanford-Pease theory of flame speeds. Experiments with heavy water suggest that the hydroxyl radical is more important than the hydrogen atom in determining the rate of flame propagation. (Contractor's abstract)

PRI. 11:159

Princeton U., N. J.

A THEORETICAL AND EXPERIMENTAL STUDY OF FINITE AMPLITUDE WAVE INTERACTIONS WITH CHANNELS OF VARYING AREA, by A. Kahane, W. R. Warren, [Jr.] and others. Nov. 23, 1953 [21]p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PR-53-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 51469 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 21: 505-525, Aug. 1954.

A theoretical and experimental investigation has been made of the interaction of waves of finite amplitude in ducts of varying cross section. A new one-dimensional method is described by which the steady-state conditions after passage of an isentropic wave may be obtained from a chart without necessity of previously required iterative procedures. The chart has proved useful in the discussion of the spectrum of physical solutions which has been presented here. Experiments were carried out in a shock tube to indicate the nature of the actual two-dimensional interaction processes occurring, and to determine how accurately one-dimensional methods could be applied to such interactions. A two-dimensional channel of area ratio 0.504 was made in such a way that the normal shock wave could be incident on either end. Density fields were measured with the aid of a Mach-Zehnder interferometer. Comparison of the transient density distribution obtained in the center of the channel with results of a one-dimensional unsteady flow calculation for the converging channel indicates excellent agreement. The establishment of steady flow was observed for a variety of incident shock strengths using both the converging and the diverging models. The isentropic theory fits the measured densities well for weak shocks. Satisfactory agreement is obtained for strong shocks using real shock theory.

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:160

Princeton U., N. J.

A COMPARISON OF THREE METHODS FOR THE ANALYSIS OF GASEOUS OZONE, by C. C. Schubert, S. J. Garvin, and D. Garvin. Mar. 1956, 7p. illus. (Proj. Squid technical rept. no. PR-63-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, Office of Ordnance Research under N6ori-10503) AD 86634 Unclassified

Ozone (O_3) at low concentrations in air or oxygen was analyzed by 3 methods: absorption in aqueous potassium iodide (KI) followed by titration with sodium thiosulfate ($Na_2S_2O_3$); IR absorption; and measurement of the gas volume increment upon thermal decomposition. Intercomparison of these methods indicates that the titration method as applied in a flow system is not precise for gas streams containing more than 1 mol-% of O_3. At higher concentrations, errors occur which tend to reduce the observed O_3 concentration below that actually present. The recommended method for the analysis of gases containing 2 to 100 mm Hg of O_3 is IR absorption based on a calibration curve obtained from absolute method analyses; the calibration curve is included.

PRI. 11:161

Princeton U. Aeronautical Engineering Lab., N. J.

A GENERALIZED PERFORMANCE ANALYSIS OF THE RAM ROCKET POWER PLANT AND ASSOCIATED APPLICATIONS (Unclassified title), by J. V. Charyk, R. R. John, and I. Glassman. July 6, 1953, 68p. illus. tables, refs. (Proj. Squid technical rept. no. PR-48-R; AEL rept. no. 235) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 28220 Confidential

PRI. 11:162

Princeton U. Frick Chemical Lab., N. J.

THE KINETICS OF THE THERMAL DECOMPOSITION OF ALUMINUM BOROHYDRIDE, by R. S. Brokaw and

PRI. 11:163 - PRI. 11:166

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

R. N. Pease. [1951] 1p. table. ([Proj. Squid technical rept. no. PR-18-P]; TM Prin-18) (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) ATI-164170 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 74: 1590, June 1952.

The rate of thermal decomposition of gaseous aluminum borohydrides at 159° and 189°C is reported. It is concluded that the reaction is first order and homogeneous. The mechanism has not yet been determined.

PRI. 11:163

Princeton U. Frick Chemical Lab., N. J.

A KINETIC STUDY OF THE DIBORANE-ETHYLENE REACTION, by A. T. Whatley and R. N. Pease. Aug. 10, 1953 [4]p. incl. illus. tables. (Proj. Squid technical rept. no. PR-50-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research and Office of Ordnance Research under N6ori-10503) AD 42986 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 835-838, Feb. 5, 1954.

The combination of ethylene with diborane yielding boron triethyl as a final product proceeds in range 120-175° at a rate given by:

$$dp/dt = k[B_2H_6]^{3/2}(1-a[B_2H_6]/[C_2H_4]).$$

As the equation indicates, the reaction becomes mildly explosive when the B_2H_6/C_2H_4 ratio is sufficiently increased (beyond about 0.5); and the excess of diborane is consumed in the process. A mechanism of ethylene addition is proposed. (Contractor's abstract)

PRI. 11:164

Princeton U. Frick Chemical Lab., N. J.

OBSERVATIONS ON THERMAL EXPLOSIONS OF DIBORANE-OXYGEN MIXTURES, by A. T. Whatley and R. N. Pease. Dec. 17, 1953 [3]p. incl. illus. tables. (Proj. Squid technical rept. no. Plt-51-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 45810 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 1997-1999, Apr. 5, 1954.

Diborane-oxygen mixtures explode after an induction period within a range of concentration at 105° to 165°. Since slow decomposition of diborane is occurring simultaneously at these temperatures, a pyrolysis product – perhaps pentaborane – may be the normal sensitizing agent. Both hydrogen and ethylene narrow the explosion limits. (Contractor's abstract)

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:165

Princeton U. Frick Chemical Lab., N. J.

BURNING VELOCITIES OF HYDROGEN-AIR FLAMES, by H. Burwasser and R. N. Pease. July 1955, 9p. illus. refs. (Proj. Squid technical rept. no. PR-57-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 67772 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 5806-5808, Nov. 20, 1955.

Burning velocities of hydrogen-air mixtures were measured by the Bunsen burner method. A modified angle technique applied to the dark outer edge of the shadow cone was used in calculating the burning velocities. An attempt was made to correlate the experimental result with approximate diffusion and thermal theories of flame propagation. Diffusion theory predicts a maximum in burning velocity at a leaner H composition than is observed experimentally, whereas thermal theory predicts a maximum at a richer composition (29 vs 42 vs 55% H_2).

PRI. 11:166

Princeton U. Frick Chemical Lab., N. J.

A COMPARISON OF THE BURNING VELOCITIES OF METHANE AND HEAVY METHANE IN NITROGEN AND ARGON "AIRS" AT ATMOSPHERIC PRESSURE, by W. H. Clingman and R. N. Pease. Nov. 1955, 11p. illus. refs. (Proj. Squid technical rept. no. PR-60-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 80813 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 2695-2698, June 20, 1956.

The burning velocities of methane (CH) and heavy methane (CD_4) were measured at atmospheric pressure and in both nitrogen (N) and argon "airs" (A) to determine whether diffusion or heat conduction is more important in flame propagation. The CD_4 was prepared by the decomposition of Al_4C_3 with D_2O following the procedure of Wright and Taylor (Canad. Jour. Research, v. 27B: 303, 1949). The apparatus used for measuring

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

the burning velocity of CD_4 was essentially that used by Brokaw and Pease (Jour. Amer. Chem. Soc., v. 75: 1954, 1953). The ratio of the burning velocity of a mixture with CH_4 to that of a mixture with CD_4 of the same composition was always greater than 1 and increased with increasing concentration of fuel. A proposal was made that the burning velocities of CH_4 and CD_4 be compared at 1 atm and varying compositions. Measurements of the burning velocity were made over a range of compositions with N-air and A-air to study the effect of isotopic substitutions at 2 flame temperatures. The results of the study were considered to favor a diffusion mechanism.

PRI. 11:167

Princeton U. Frick Chemical Lab., N. J.

CRITICAL CONSIDERATIONS IN THE MEASUREMENT OF BURNING VELOCITIES OF BUNSEN BURNER FLAMES AND INTERPRETATION OF THE PRESSURE EFFECT, by W. H. Clingman and R. N. Pease. Nov. 1955, 17p. illus. refs. (Proj. Squid technical rept. no. PR-59-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 81192 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1775-1780, May 5, 1956.

An investigation was conducted of the burning velocity of CH_4 under various conditions. Experimental results were compared with the Semenov theory (Prog. Phys. Sci. (USSR), v. 24: no. 4, 1940) and a modified form of the Tanford-Pease theory of flame propagation (Jour. Chem. Phys., v. 15: 861, 1947). An improved Bunsen burner method of determining the burning velocity is presented in which it is determined for each flame observed whether there is a region of the flame cone over which the flame velocity is constant. This method yields burning-velocity values which are independent of flow rate and burner diameter. The Tanford-Pease theory qualitatively predicted the results.

PRI. 11:168

Princeton U. [Frick Chemical Lab.] N. J.

REACTION OF PARAFFIN HYDROCARBONS WITH IONIZED OXYGEN. POSSIBLE ROLE OF OZONE IN NORMAL COMBUSTION, by C. C. Schubert and R. N. Pease. Nov. 1955, 4p. refs. (Project Squid technical rept. no. PR-58-M; technical rept. no. 34) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 78361 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Also published in Jour. Chem. Phys., v. 24: 919-920, Apr. 1956.

A study was undertaken of the thermal reaction between ozonized O and the lower paraffin hydrocarbons. Literature was reviewed concerning the possible role of O_3 as an intermediate in hydrocarbon combustion. The reaction $ROO\cdot + O_2$ $RO\cdot + O_3$ was considered in bringing O_3 into the general hydrocarbon-O reaction scheme; this reaction might be related to the phenomenon of the detection of O_3 in smog.

PRI. 11:169

Princeton U. Frick Chemical Lab., N. J.

THE VAPOR PHASE INFRA-RED SPECTRA OF OZONIDES OF ETHYLENE, PROPYLENE AND ISOBUTYLENE, by C. C. Schubert and D. Garvin. Nov. 1955, 4p. incl. illus. (Proj. Squid technical rept. no. PR-61-M) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 80812 Unclassified

Also published in Jour. Phys. Chem., v. 60: 807-808, June 1956.

The ozonides of ethylene, propylene, and isobutylene after ozonization at -78°C in an inert solvent showed no strong absorption in the carbonyl region (about 5.7μ). Vapor-phase IR spectra are presented which indicate that any absorption in the 5.7 region is weak compared with absorptions at other wavelengths. Pure isobutylene ozonide was very resistant to decomposition in the presence of water vapor, but showed rapid hydrolysis in concentrated HCl. The results suggest that ozonide identification should be based on characteristic bands in spectral regions other than the carbonyl region.

PRI. 11:170

Princeton U. [Frick Chemical Lab.] N. J.

THE OXIDATION OF LOWER PARAFFIN HYDROCARBONS. PART I. ROOM TEMPERATURE REACTION OF METHANE, PROPANE, n-BUTANE AND ISOBUTANE WITH OZONIZED OXYGEN, by C. C. Schubert and R. N. Pease. Jan. 1956 [18] p. incl. illus. table, refs. (Proj. Squid technical rept. no. PR-62-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 83361 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 2044-2048, May 20, 1956.

PRI. 11:171 - PRI. 11:174

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Reaction rates of ozonized oxygen (ca 3 mole % O_3) with methane, propane, n-butane, and isobutane were measured, in situ, in a temperature-controlled infrared absorption cell by observing the decrease of ozone concentration as measured by the absorption at 1055 cm^{-1}. The activation energies calculated on the basis of a reaction first-order with respect to ozone were 14.9, 12.1, 11.1 and 10.3 kcal, respectively. The pre-exponential term for the methane-ozone 3.1×10^9, for n-butane - ozone 8.2×10^8 and for isobutane-ozone 4.4×10^8 cc $mole^{-1}$ sec^{-1} estimated on the basis of a reaction $\alpha[O_3]\cdot[HCl]$. The isobutane-ozone reaction was predominantly homogeneous; n-butane-ozone showed some acceleration in rate due to increased Pyrex surface, little dependence on sodium chloride surface. The main gaseous product of the isobutane-ozone reaction was t-butanol with smaller amounts of acetone and 1-carbon products approximately equal to molar amounts of acetone. A mechanism based on the postulation of a low lying triplet state of ozone is presented. (Contractor's abstract)

PRI. 11:171

Princeton U. [Frick Chemical Lab.] N. J.

THE OXIDATION OF LOWER PARAFFIN HYDROCARBONS. PART II. OBSERVATIONS ON THE ROLE OF OZONE IN THE SLOW COMBUSTION OF ISOBUTANE, by C. C. Schubert and R. N. Pease. Apr. 1956, 15p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PR-65-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 90461 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 5553-5556, Nov. 5, 1956.

The reaction of ozonized oxygen (ca 3-6 mole % O_3) with isobutane in the temperature range 110° to 270°C was compared with the slow uncatalyzed reaction with oxygen alone. The ratio of gram atoms of oxygen fixed in liquid product to moles of ozone added increased from 3.4 at 125°C to 4.2 at 200° and 5.0 at 225°. The ozone-induced oxidation merges into the normal slow combustion reaction at ca 265°C. Approximately one third of the condensed products of isobutane-ozone reaction at 150°C was found to be t-butyl hydroxymethyl peroxide. The same peroxide was indicated to be a product of the isobutane-oxygen reaction at 270°C by a comparison of infrared spectra. It is proposed that ozone may be the active intermediate responsible for chain branching during the slow combustion of hydrocarbons in oxygen. Ozone might result from the reaction: $RO_2^{\cdot} + O_2 \rightarrow O_3 + RO$. Ozone probably has the stability requirements to account for the cool flame reaction and negative temperature coefficient region observed in the combustion of hydrocarbons. Preliminary attempts to detect ozone during the normal slow reaction by observing the ultraviolet absorption in a 3-meter tube were unsuccessful due to general absorption in the 2500 Å region. (Contractor's abstract).

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:172

Princeton U. Frick Chemical Lab., N. J.

A PRELIMINARY STUDY OF THE PHOTOLYSIS OF PENTABORANE VAPOR, by H. Burwasser and R. N. Pease. June 1956, 5p. incl. table. (Proj. Squid technical rept. no. PR-66-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 95526 Unclassified

Also published in Jour. Phys. Chem., v. 60: 1589-1590, Nov. 1956.

A preliminary investigation was made of the results of exposing pentaborane vapor to an H arc through a thin SiO_2 window. Results demonstrated that increasing the exposure time beyond 1/2 hr only moderately increased the extent of the reaction; this is probably the result of solid deposition on the cell window upon rinsing with water, the solid product seemed to consist of small white crystals which went into solution slowly; the characteristically strong odor of B hydrides was detected. The freshly prepared solution reduced permanganate solution partially. The presence of borate ion was confirmed by fluorescence test of White, Weissler and Busker (Anal. Chem., v. 19: 802, 1947) involving an alcoholic benzoin solution complex with borate ion. Experiments with D were undertaken. A mixture of H, D, and HD was produced in approximately equilibrium concentrations when 11 mm each of D and pentaborane were irradiated for 1 hr.

PRI. 11:173

Princeton U. James Forrestal Research Center, N. J.

APPLICATION OF THE RAM ROCKET AS A HELICOPTER PROPULSION SYSTEM (Unclassified title), by J. V. Charyk and J. E. Scott, Jr. Jan. 23, 1953, 38p. incl. illus. (Proj. Squid technical memo. no. PR-20) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 15839 Confidential

PRI. 11:174

Princeton U. James Forrestal Research Center, N. J.

THE MIXING OF AN AXIALLY SYMMETRIC COMPRESSIBLE JET WITH QUIESCENT AIR, by W. R. Warren, Jr. Sept. 30, 1953. 43 p. incl. illus. refs.

Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID)

(AEL rept. no. 252) (Sponsored jotntly by Offtce of Naval Research, [Atr Force Offtce of Scientific Research] and Office of Ordnance Research under N6ort-10503) AD 44222 Unclasstfted

A semi-emptrtcal theory ts presented for predtcting the boundartes, velocity decay on the axis, and the velocttty at any potnt in an air jet or vartable denstty exhausting tnto atr at rest. The tntegrated momentum equation ts employed as the basic equation tn the analysts and an approximate expression for density variation ts presented and analyzed. The shear stress is represented by a form suggested by Retchardt. This form is simpler than the ordinary Prandti expresston. Calculattons are made for range of denstty ratios and an analysis of the results ts attempted. A compartson with expertment ts made tndtcating that the mixtng parameter $\frac{k}{u}$, is dependent upon the denstty ratio. A method for solution of the mixing problem ustng a more exact density varlation ts tndicated tn Appendtx 1. (Contractor's abstract)

PRI. 11:175

Princeton U. [James Forrestal Research Center] N. J.

AGARD COMBUSTION COLLOQUIUM. SELECTIONS. [1954] 1v. incl. illus. tables, refs. (Proj. Squtd technical rept. no. PR-52-P) (Sponsored jointly by Office of Naval Research, [Atr Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 53579 Unclasstfied

Contrihutions by Project Squid authors to the Combustion Colloquium at Cambridge, England, in Dec. 1953 which was sponsored by the Advtsory Group for Aeronautical Research and Development (AGARD), North Atlantic Treaty Organizatton (NATO) are: A Turbulent Flame Theory Derived From Experiments, by B. Karlovitz; Remarks On The Combustion Wave, by B. Lewis; Discussion On Turbulent Combustion, by G. H. Marstein; Experimental Studies On Turbulent Flames, by A. C. Scurlock and J. H. Grover; and Discussion On Turbulent Flames and Flame Spectroscopy, by K. Wohl.

PRI. 11:176

Princeton U. James Forrestal Research Center, N. J.

PROJECT SQUID CONFERENCE ON RAM ROCKET POWER PLANTS HELD AT PRINCETON UNIVERSITY, JUNE 29-30, 1954 (Unclassified title). [1954. 354p. incl. illus. tables. (Proj. Squid technical rept. no. PR-54-C) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 68721 Confidenttal

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:177

Princeton U. James Forrestal Research Center, N. J.

PROJECT SQUID CONFERENCE ON WAVE ENGINES AND PULSE JETS HELD AT PRINCETON UNIVERSITY, NOVEMBER 9-10, 1954 (Unclasstfted title). [1954] [338]p. tncl. illus. tables. (Proj. Squtd technical rept. no. PR-55-C) (Sponsored jotntly by Offtce of Naval Research, [Air Force] Office of Scientiftc Research, and Offtce of Ordnance Research under N6ort-10503) AD 68722 Conftdential

PRI. 11:178

Princeton U. James Forrestal Research Center, N. J.

THE STATIC PRESSURE VARIATION IN COMPRESSIBLE FREE JETS, by W. R. Warren, Jr. July 16, 1954, 9p. illus. ([Proj. Squtd technical rept. no. PR-64-P]; AEL rept. no. 270) (Sponsored jotntly by Office of Naval Research, [Air Force Offtce of Sctenttftc Research] and Office of Ordnance Research under N6ort-10503) AD 57735; AD 97480 Unclasstfted

Also published in Jour. Aeronaut. Sciences, v. 22: 205-207, Mar. 1955.

Experimental static pressure profiles are presented for free axial symmetric jets of 0.97 and 2.60 tnitial Mach number. The accuracy of the constant pressure assumption in free jets is discussed, and it ts shown that this assumption becomes less valid with tncreasing initial jet Mach number. Conclusions are reached concernting the mechanisms governing the physical structure of a free jet. The shape of velocity profiles as a function of initial jet Mach number is discussed briefly. It is shown that turbulence corrections to test readings would only accentuate the conclusions drawn. (Contractor's abstract)

PRI. 11:179

Princeton U. James Forrestal Research Center, N. J.

TEN YEARS OF PROJECT SQUID, A BIBLIOGRAPHY. June 1, 1956 [25]p. 255 refs. (Proj. Squid technical rept. no. PR-67-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 112552 Unclassified

Also published in Jet. Propulston, v. 26: 660-680, Aug. 1956.

A brief history of the ten years of Project SQUID (1946-1956) is presented. This is followed by a complete bibliography with abstracts of all unclassified

PRI. 11:180 - PRI. 11:183

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

SQUID technical publtcations and reports which appeared before June 1, 1956. The scope of the research, initially devoted to problems arising in the devetopment of pulsejet and ltquid rocket engtnes, was broadened to tnclude more bastc sctence pertinent to the general fteld of jet propulsion, with emphasis prtmarity on combustion, fluid flow, and heat transfer. The properties of structural matertals such as metals and ceramtcs are spectfically excepted. The 255 bibliographic items (or abstracts) are arranged according to a subject ctassiftcation which tncludes properties of gases, ltquids and soltds, phystcal and chemtcal processes, combustion phenomena, engines and propulstve systems, and instrumentation. An authors' index ts included.

PRI. 11:180

Prtnceton U. James Forrestal Research Center, N. J.

JETS - REVIEW OF LITERATURE, by M. Z. von Krzywobtocki. Nov. 1956 [20]p. refs. (Proj. Squid technical rept. no. PR-68-P) (Sponsored jotntly by Offtce of Naval Research, Air Force Offtce of Scientiftc Research, and Office of Ordnance Research under N6ort-10503) AD 116101 Unclasstfted

Also published in Jet Propulston, v. 26: 760-779, Sept. 1956.

This revtew deals with the fundamentats and mathematical theory of free boundary flow and jet; wtth the dtsirtbution of velocity, denstty, pressure and temperature in laminar jets; transport of mass, momentum and energy in turbulent jets; and with closely related phenomena - the acoustical ones, designing of nozzles, orifices, wind tunnels with open jets, etc., being excluded. The review is dtvtded tnto eight sections. (Contractor's tnitroduction)

PRI. t1:t8t

Purdue U. Lafayette, Ind.

AN EVALUATION OF THE HEAT TRANSFER ENCOUNTERED IN A ROCKET MOTOR OPERATING AT HIGH CHAMBER PRESSURES, by C. F. Warner and M. J. Zucrow. July 20, t949, 24p. incl. diagrs. table, refs. ([Proj. Squid technical rept. no. PUR-2t-R]; technical rept. no. 18) (Sponsored jointly by Office of Naval Research and [Atr Force Office of Scientific Research] under N6ort-1040t and [N6ort-10503]) U11871; ATI-8t556 Unclassified

The theoretical rates of heat transfer between the walls of a 500-lb-thrust rocket motor and the combusiton gases resulting from the oxtdation of octane and aniline by white fuming nitric acid are obtained as a function of the rocket motor chamber pressure. The convective heat transfer coefficients, obtained by using the McAdams correlation, are compared with the rates obtained by Humble-Lowdermilk-Grele correlation. The radiant heat transfer rates are obtained by the Hottel-Egbert method. It was found that the chamber and nozzle heat transfer rates increase linearly with chamber pressure and that the nozzle heat transfer rates become extremely high at chamber pressures beyond 1500 psia.

Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:182

Purdue U., Lafayette, Ind.

PROGRESS REPORT ON THE STABILITY OF LIQUID FILMS FOR COOLING ROCKET MOTORS, by M. J. Zucrow, C. M. Betghley, and E. Knuth. Nov. 30, 1950, 33p. tncl. diagr. table, refs. ([Proj. Squtd technical rept. no. PUR-22-R]; technical rept. no. 23) (Sponsored jointty by Office of Naval Research and [Air Force Office of Sctentiftc Research] under N6ort-10401 and [N6ort-10503]) U15690; ATI-95562 Unclasstfted

Presented at annual meeting of the Amer. Rocket Soc., New York, Nov. 30, 1950.

A prelimtnary report ts made of an experimental study of coottng rocket motor walls by tnjecting ltquids through slots to form a liquid film along the wall while air is blown through the test station. Vtsual determtnation of the point at which the liquid separates and flows tnto the air stream rather than along the wall shows that as the velocity of the air increases, the velocity of liquid flow can be increased. The width of the injection slot, the angle of injection, and the viscosity and density of the liquid influence the maximum rate for nonseparating flow; the attitude of the injector, the surface tension of the ltquid, and the size of the gas duct do not affect it.

PRI. 1t:183

Purdue U., Lafayette, Ind.

THE EFFECTS OF SEVERAL VARIABLES UPON THE IGNITION LAG OF HYPERGOLIC FUELS OXIDIZED BY NITRIC ACID, by S. V. Gunn. [t951] [6]p. incl. dtagrs. refs. ([Proj. Squtd technical rept. no. PUR-17-P-R-M; technical rept. no. 38] (Sponsored jointly by Offtce of Naval Research and [Air Force Office of Scientiftc Research] under N6ort-10401 and [N6ort-t0503]) U23018; ATI-t56280 Unclassified

Also published in Jour. Amer. Rocket Soc., v. 22: 33-38, Jan. Feb. t952.

A method ts described for measurtng the tgnitton lag of self-tgnition (hypergolic) bipropellant combtnattons. Ignitton lag data are reported for combinattons of nitric

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acid with aniline, furfuryl alcohol, and mixtures of aniline and furfuryl alcohol. The ignition lags ranged from about 10 to about 400 milliseconds, depending upon such variables as temperature, acid composition, fuel composition, and metallic additives. (Contractor's abstract)

PRI. 11:184

Purdue U., Lafayette, Ind.

PROCEEDINGS OF THE CONFERENCE ON IGNITION OF LIQUID ROCKET PROPELLANTS, NOV. 2 AND 3, 1950 (Unclassified title), by M. J. Zucrow, C. H. Trent, and S. V. Gunn. June 1, 1951, 155p. incl. illus. diagrs. refs. (Proj. Squid technical rept. no. PUR-29) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under [N6ori-10401 and N6ori-10503]) C7223; ATI-125133
Confidential

PRI. 11:185

Purdue U., Lafayette, Ind.

THE IGNITION OF FUEL DROPLETS DESCENDING THROUGH AN OXIDIZING ATMOSPHERE, by H. L. Wood and D. A. Charvonia. [1953] [4]p. incl. illus. refs. (Proj. Squid technical rept. no. PUR-25-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ort-10503) AD 46131
Unclassified

Presented at Eighth annual convention of the Amer. Rocket Soc., New York, N. Y., Dec. 3, 1953.

Also published in Jet Propulsion, v. 24: 162-165, May-June 1954.

Ignition studies with three organic fuels, triethylamine, allylamine, and cyclohexene, as they descend in single droplets through the decomposition vapors of white fuming nitric acid are discussed. The pertinent parameters varied were acid vapor temperature (350° to 550°C), fuel temperature (10° to 70°C), and fuel-drop diameter (2.6 to 4.2 mm). Theoretical approaches to explain the observed ignition delays have not been successful. (Contractor's abstract)

PRI. 11:186

Purdue U., Lafayette, Ind.

HEAT TRANSFER COEFFICIENTS FOR GASES: EFFECT OF TEMPERATURE LEVEL AND RADIATION, by H. J. Ramey, J. B. Henderson, and J. M. Smith. Dec. 1953, 11p. illus. refs. [Proj. Squid technical rept. no. PUR-24-P] (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under [N6ori-10503]) AD 42988
Unclassified

Presented at annual meeting of the Heat Transfer Symposium, St. Louis, Mo., Dec. 13-16, 1953.

Convection heat transfer coefficients for the cooling of steam and air flowing inside a 2-in. pipe were measured from 500° to 1200°F at gas-to-wall temperature differentials of 300° to 1000°F, and over a range of Reynolds numbers from 2000 to 20,000 for air and 5,000 to 60,000 for steam. The convection heat transfer coefficients for air increased slowly with temperature level. Similar measurements with steam indicated that published information on the emissivity of steam were satisfactory for predicting radiation contribution encountered within the above range of variables. Data taken with different entrance conditions indicated that the convection coefficients could be increased several hundred percent at constant Reynolds number by substituting a jet entry for the usual straight entrance section with well developed turbulence. (Contractor's abstract)

PRI. 11:187

Purdue U. Lafayette, Ind.

LATTICE PARAMETERS OF THE $FeFe_{(2-x)}Cr_xO_4$ SPINEL SYSTEM, by H. J. Yearian, J. M. Kortright, and R. H. Langenheim. Feb. 9, 1954, 3p. incl. illus. table, refs. (Proj. Squid technical rept. no. PUR-26-P) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503, N6ori-10401, and N7onr-39419) AD 50674 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1196-1198, July 1954.

Spinels of the $FeFe_{(2-x)}Cr_xO_4$, $0 < x < 2$, system have been made by reduction of the corresponding sesquioxide solid solution at 1180°, 1100°, and 950°C and the lattice parameters determined at room temperature. The solutions of approximately stoichiometric composition have lattice parameters which vary with x in a nonlinear manner from 8.396 ± 0.002A at $x = 0$ to 0.376 ± 0.002A at $x = 2$. The four essentially linear segments comprising the total curve are interpreted as follows: from $x = 0$ to $x = 0.3$ the structure is completely inversed; from $x = 1.28$ to $x = 2.0$ it is completely normal; between these regions reversion from the inversed to the normal form occurs in two successive stages. Oxygen rich spinels crystallized at 950°C show the same general variations of parameter but the region of complete inversion extends to approximately $x = 0.6$.

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Purdue U. Lafayette, Ind.

THE STRUCTURE OF OXIDE SCALES ON CHROMIUM STEELS, by H. J. Yeartan, E. C. Randell and T. A. Longo. July 18, 1955, 11p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PUR-30-P) (Sponsored jotntly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503, [N6ori-10401, and N7onr-39419]) AD 123681 Unclassified

Also published in Corrosion, v. 12: 515-525, Oct. 1956.

The structure of the oxide scale which ts formed on commercial Cr steels containing from 5 to 26% Cr when oxidtzed in air or O from 700° to 1160°C for times up to 100 hr was determtned by x-ray dtffraction methods supplemented in some tnstances by chemical analysis. Two dtstinct scale types were observed: an A type scale occurs when the rate of metal loss ts less than approximately 10 mg/sq cm/day, and a B type occurs when the attack rate is tn the excesstve range. For exposures near the critical conditions, an tnitial A type scale transforms to B type durtng oxidation. The essential component of the A type scale is Cr_2O_3 which is usually accompanied by αFe_2O_3 in an amount which tncreases with the Fe conteni of the alloy. The B type scale, which ts more complex than A scale, may be considered as 2 layers. The duplex outer layers is similar to the Fe_3O_4 and Fe_2O_3 layer of the scale on pure Fe. The maior constituent of the inner layer, corresponding to the FeO layer on pure Fe ts a solid solution $FeFe_{(2-x)}Cr_xO_4$, of the spinel type. Experimental data are compared and contrasted with existing data and are qualttatively interpreted by use of a tentatively proposed Fe-Cr-O phase diagram and a special theory of alloy oxidation.

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Purdue U., Lafayette, Ind.

STRUCTURE OF OXIDE SCALES ON NICKEL-CHROMIUM STEELS, by H. J. Yearian, H. E. Boren, Jr., and R. E. Warr. July 18, 1955, 8p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PUR-31-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503, [N6ori-10401], and N6onr-39419) AD 123682 Unclassified

Also published in Corrosion, v. 12: 561-564, Nov. 1956.

The structure of the scales formed on a series of typical Ni-Cr steels when oxidized for 100 hr in air at temperatures from 1600° to 2200°F were investigated by x-ray diffraction methods. The scales are of two distinct types. The principal and definitive constituent of the more protective type is Cr_2O_3. A solid solution of Fe_2O_3 - Cr_2O_3 also may be present; in such cases its Fe_2O_3 content tends to increase with attack rate at any given temperature. For very low attack rates considerable amounts of $MnCr_2O_4$ occur when the alloy contains a few tenths percent of Mn. As the attack rate increases this Mn-chromite spinel ts replaced by a Ni-Cr-Fe spinel, the amount and the alloying element content of which increase with temperature and wtth the Ni level of the alloy. For an 80 Nt-20 Cr alloy, NtO is also present. When the attack rate becomes excesstve the scale changes to a type containing no Cr_2O_3 phase but consisting of one or more Fe_2O_3-Cr_2O_3 solutions and Ni-Cr-Fe spinels. The ferrtc-chromic oxide solution tends to concentrate in the outer layer and tt then contains less than 10 mole per cent Cr_2O_3; the proportion may increase when tt occurs tn an tnner layer. Sptnels are present tn all layers but thetr content of the alloying elements tncreases tn the tnward direction. These results are compared with existing data and tnterpreted using a theory of selective oxidation and depletion. (Contractor's abstract)

PRI. tt:t90

Purdue U., Lafayette, Ind.

A LITERATURE SURVEY ON SOME PHYSICAL ASPECTS OF THE COMBUSTION OF FALLING FUEL DROPS, by P. M. Blair. Nov. 1955, 79p. incl. illus. refs. (Proj. Squid technical rept. no. PUR-27-R) (Sponsored jotntly by Office of Naval Research, Atr Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 757t2 Unctassified

Dynamics of falling drops: A classtfication by size is proposed for small homogeneous solid and liquid gas dispersoid particles in order to provide a frame of reference for comparing the stzes of fuel drops in a turbojet combustor with other particles. Vartous methods for studytng the combustion of individual fuel droplets are discussed. The dynamics of rigid spheres are revtewed, and available terminal velocity and drag coefficient data are given for liquid drops falling in 70°F air. Factors determining the size and shape of stable falling drops are discussed. Heat transfer for drops and spheres: Summarles are given of theoretical analyses which have been reported on (t) heat transfer to a sphere immersed in flowing fluid in the absence of mass transfer, and (2) heat transfer to a hypothetical spherical fuel drop burning in still air and surrounded by a concentric flame front. Data are presented which show an increase in the Nusselt numbe: with increasing turbulence intensity for spheres in a turbulent air

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stream. Mass transfer for drops and spheres: The laws for molecular and eddy diffusion are given for mass transfer in the absence of heat transfer, and experimental results showing the effect of relative air velocity on such mass transfer coefficients are summarized. A report is given of investigations which show the effect of instantaneous drop diameter on the mass transfer rate of drops in still air and drops in an air stream. The derivation of a general 3-dimensional heat-conduction equation is outlined.

PRI. 11:191

Purdue U., Lafayette, Ind.

INVESTIGATION OF THE FACTORS AFFECTING THE ATTACHMENT OF A LIQUID FILM TO A SOLID SURFACE, by C. F. Warner and B. A. Reese. June 1956 [30] p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PUR-28-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 98478 Unclassified

Presented at fall meeting of the Amer. Rocket Soc., Buffalo, N. Y., Sept. 24-26, 1956.

Results are summarized for an experimental investigation of the film-attachment phase of the film-flow study and of an empirical equation based on momentum exchange which correlates the film-attachment results with 2- and 3-dimensional flow fields. The injection of liquid through slots resulted in the establishment of stable films on solid surfaces over a relatively large range of liquid flow rates with a variety of geometric configurations for air velocities ranging from 40 to 630 fps. The critical velocity of injection decreased with increases in slot width and increased with increases in air velocity and angle of injection; separation was not obtained with angles larger than 75°. The critical velocity of injection (V_i^*) is independent of liquid surface tension and viscosity but is a function of the liquid and air densities (momentum). Equations are presented for predicting V_i^*. Large velocities of injection, below but approaching V_i^*, resulted in the formation of surface disturbances on the film surface and the entrainment of a considerable portion of the injected liquid by the air stream.

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Purdue U., Lafayette, Ind.

THE FORMATION OF OXIDE FILMS ON CHROMIUM AND 18 Cr-8 Ni STEELS, by H. J. Yearian, W. D. Derbyshire, and J. F. Radavich. June 22, 1956 [11 p. incl. illus. tables, refs. (Proj. Squid technical rept. no. PUR-36-P) (Sponsored jointly by Office of Naval Research and [Air Force Office of Scientific Research] under N6ori-10401, N7onr-39419, and [N6ori-10503]) AD 205692 Unclassified

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

Also published in Corrosion, v. 13: 597-607, Sept. 1957.

The formation of oxide films on simple chromium steels and 18-8 stainless steels oxidized in air at temperatures of 300° to 700°C has been studied by electron microscopy, electron diffraction and x-ray diffraction methods. A thin uniform film forms in the first few minutes of oxidation and grows very slowly thereafter. As oxidation proceeds the protectiveness of the base film fails at randomly distributed positions, permitting the rapid growth of localized polycrystalline nodules of oxide. These nodules continue to grow and new ones are formed until the base film is completely covered. The rate at which the process proceeds depends on alloy composition and temperature in the same way as does the scaling rate at higher temperatures. There is no evidence that the failure is due to cracking of the base film. There seems to be no deterimental effect produced by the usual amounts of minor constituents in the alloys. Local failure may be due to blistering or recrystallization. The principal component of the base film is a solid solution of ferric and chromic oxides preferentially oriented with the (111) plane parallel to the surface. The degree of the orientation and the chromic oxide content of the solution increase with time of oxidation. A small amount of spinel may be present also. In the case of the 18 Cr-8 Ni alloy the spinel contains some Ni. The nodules are principally Fe_2O_3 or a low chrome ferric-chromic oxide solution and contain somewhat more spinel than does the base film. (Contractor's abstract)

PRI. 11:193

Purdue U., Lafayette, Ind.

SOME CONSIDERATIONS OF FILM COOLING FOR ROCKET MOTORS, by M. J. Zucrow and A. R. Graham. July 1956 [40] p. incl. illus. table, refs. (Proj. Squid technical rept. no. PUR-29-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 108768 Unclassified

Presented at fall meeting of the Amer. Rocket Soc., Buffalo, N. Y., Sept. 24-26, 1956.

The basic considerations pertinent to the film cooling of a circular duct with a liquid are presented. Film thickness studies and a study of the theoretical correlation equations for the heat-transfer coefficient for a film-cooled duct indicate that, before film cooling of rocket motors can be put on a sound engineering basis, experimental data are required on the relationships between the friction coefficient, the film coolant

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flow, and the Reynolds number for the gas flow. Data are also required for relating the film-cooled length, the liquid-coolant flow rate, and the properties of the liquid coolant. Tests are needed to determine the effect of film cooling on performance when reactive film coolants such as jet engine fuel and WFNA are used.

PRI. 11:194

Purdue U. [Rocket Lab] Lafayette, Ind.

THE HYPERGOLIC REACTION OF DICYCLOPENTADIENE WITH WHITE FUMING NITRIC ACID, by C. H. Trent and M. J. Zucrow. June 15, 1951 [3]p. incl. illus. tables. [Proj. Squid technical rept. no. PUR-13-P; technical rept. no. 43] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-10503) AD 9094 Unclassified

Also published in Jour. Amer. Rocket Soc., v. 21: 129-131, Sept. 1951.

The photographic study of the hypergolic reaction between dicyclopentadiene and anhydrous nitric acid indicates that a solid phase is formed prior to ignition and that the ignition of the propellant is propagated from the solid phase. The latter has been isolated. Although the identity of the solid phase remains unknown, characterization tests have indicated that it is a nitrated polymer containing the nitro group and the nitrate ester group. (Contractor's abstract)

PRI. 11:195

Purdue U. Rocket Lab., Lafayette, Ind.

BEHAVIOR OF LIQUID HYDROCARBONS WITH WHITE FUMING NITRIC ACID, by C. H. Trent and M. J. Zucrow. Feb. 26, 1952 [7]p. incl. illus. tables. refs. [Proj. Squid technical rept. no. PUR-18-P; technical rept. no. 43] (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under N6ori-10503) AD 9093 Unclassified

Also published in Indus. Engineering Chem., v. 44: 2668-2673, Nov. 1952.

A problem often encountered in the development of liquid bipropellant rocket engines is that of reliably igniting propellants that are not spontaneously inflammable upon contact. One fuel currently specified for certain types of rocket engines is a hydrocarbon fuel endowed with physical properties common to both gasoline and kerosene. That fuel is not spontaneously inflammable with either liquid oxygen or white fuming nitric acid, and presents the problem of igniting these propellant combinations in the rocket motor. The lack of knowledge of the ignition behavior of hydrocarbon fuels when

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oxidized by white fuming nitric acid provided the impetus behind an experimental study of the ignition behavior with white fuming nitric acid of a number of pure hydrocarbons reacted under conditions simulating those found in actual rocket motors. Twenty hydrocarbon compounds possessing different molecular structures were treated with anhydrous nitric acid and the relative rates of reaction (determined by measuring rates of temperature rise, during the liquid phase reaction), the maximum reaction temperatures produced, and the minimum ignition temperature were measured. The correlation among the time to reach maximum reaction temperature, the maximum reaction temperature produced, and the minimum ignition temperature indicates that the principal factors governing the minimum ignition temperature are the concentration and the thermal instability of the unstable intermediate products formed. The maximum reaction temperature produced is a factor in determining the quantity of additional energy necessary to initiate combustion. The present study indicates, that from the standpoint of ease of ignition, the presence of high concentrations of unsaturated hydrocarbons, especially diolefins, in hydrocarbon fuels is desirable, as these compounds react rapidly with white fuming nitric acid, produce high maximum temperatures, and require relatively low temperatures to initiate combustion. Highly aromatic hydrocarbon fuels may be undesirable. Despite their rapid reaction in the liquid phase, all the aromatic hydrocarbons tested exhibited high ignition temperatures. (Contractor's abstract)

PRI. 11:196

Purdue U. [Rocket Lab.] Lafayette, Ind.

EXPERIMENTAL PERFORMANCE OF WFNA-JP-3 ROCKET MOTORS AT DIFFERENT COMBUSTION PRESSURES, by M. J. Zucrow and C. M. Beighley. May 19, 1952 [8]p. incl. illus. tables. [Proj. Squid technical rept. no. PUR-19-P; technical rept. no. 46] (Sponsored jointly by [Office of Naval Research and Air Force Office of Scientific Research] under N6ori-10503) AD 9143 Unclassified

Also published in Jour. Amer. Rocket Soc., v. 22: 323-330, Nov.-Dec., 1952.

The performance and heat transfer rates for 500-lb thrust, L* = 100 in., rocket motors were determined experimentally as a function of mixture ratio at 300-, 500-, and 700-psia combustion pressures. In all cases the propellants used were white fuming nitric acid (WFNA) and jet engine fuel (JP-3). The maximum values of specific impulse were obtained at a mixture ratio of 4.5 and the values were 222, 235, and 246 for 300-, 500-, and 700-psia combustion pressure, respectively. Raising the combustion pressure from 300 psia to 700 psia increased the over-all heat transfer for the thrust cylinder from 1.3 to 2.3

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Btu/sq. in./sec and that for the nozzle from 2.8 to 6.0 Btu/sq. in./sec. (Contractor's abstract)

PRI. 11:197

Wisconsin U. Naval Research Lab., Madison.

EQUATIONS OF A SIMPLE FLAME SOLVED BY SUCESSIVE APPROXIMATIONS TO THE SOLUTION OF AN INTEGRAL EQUATION. PART I. FIRST ORDER REACTION, by G. Klein. June 9, 1954, 24p. incl. illus. tables. ([Proj. Squid technical rept. no. WIS-1-R, pt. 1]; WIS-ONR-8) (Also bound with its AD 64151, as part 1) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and N7onr-28511) AD 37302
Unclassified

The problem of idealized flame whose underlying chemical reaction is unimolecular, reversible, and of the first order, is reconsidered; the kinetic energy of the gas stream is neglected. The solution depends on the solution of an integral equation which contains an unknown parameter whose eigenvalue has to be determined. The equation is solved by a method of sucessive approximations.

PRI. 11:198

Wisconsin U. Naval Research Lab., Madison.

EQUATIONS OF A SIMPLE FLAME SOLVED BY SUCCESSIVE APPROXIMATIONS TO THE SOLUTION OF AN INTEGRAL EQUATION. PART II. SECOND ORDER REACTION, by G. Klein. Sept. 30, 1954, 60p. incl. illus. tables. ([Proj. Squid technical rept. no. WIS-1-R, pt. 2]; WIS-ONR-13) (Also bound with its AD 64151, as part 2) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503 and N7onr-28511) AD 46170
Unclassified

The problem of an idealized flame whose underlying chemical reaction is unimolecular and reversible (where the kinetic energy of the gas stream is neglected), which has been solved by integral equation method of successive approximations for a first reaction (Part I), is now extended to a second order reaction. The problem is very nearly equivalent to that of a simple chain reaction flame in which the catalyst reactions are assumed to be in equilibrium. In this case the behavior near the hot boundary of the functions involved is very different from that of the case of a first order reaction, and a careful choice of the integral equation and of the lowest approximation to be adopted has to be made. The diffusion coefficient is assumed constant: for a certain value of this constant

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the problem simplifies considerably, and for other values an alternative perturbation and expansion method is proposed which involves only linear differential equations. It is verified that neglect of of the back reaction affects the method and results immaterially, and the effect of varying the hot boundary temperatures is briefly considered. (Contractor's abstract)

PRI. 11:199

Wisconsin U. Naval Research Lab., Madison.

EQUATIONS OF A SIMPLE FLAME SOLVED BY SUCCESSIVE APPROXIMATIONS TO THE SOLUTION OF AN INTEGRAL EQUATION. PART III. A SIMPLE IDEAL NON-BRANCHING CHAIN REACTION FLAME, by G. Klein. Feb. 25, 1955 [40]p. incl. illus. tables. ([Proj. Squid technical rept. no. WIS-1-R, pt. 3]; WIS-Squid-2) (Also bound with its AD 64151, as part 3) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 58376
Unclassified

A chain reaction flame of the type $A \rightleftharpoons B$, $AB \rightleftharpoons B + C$ is considered and its equations are solved by a generalization of the method employed in Parts I and II. The reaction rate of the second reaction is assumed of the form $R_c = \omega \left\{ x_A x_B F_{AB}^{(\tau)} - X_B X_C F_{BC}^{(\tau)} \right\}$ where ω is a parameter whose value is left open. It is assumed that the reaction rate of the first reaction, $R_B = X_A f_A^{(\tau)} - X_B f_B^{(\tau)}$ can be expanded in the form $R_B = \omega r(\tau;\omega) = \omega \left\{ r_0^{(\tau)} + \omega r_1^{(\tau)} + \omega^2 r_2^{(\tau)} + \dots \right\}$, a hypothesis which appears justified by the rapidity of the convergence obtained. For the standard value of the reduced diffusion constant ($\delta = 1$) the rate of production of B is negative near the cold boundary, showing that the component corresponding to a free radical of a real flame occurs in the low temperature region overwhelmingly by diffusion. (Contractor's abstract)

PRI. 11:200

Wisconsin U. Naval Research Lab., Madison.

EQUATIONS OF A SIMPLE FLAME SOLVED BY SUCCESSIVE APPROXIMATIONS TO THE SOLUTION OF AN INTEGRAL EQUATION. PART IV. SIMPLE IDEAL FLAME MODEL SUGGESTED BY THE HBr FLAME, by G. Klein. Apr. 18, 1955 [18]p. incl. illus. tables. ([Proj. Squid technical rept. no. WIS-1-R, pt. 4]; WIS-Squid-3) (Also bound with its AD 64151, as part 4) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 61774
Unclassified

PRI. 11:201 - PRI. 11:203

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

The method of Paris I - III has been adapted to an ideal flame based on the reaction $A + B \rightleftharpoons C$ where the masses and the mutual diffusion coefficients in the three component system are unequal. The form of the reaction rate and the numerical data used were suggested by the data for the HBr flame of which the present problem is an idealization. (Contractor's abstract)

PRI. 11:201

Wisconsin U. Naval Research Lab., Madison.

EQUATIONS OF A SIMPLE FLAME SOLVED BY SUCCESSIVE APPROXIMATIONS TO THE SOLUTION OF AN INTEGRAL EQUATION. PART V. A SIMPLE IDEAL BRANCHING CHAIN REACTION FLAME, by G. Klein. Aug. 5, 1955 [37]p. incl. illus. tables. ([Proj. Squid technical rept. no. WIS-1-R, pt. 5]; WIS-Squid-4) (Also bound with its AD 64151, as part 5) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 75714
Unclassified

The equations of a one-dimensional stationary flame $A \rightleftharpoons 2B$ and $A + B \rightleftharpoons B + C$ are solved by a perturbation method. The unperturbed equations are those of the reduced problem in which (1) the first reaction is in equilibrium, and (2) the diffusion constant, $\delta = \delta_{AB} = \delta_{AC} = \delta_{BC}$, has the special value unity; the reduced problem is solved by successive approximations to the solution of an integral equation. The results are qualitatively very similar to those of the $A \rightleftharpoons B$, $A + B \rightleftharpoons B + C$ problem already treated, (cf. Part III); in particular, one finds that the component B, corresponding to a free radical in a real flame, occurs in the cold temperature region overwhelmingly by diffusion, its rate of chemical production there being negative. (Contractor's abstract)

PRI. 11:202

Wisconsin U. Naval Research Lab., Madison.

DERIVATION OF THE FLAME EQUATIONS, THEIR TRANSFORMATION AND SUGGESTED METHOD OF THEIR SOLUTION, by G. Klein. Feb. 25, 1955, 92p. incl. illus. tables, refs. (Proj. Squid technical rept. no. WIS-2-R; rept. no. WIS-Squid-1) (Sponsored jointly by Office of Naval Research, [Air Force] Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 75715; AD 74926
Unclassified

The equations of a one-dimensional flame under stationary conditions are deduced from the general equations of a gas mixture, and their boundary conditions are discussed. These flame equations are transformed so as to make them amenable to solution by a perturbation method of successive approximations. They are divided into (a) two principal equations, formally analogous to the equations of a unimolecular reaction flame $A \rightleftharpoons B$, and (b) subsidiary equations containing the remaining physical relations. The core of the flame problem is then an ordinary, non-linear differential equation involving an eigenvalue parameter, and a method of its solution as an integral equation is given. It is suggested that the general flame equations should be solved by several stages of simplified problems (ideal flames). Earlier work on ideal flames, such as $A \rightleftharpoons 2B$, $A + B \rightleftharpoons B + C$, is reviewed, and the general formalism is illustrated by reference to the HBr flame.

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PRI. 11:203

Wisconsin U. Naval Research Lab., Madison.

FLAME PROPERTIES AND THE KINETICS OF CHAIN-BRANCHING REACTIONS, by J. C. Giddings and J. O. Hirschfelder. May 1956, 31p. incl. illus. tables, refs. (Proj. Squid technical rept. no. WIS-3-R) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 94370
Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 199-212.

Calculations are presented for the flame velocity and chemical profiles of a prototype chain-branching system with a second-order chain-breaking step: $2B \xrightarrow{k_1} A$ and $A + B \xrightarrow{k_2} 2B + C$. The constants which were used were chosen to reproduce some of the features of H-O combustion. The values of the assumed diffusion coefficients were varied greatly without appreciably affecting either the flame velocities or the chemical profiles. A criterion is presented for the deviation of the free-radical concentrations from their pseudo-steady-state values. Deviations from the pseudo steady state are explained in terms of a time lag in the formation and destruction of the free radicals with a diffusional effect which varies as the second derivative of the free-radical concentration with respect to the coordinate. The purely diffusional theories of flames are shown to be incorrect in 2 respects: (1) the free radicals actually diffuse away from the flame-holder in the hot part of the flame where most of the reactions occur, and (2) the flame velocity is almost independent of the coefficients of diffusion of the radicals. The ABC flame studied by Klein (rept. no. WIS-SQUID-1; item no. PRI. 11:202) was used as an example for the deviations from the pseudo steady state as a function of t_B/t_A. t_B and t_A are the relaxation times for free-radical formation and the over-all reaction, respectively.

Princeton U. James Forrestal Research Center, N. J. (Project SQUID)

PRI. 11:204

Wisconsin U. Naval Research Lab., Madison.

A RELAXATION-TIME MODEL FOR FREE RADICAL CONCENTRATION, by J. C. Giddings. Aug. 1956, 18p. refs. (Proj. Squid technical rept. no. WIS-4-P) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 104499 Unclassified

A relaxation-time model was used for examining the accuracy of the quasi-equilibrium approximation in chemical kinetic studies. In the 2 general cases (time-lag and diffusion) which arise, the proposed model yields the same results as an approximate mathematical treatment. The kinetic processes in a flame front were examined and shown to involve the time-lag and diffusion cases. The model was justified by an independent approximate method. The model was examined in the region of the flame near the point of maximum reaction rate. A simple expression was found for the radical concentration at this point.

PRI. 11:205

Wisconsin U. Naval Research Lab., Madison.

THE PROPERTIES OF FLAMES SUPPORTED BY CHAIN-BRANCHING REACTIONS, by J. C. Giddings and J. O. Hirschfelder. Nov. 1956, 14p. incl. illus. tables. (Proj. Squid technical rept. no. WIS-5-P; WIS-Squid-7) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research under N6ori-10503) AD 112175; AD 109592 Unclassified

Presented at Ninth International Congress of Appl. Mech., Brussels (Belgium), Sept. 5-13, 1956.

A Semenoff-type kinetic scheme in which the chain-breaking step is first order in radical concentration (FOB) is compared with a non-Semenoff scheme with second-order chain breaking (SOB). Both reaction schemes have 3 components: a reactant (A), an intermediate free radical (B), and a product (C). In contradiction to diffusion theories of flame-propagation, data showed that a large increase in radical diffusion coefficient resulted in a slight decrease in flame velocity. For the FOB Semenoff kinetic scheme, an explosion limit exists at the point at which the rate of branching, k_3AB, equals the chain-breaking rate k_2B. Beyond this point, the rate of production of radicals becomes greater than their rate of destruction. The radical increases until the A disappears. The rate of heat release is so large that it can be considered an explosion. Numerical calculations were made on flames supported by the FOB Semenoff type sequence. Attainment of the explosion point at which the radical concentration and reaction rate go to infinity depends for a particular flame on the assumed reaction rates. The Klein Method (item no. PRI. 11:023) was used for solving the flame equations for 5 cases. The deviation of the actual concentration of B from the pseudostationary concentration $(B)^*$ is measured by ϵ, where $B = (1 + \epsilon)(B)^*$. A procedure is given for making a preliminary estimation of ϵ in the reaction zone which is very accurate. The estimation of ϵ was useful in selecting the flame parameters, since the Klein method of integration does not converge if ϵ is greater than about 0.4.

PRI. 12:001

Princeton U. [Dept. of Aeronautical Engineering] N. J.

HIGH SPEED AERODYNAMICS AND JET PROPULSION. VOLUME VI. GENERAL THEORY OF HIGH SPEED AERODYNAMICS, ed. by W. R. Sears. N. J., Princeton University Press, 1954, 758p. incl. illus. diagrs. tables, refs. ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Office of Ordnance Research] under Nonr-03201) Unclassified

This volume summarizes present-day knowledge in the theory of high speed aerodynamics. It begins with an over-all sketch of the subject by T. von Kármán. Largely nonmathematical, this section touches on the major features of subsonic, transonic, and supersonic, and hypersonic flows and emphasizes both important recent developments and some problems still unsolved. K. O. Friedrichs presents a new study of the mathematical nature of hyperbolic flows, i.e. supersonic or unsteady compressible flows. Following these introductory sections, attention is directed especially toward the theories based on the small disturbance hypothesis. W. R. Sears presents and summarizes subsonic small perturbation theory, with emphasis on recent studies that unify and clarify this subject, and on rotational and unsteady flows. M. A. Heaslet and H. Lomax present in a unified manner the whole subject of linearized supersonic theory, especially with application to wings. Also included in this section are the transonic and hypersonic nonlinear approximations. M. J. Lighthill discusses the methods of higher approximation which are used to improve the first order theories and to explain and eliminate their shortcomings. Y. H. Kuo and W. R. Sears collaborate in a section presenting a review of the theory of potential subsonic and mixed supersonic-subsonic plane flows based on the hodograph method. Finally in two sections, A. Ferri writes on the method of characteristics applied to steady two- and three-dimensional flows and flow patterns characterized by the presence of shock waves, including Ferri's recent work on the linearized methods of characteristics.

PRI. 12:002

Princeton U. [Dept. of Aeronautical Engineering] N. J.

HIGH SPEED AERODYNAMICS AND JET PROPULSION.

PRI. 12:003 - PRO. 01:001

VOLUME IX. PHYSICAL MEASUREMENTS IN GAS DYNAMICS AND COMBUSTION, ed. by R. W. Ladenburg, B. Lewis, and others. N. J., Princeton University Press, 1954, 578p. incl. illus. diagrs. tablee, refs. ([Sponsored jointly by Office of Naval Research, Air Force Office of Scientiftc Research, and Offtce of Ordnance Research] under Nonr-03201) Unclassified

This volume is concerned with physical measurements in gae dynamics and with the corresponding measurements in combustion processes. It recorde varying techniques whtch can be employed to measure denetty, pressure, velocttty, and temperature in gaseous eystems. It deals wtth shock front measurements by light reflectivity, turbulence measurements, condensation study by absorption or scattering of light, and analogue methods. The second half of the volume ts concerned with techniques and the measurement of properties in matertals undergoing combustion procesees.

PRI. 12:003

Princeton U. [Dept. of Aeronautical Engineertng] N. J.

HIGH SPEED AERODYNAMICS AND JET PROPULSION. VOLUME I. THERMODYNAMICS AND PHYSICS OF MATTER, ed. by F. D. Rossini. N. J., Princeton Universtty Press, 1955, 812p. incl. diagrs. tables, refs. ([Sponsored jointly by Offtce of Naval Research, Air Force Offtce of Sctentiftc Research, and Office of Ordnance Rseearch] under Nonr-03201) Unclaesifted

The bastc prtnctples of the thermodynamice and phystcs of maiter are presented from the standpoint of thetr applicabilily to a belter understanding of high speed aerodynamtcs and jet propulston. The volume ts dtvtded lnto the fotlowtng ten sections: Section A by F. D. Rosstni covers the fundamentale of thermodynamtcs; tn Section B, K. F. Herzfeld and V. Griffing discuss quantum mechanics, molecular structure, bond energies, and activation energies, and J. O. Htrschfelder, C. F. Curtiss, R. B. Btrd, and E. L. Spotz presenl slatistical mechanics and the kinetic theory of gases; Section C by J. A. Beattie gives a compleie treaiment of the thermodynamic properites of real gases and their mtxtures; in Section D, J. O. Hirechfelder, C. F. Curtiss, R. B. Btrd, and E. L. Spotz discuss the iransport properties of gases and gaseous mtxiures; in Section E, O. K. Rice covers critical phenomena, including association and condensation; Section F by J. M. Richardson and S. R. Brinkley, Jr. presents the theories of liquids and liquid solution; tn Section G, P. P. Ewald discusses solids and solid solutions, covering crystals, conductors, tnsulators, energy bands, and cooperaitve phenomena; Section H by K. F. Herzfeld covers relaxation phenomena in gases, including theory and experiment; tn Section I, I. Estermann presents a discussion of gases at tow densities, including molecular beams; in Section J, C. F. Curtiss discusses the thermodynamics of irreverstble processes, tncludtng flow processes, viscosity, thermal conductivity, and diffusion.

PRI. 12:004

Princeton U. [Dept. of Aeronautical Engineering] N. J.

HIGH SPEED AERODYNAMICS AND JET PROPULSION. VOLUME II. COMBUSTION PROCESSES, ed. by B. Lewis, R. N. Peaee, and H. S. Taylor. N. J., Princeton Universtiy Press, 1956, 662p. incl. illus. dtagre. tables, refs. ([Sponsored jointly by Office of Naval Research, Air Force Offtce of Sctentific Research, and Office of Ordnance Reeearch] undsr Nonr-03201) Unclaesifted

Thts volume ts concerned wtth combuetion processes in thstr various aepecte, encompaestng chemical kinetice, the kinetice of transport proceseee, fluid dynamics, and thermodynamtcs. It deale, therefore, with rate processes in chemtcal reactione, with the propagation of chemical reaction by the mechanieme of combustion waves and detonation wavee, with the effect of turbulence on combuetion wavee, with proceesee of simultaneoue mixing and combuetion of fuele and oxidante, and wtth chemical equilibrta. These eubjecte are bastc for an underetanding of the role of combustion in propulston processes. After a survey of basic principlee the preeentatton continuee with oxidation and flame propagation in gaseous systems and the combustion of liquid and solid fuels and propellants. Final sections of the book are devoted to detonation proceeeee and the princtplee of energy production by nuclear rsaction.

PRO. 01:001

Propulsion Research Corp., Santa Monica, Calif.

THEORETICAL AND EXPERIMENTAL INVESTIGATION OF A TWO-DIMENSIONAL ALL-SUPERSONIC DIFFUSING CASCADE AT MACH NUMBER 2.5, by E. Bedsr. June 1, 1955, 1v. tncl. tllus. dtagrs. tables, refs. (Rept. no. R-155) (AFOSR-TN-56-15) (AF 18(600)1143) AD 81780 Unclassifted

An all-supersonic 2-dimensional diffusing cascade was destgned for M = 2.5 and a slatic pressure ratio of 3.5:1. The tnlet flow angle from the cascade normal was 45°. Ths toial Mach number relative to ths blades remained supersonic, bui tts normal component was diffused from supersonic to subsonic (theoretically wtthoui the usual slrong transition shocks). Flow solutions were calcutated theoretically by the method of charactertstics. A 2-bladed model of the cascade, with an aspect ratio of 1.0 and a chord of t.625 tn., was tesied in a wind tunnel at M = 2.5 and Re/tn. ≈ 400,000. As an aid in investigating flow starting, breakdown, and changes in the slructure of slarted flows, (pressure gradients, throat location, etc.), the model design permitted adjustability (durtng running) of the following geometrical features: solidtty, inlet flow angle, back pressure, and discharge-flow passage angle. Blade surface slatic pressures, Schlieren photographs, and pitot-pressure surveys were taken. Qualitative effects of sidewall boundary-tayer bleed were investigated. Theoretical and experimental

results were compared for starting throat capture area ratios, and surface static pressures and waves of started flows.

PRO. 01:002

Propulsion Research Corp., Santa Monica, Calif.

THE STREAMSURFACE CHARACTERISTICS METHOD FOR SUPERSONIC FLOW, WITH APPLICATION TO SUPERSONIC COMPRESSORS, by H. G. Loos. May 1956, 93p. incl. diagrs. (Rept. no. R-207) (AFOSR-TN-56-367) (AF 18(600)1143) AD 95803 Unclassified

The characteristics method was developed for the analysis of supersonic flows along a curved surface S of general but given shape and with a given dtstance A to an inftnitesimally adjacent streamsurface. The resulting compatibility equations have a simple form and from them the equations for all possible applications of the 2-dimensional charactertstics method to the analysis of tsentropic supersonic flows can be derived. Application to the axisymmetric approximation of the supersonic flow through a compressor rotor is estimated to give a 30% labor saving, compared with an earlier method. A simple semigraphtcal method is suggested that can be used when S is developable tn a plane and no body forces are present. (Contractor's abstract)

PRF. 01:001

Purdue Research Foundation, Lafayette, Ind.

A PROCESS OF RETRACTION, by L. Cesari. Dec. 1955, 14p. refs. (Technical note no. 1) (AFOSR-TN-56-19) (AF 18(600)1484) AD 104815 Unclassified

The concept of retraction, applied in a previous analysis (Surface Area, Princeton Univ. Press, 1956) to surfaces deftned as continuous mappings from a simple closed Jordan region A, ts extended to the case of surfaces deftned as continuous mappings from a finitely connected Jordan region A = J of type ν, where ν ts the connectivtty of J, $0 \leq \nu < \omega$.

PRF. 01:002

Purdue Research Foundation, Lafayette, Ind.

PROPERTIES OF CONTOURS, by L. Cesari. Dec. 1955, 42p. refs. (Technical note no. 2) (AFOSR-TN-56-20) (AF 18(600)1484) AD 104816 Unclassified

Also pubitshed tn Rend. Matem. Appl., Roma, v. 15: 341-365, 1956.

The concept of a continuum of the boundary of an open set ts introduced. This concept ts related to that of prime-end (Math. Annalen, v. 73: 323-370, 1913) and the concept of the left and rtght wing of a prime-end (Memoirs Amer. Math. Soc., v. 3: 1951). A smoothing process for contours is introduced through topological considerations. This process results in more slender continua contained in a given contour with the property that they can be approached from both sides, a property which may not be shared by ordinary contours and general continuous surfaces.

PRF. 01:003

Purdue Research Foundation, Lafayette, Ind.

B-SETS AND FINE CYCLIC ELEMENTS, by C. J. Neugebauer. July 1956, 38p. (Technical note no. 4) (AFOSR-TN-56-356) (AF 18(600)1484) AD 95442 Unclassified

A decomposition of proper cyclic elements for certain surfaces is reanalyzed by generalizing the concept of a set being cyclic. The analysis is with reference to Peano spaces P in which a proper cyclic element is a cyclic A-set, a closed set A of P with the property that each component of P-A has only a single frontier point. This concept is generalized to that of a continuum B of P such that the frontier of each component of P-B decomposes into a finite number of points. Such sets are called B-sets, and a fine cyclic element is defined as a B-set which remains connected after the removal of a finite set of points. Since a B-set need not be a Peano space, only Peano spaces are considered whose degree of multicoherence ts finite.

PRF. 01:004

Purdue Research Foundation, Lafayette, Ind.

NON DEGENERATE SURFACES OF FINITE TOPOLOGICAL TYPE, by W. H. Fleming. July 1956, 6p. (Technical note no. 5) (AFOSR-TN-56-357) (AF 18(600)1484) AD 95443 Unclassified

A direct generalization is given of Morrey's theorem to surfaces of the topological type of any compact connected 2-manifold, orientable or not, with or without boundary. The main theorem states that every nondegenerate Fréchet surface of any finite topological type τ with finite Lebesque area has a quasi-conformal representation T(w). The domain of T(w) may be taken as a certain normalized parallel slit domain. T(w) ts defined as a continuous mapping from A (a compact, connected 2-manifold) tnto euclidean N-space E_N ($N \geq 3$). A surface S is called nondegenerate (of topological type τ) if S has a representation (T, A) such that for every $g \in \Gamma(T, A)$: (1) no boundary γ_t of A is contained tn g, or A ts not contained tn g when A ts closed; (2) $g \cap \gamma_t$ ts nonempty for at most one value of t; (3) g does not separate A; and (4) an open set $G \supset g$ exists such that any relatively closed curve ζ situated tn G separates A.

PRF. 01:005

Purdue Research Foundation, Lafayette, Ind.

ON SURFACES OF THE TYPE ν, by L. Cesari. Apr.

PRF.01:006 - PRF.02:003

1956, 76p. incl. diagrs. refs. (Technical note no. 3) (AFOSR-TN-56-358) (AF 18(600)1484) AD 95444 Unclassified

The tools introduced by Cesari in his book (Surface Area, Princeton Univ. Press, 1956) are developed. The concept of retraction is discussed for continuous mappings S = (T, A) from a finitely connected Jordan region A = J, mappings, or surfaces of the ν-type with ν the connectivity of J, $0 \leq \nu < \infty$. For certain simple elements of a Jordan region of type $\nu \geq 1$, a concept of fine cyclic element σ of the surface S = (T, A) is introduced as a retraction. The concept and properties of these fine-cyclic elements are discussed in great detail

PRF.01:006

[Purdue Research Foundation, Lafayette, Ind.]

FINE-CYCLIC ELEMENTS OF SURFACES OF THE TYPE ν, by L. Cesari. [1956] 39p. incl. refs. [AF 18(600)1484] Unclassified

Published in Riv. Matem. Univ. Parma, v. 7: 149-185, 1956.

Let T be a single valued continuous mapping from a closed finitely connected Jordan region J in two-space into n-space. Denote by Γ the class of all the disjoint maximal continua of constancy for T in J. A continuum K in J is said to have property P_1 with respect to (T, J) if for every component ν of J−K the mapping T is constant on each component of the boundary of ν in J. A continuum K in J is said to have property P_2 with respect to (T, J) if for every component ν of J−K the common part of γ and its boundary is either empty or a subset of exactly one of the curves bounding J. A continuum K in J is said to have property P' with respect to (T, J) if every element of Γ which intersects K is a subset of K. A non-empty continuum K in J is defined to be a fine cyclic element of (T, J) if (1) K has both properties P_1 and P'; (2) T is not constant on K; (3) K is minimal with respect to properties (1) and (2). For each point w_0 in J let Ω denote the set of all points w in J for each of which there does not exist a finite subset of Γ whose union separates w_0 from w in J. It is shown that either Ω is the element of Γ containing w_0 or there are fine cyclic elements of (T, J) containing w_0 and Ω is the union of all such. It is proved that the class of fine cyclic elements of (T, J) is countable. Each fine cyclic element K_i of (T, J) is contained in a finitely connected closed Jordan region J_i contained in J and such that K_i has properties P_1, P_2, P' with respect to (T, J_i). The mapping T_i defined on J_i by the requirements that it agree with T on K_i, and map each component of $J_i - K_i$ onto the point onto which T maps the boundary of that component relative to J_i, is termed the retraction of (T, J) with respect to K_i in J_i. It is shown that the Lebesgue area $L(T_i, J_i)$ of the surface represented by (T_i, J_i) is independent of the choice of the region J_i subject to the conditions described above. If L(T, J) denotes the Lebesgue area of the surface represented by (T, J) it is proved that $L(T, J) = \sum L(T_i, J_i)$. (Math. Rev. abstract)

PRF.02:001

Purdue Research Foundation, Lafayette, Ind.

COMMUTATORS AND ABSOLUTELY CONTINUOUS OPERATORS, by C. R. Putnam. July 1957, 17p. refs. [Technical note no. 1] (AFOSR-TN-56-457) (AF 18(603)139) AD 97073 Unclassified

Also published in Trans. Amer. Math. Soc., v. 87: 513-525, Mar. 1958.

Two parts form the paper on commutators and absolutely continuous operators; Part I has five general theorems on commutators C and the associated sets W_C, while Part II will be devoted to applications of some of these results, in particular to Toeplitz, Hankel, and Jacobi, with three additional theorems. The methods of C. R. Putnam (Proc. Amer. Math. Soc., v. 7: 1026-1030, 1956) used with operators which are bounded linear transformations on a Hilbert space consisting of elements x, give the results.

PRF.02:002

Purdue Research Foundation, Lafayette, Ind.

ON SQUARE ROOTS OF NORMAL OPERATORS, by C. R. Putnam. July 1957 [3]p. (Technical note no. 2) (AFOSR-TN-56-479) (AF 18(603)139) AD 97363 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 768-769, Aug. 1957.

The closed, convex set $W = W_A$ is investigated such that a criterion is found guaranteeing that the square root A of the normal operator N is normal due to the closure of the set of values (Ax, x) where $||x|| = 1$. It is proved that when N is a fixed normal operator and A an arbitrary solution of $A^2 = N$, if a line L exists in the complex plane passing through the origin and lying entirely on one side of (and all, or partly, in) the set W_A, then A is normal.

PRF.02:003

Purdue Research Foundation, Lafayette, Ind.

A NOTE ON FINITE MATRICES, by C. R. Putnam. [1956] 3p. (AFOSR-TN-56-480) (AF 18(603)139) AD 97364 Unclassified

It is shown that the number 0 is interior to the set W, a convex set consisting of values (Cx, x) where C = AB-BA from finite m x n matrices A and B and x, a complex-valued, n component vector of length 1, in the following senses. Either W consists of 0 alone or, if W is a segment or a two-dimensional set, 0 is in W, but is not a boundary point. The proof is independent of the trace arrangement and is valid in the case in which all the diagonal elements of C are zero

Purdue U., Lafayette, Ind.

N6ori-10503, N6ori-10401, and N7onr-39419, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:181-PRI. 11:193.

PUR. 01:001

Purdue U. Dept. of Chemistry, Lafayette, Ind.

ON THE STRUCTURE OF THE RHENIDE ION, by J. W. Cobble. July 26, 1956, 10p. incl. diagr. refs. (AFOSR-TN-56-348) (AF 18(600)1525) AD 95434 Unclassified

Also published in Jour. Phys. Chem., v. 61: 727-729, June 1957.

In this study, the thermodynamic factors controlling the stability of the rhenide ion are examined. It is concluded that the structure of the aqueous ion is not simple, consisting rather of some type of an oxygenated complex such as $H_8ReO_4^-$. The instability of a hypothetical simple Re^- ion based essentially through analysis of the Born cycle, upon a high sublimation energy for Re metal which cannot be compensated by a reasonable electron affinity. The expectation is that solid rhenides must be "hydrated" to be stable. Other ions of this general type are also examined, and it is considered that, $W(H_2O)_4^=$ likely would not be stable while $Ta(H_2O)_8^-$ and $Tc(H_2O)_4^-$ might be. (Contractor's abstract, modified)

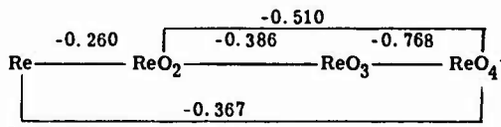
PUR. 01:002

Purdue U. Dept. of Chemistry, Lafayette, Ind.

THERMODYNAMIC PROPERTIES OF TECHNETIUM AND RHENIUM COMPOUNDS. VI. THE POTENTIAL OF THE ReO_3/ReO_4^- ELECTRODE AND THE THERMODYNAMICS OF RHENIUM TRIOXIDE, by J. P. King and J. W. Cobble. July 20, 1956, 15p. incl. diagr. tables, refs. (AFOSR-TN-56-349) (AF 18(600)-1525) AD 95435 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 1559-1563, Apr. 5, 1957.

The potential of the ReO_3/ReO_4^- electrode was measured over a wide range of concentration and pH and the standard electrode potential for the half reaction $ReO_3 + H_2O = ReO_4^- + 2H^+ + e^-$ was found to be -0.768 ± 0.005 v. The cell was demonstrated to be satisfactorily reversible by close agreement of the standard potential calculated from measurements in both acidic and basic solutions, as well as from the reasonable entropy values obtained from a determination of the temperature coefficient. The thermodynamic functions for ReO_3 (c) were found to be -146.1 ± 0.8 kcal mol^{-1}, -128.1 ± 0.8 kcal mol^{-1} and 19.3 ± 2.5 cal mol^{-1} deg^{-1} for the heat of formation, free energy of formation, and the entropy, respectively. The revised potential diagram for Re in acid solutions becomes:



In speculation on the stability of the rhenate ion $ReO_4^=$ in aqueous media, it was considered feasible to prepare moderate concentrations of the rhenate ion and study the $ReO_4^=/ReO_4^-$ potential directly. The technitate ion $TcO_4^=$ was expected to be sufficiently stable in basic media and very dilute acids to allow cell measurements. (Contractor's abstract, modified)

PUR. 02:001

Purdue U. Dept. of Mathematics, Lafayette, Ind.

ON THE SPECTRA OF CERTAIN LAURENT MATRICES, by G. L. Krabbe. Nov. 16, 1956, 5p. (Technical note no. 1) (AFOSR-TN-56-586) (AF 18(603)44) AD 115010 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 894-897, Oct. 1957.

For G the set $\{0, \pm 1, \pm 2, \pm 3, \ldots\}$, the convolution a*b of two sequences a and b of the sequence space $L^p(G)$ which contains $a = \{a_n\}_n$ for $p = 1$, then the Laurent matrix (a_{n-v}) is shown to be a transformation $c \longrightarrow c*a$ of $L^p(G)$ into itself called a_{*p}. It is shown that if $p \geq 1$ and $a \in L^p(G)$, then the spectrum of a_{*p} is the set $\{A(\theta): -\pi \leq \theta \leq \pi\}$, where $A(\theta) = \sum_n^{\omega} = -\omega\ a_{ne}\ in\ \theta$.

PUR. 03:001

Purdue U. [Dept. of Physics] Lafayette, Ind.

VECTORIAL CHARGE DISPLACEMENT, by D. C. Peaslee. Oct. 5, 1956, 10p. (AFOSR-TN-56-212) (AF 18(600)1579) AD 87526 Unclassified

Also published in Nuovo Cimento, Series X, v. 4: 1583-1584, Dec. 1956.

The consequences are examined of recognizing an extreme symmetry between the nucleon and cascade (Ξ) particle. The simplest formalism for expressing this symmetry is to take the charge displacement number $a = q - 1_z$ for heavy particles as the z-component of a second, independent vector $\underline{A}$ in charge space. This scheme makes evident the possibility of 2 independent charge conjugation operators C and C' for heavy particles; it also has suggestive applications to the θ_1, θ_2 scheme and the π-e decay problem. Experimental tests for vectorial $\underline{A}$ appear remote. (Contractor's abstract)

PUR. 03:002 - PUR. 03:006

PUR. 03:002

Purdue U. [Dept. of Physics] Lafayette, Ind.

COMPOUND MODEL FOR V-PARTICLES, by R. W. King and D. C. Peaslee. Oct. 24, 1956, 15p. refs. (AFOSR-TN-56-326) (AF 18(600)1579) AD 95202 Unclassified

Also published in Phys. Rev., v. 106: 360-363, Apr. 15, 1957.

A static model is considered in which all heavy particles are compounded out of 2 basic units, taken here to be the Λ and nucleon N (and/or the cascade particle Ξ). The model suggests the existence of some unstable particle states accessible to experiment: the ρ meson, a boson with I = 0; the Λ^{**}, a highly excited I = 0 state of the Λ; the Z hyperon unstable against rapid decay by $Z \rightarrow K + N$. Without artificial assumption the model directly indicates that in the present strangeness classification no metastable V-particles exist beyond those already known. The model is compatible with and somewhat favors the assumption of a high degree of symmetry between N and Ξ. Its general tenor is thus to emphasize the charge displacement $a = q - I_z$ as a physically significant parameter rather than the strangeness S. An inescapable implication of the model is that all heavy particles have comparable interaction strengths, apparent exceptions being possible over limited energy ranges. The model provides a vehicle for study of the parity doublet scheme, which introduces greater complication in return for an added flexibility at present unnecessary in the model. (Contractor's abstract)

PUR. 03:003

Purdue U. [Dept. of Physics] Lafayette, Ind.

ANTISYMMETRIZATION AND E_1 SUM RULES, by D. C. Peaslee. Dec. 5, 1956 [8]p. (AFOSR-TN-56-587a) (AF 18(600)1579) AD 115012 Unclassified

A schematic method of taking nucleon correlations in the ground state into account is given E_1 sum rules without knowing fine features of nuclear matter. The phenomenological treatment is made with constants, fitted to experiment, which are consistent with the exchange term for Coulomb energies of light nuclei. Subunits are not introduced. The procedure is outlined for the harmonic sum σ_H and applied to the exchange terms in the direct E_1 sum $\sigma_D = \int \sigma dW$, which leads to the result.

PUR. 03:004

Purdue U. [Dept. of Physics] Lafayette, Ind.

ISOTOPIC SPIN IN E_1 SUM RULES, by D. C. Peaslee. Nov. 23, 1956 [5]p. (AFOSR-TN-56-588) (AF 18-(600)1579) AD 115013 Unclassified

The electric dipole (E_1) sum rules for the ground states of light nuclei isotopic spin $T = T_0$ and elevated $T = T_0 + 1$ are obtained separately by inserting a suitable projection operator. To the first order effect, all sum rules show: $\sigma(T_0)/\sigma(T_0 + 1) \approx T_0$, with T_0 the ground state isotopic spin. The experimental implications of this result are discussed.

PUR. 03:005

Purdue U. [Dept. of Physics] Lafayette, Ind.

QUESTION OF VECTORIAL STRANGENESS (Abstract), by D. C. Peaslee. [1956] [1]p. [AF 18(600)1579] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 209, Apr. 26, 1956.

It is not clear from present experiment or theory whether the V-particle strangeness number a should be viewed as a scalar or as the z-component of another vector like t. Direct observations bearing on this question appear difficult: e.g., the decay possibility $\Xi^- \rightarrow \beta^- + \nu + n$, reactions like $K^- + n \rightarrow \Xi^- + K^+$, proof of τ^0 nonexistence. The assumption of vectorial a, whether realistic or not, appears formally convenient in some cases.

PUR. 03:006

Purdue U. [Dept. of Physics] Lafayette, Ind.

ON ISOTROPIC SPIN OF ANTIPARTICLES (Abstract), by M. Sugawara. [1956] [1]p. [AF 18(600)1579] Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 304, June 21, 1956.

J. V. Lepore has argued that protons and antiprotons (or neutrons and antineutrons) should be assigned the same eigenvalues of τ_3, isotropic spin operator describing nucleons, by requiring that a theory involving nucleons, mesons, and electromagnetic field should be invariant under charge conjugation. The present note states that, although his approach is quite correct, his interpretation is not entirely satisfactory, since it rests on one-particle Dirac theory. We should correctly base ourselves on field theory and calculate the eigenvalue of the total isotropic spin operator $\int \psi^* \tau_3 \psi dv$ of the nucleon field in a one-antinucleon state. Such considerations have already been given; they showed that protons and antineutrons have the same eigenvalue, which is opposite to that of neutrons and antiprotons, without arbitrariness in these assignments.

Purdue U. Rocket Lab., Lafayette, Ind.

N6ori-10503, Project Squid see under Princeton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:194-PRI 11:196.

PUR. 04:001

Purdue U. School of Aeronautical Engineering, Lafayette, Ind.

AN EXTENSION OF THE THEORY OF THE OPTIMUM BURNING PROGRAM FOR THE LEVEL FLIGHT OF A ROCKET-POWERED AIRCRAFT, by A. Miele. June 1956 [61] p. incl diagrs. (Rept. no. A-56-1) (AFOSR-TN-56-302) (AF 18(603)69) AD 90015 Unclassified

Also published tn Jour. Aeronaut. Sciences, v. 24: 874-884, Dec. 1957.

The burning program for the horizontal flight of a rocket-powdered aircrafi is analyzed matheinatically. The results of previous theories are extended to cover the general problem of minimizing an arbitrary function of the final values of time, mass, dtstance, and velocity. By using the indirect methods of the calculus of variations, ii is shown that the toiality of extremal arcs is composed of zero thrust subarcs, subarcs to be flown with maximum engine output and variable thrust subarcs. For the latter, a closed solution is obtained. Particular problems, such as maxtmum range, maximum endurance, minimum propellant consumption, and maximum velocity increase, are treated within the general frame of the present theory for various types of boundary conditions. Detailed attention is devoted to the thrust programming which maximizes the range for the case where the over-all flying time is prescribed. A method for constructing extremal paths is supplied under the assumption of a parabolic drag polar having either constant coefficients or coefficients depending on the Mach number. By a suitable choice of the burning technique, the over-all time can be considerably decreased with respect to the time associated with the solution of maximum absolute range. Numerical examples show that up to 25% savings in time can be achieved with a penalty of less than 5% in range. An important difficulty associated with the linear aspect of the present problem is constituted by the fact that the Legendre-Clebsch condition fails to yield any information on the minimum or maximum character of the Eulerian paths. Moreover, the Weierstrassian function is zero at all points of the variable thrust subarc. These difficulties are overcome with a generalization of a previous method of the same author, based on the use of Green's theorem. In appendixes, a method is presented for computing the distribution of the Lagrange multipliers λ_1 and λ_3 along the constant thrust subarcs of the Eulerian solution; and an application is demonstrated of the method in the analysis of the continuity conditions due to Erdmann and Weierstrass. (Contractor's abstract)

PUR. 05:001

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

NEW DEVELOPMENTS IN THE CHEMISTRY OF DIBORANE AND THE BOROHYDRIDES. I. GENERAL SUMMARY, by H. I. Schlesinger, H. C. Brown and others. [1953] [5] p. incl. refs. (Sponsored jointly by National Defense Research Committee, Signal Corps, Office of Naval Research, and [Air Force Office of Scientific Research under AF 18(600)310] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 186-190, Jan. 5, 1953.

New developments are described regarding methods of preparation and the chemistry of diborane and the borohydrides. New and practical methods for the preparation of borohydrides (a) from diborane, and (b) without the use of diborane are discussed. As a result of the availability of borohydrides, prepared without the use of diborane, methods, far more satisfactory than those hitherto known for the preparation of the latter, have been developed. The investigation has led to the preparation of the hitherto unknown borohydrides of sodium, of potassium and of uranium, and some of their derivatives, as well as of a new type of substance, such as sodium trimethoxyborohydride, $NaBH(OCH_3)_3$, formed by the addition of compounds of trivalent boron to alkali metal hydrides. Sodium borohydride, as well as sodium trimethoxyborohydride, are of special interest because of their potential usefulness as reducing agents and sources for the generation of hydrogen; uranium (IV) borohydride and its derivatives are of interest because they are the most volatile compounds of uranium except the hexafluoride. A number of recent observations made are surveyed, and the subject matter is organized in the light of the application of the Lewis generalized acid-base concept to the reactions of diborane, of the salt-like hydrides and of the borohydrides. (Contractor's abstract, modified)

PUR. 05:002

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE REACTION OF SILVER NITRITE WITH PRIMARY ALKYL HALIDES, by N. Kornblum, B. Taub, and H. E. Ungnade. [1954] 12p. incl. tables, refs. (Paper no. 5) [ASOSR-TN-54-14] (AF 18(600)310) AD 46096 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 3209-3211, June 20, 1954.

A procedure is described in which the reaction of $AgNO_2$ with primary straight-chain halides gives 73 to 81% yields of pure nitroparaffins. Reaction is initiated at ice temperature and completed at room temperature; diethyl ether is used as a diluent.

PUR. 05:003 - PUR. 05:007

Branchtng in the vicinity of the reactive stte lmpedes the reaction; no reaction occurs wtth neopentyl todide. Tables are tncluded of (1) the nitroparafftns produced by the reaction of $AgNO_2$ wtth alkyl halides, and (2) yields obtained from the reaction of straight-chain and branched-chain prtmary halides wlth $AgNO_2$. (ASTIA abstract)

PUR. 05:003

[Purdue U. School of Chemtcal and Metallurgical Engineertng, Lafayette, Ind.]

1-NITROOCTANE. $CH_3(CH_2)_7Br + AgNO_2 \rightarrow CH_3(CH_2)_7NO_2$, by N. Kornblum and H. E. Ungnade. June 1954, 5p. tncl. table. ([AF]OSR-TN-54-163) [AF 18(600)310] AD 106179 Unclassifled

Also published in Org. Syntheses, v. 38: 75-78, 1958.

The preparation of 1-nitrooctane fron n-octyl bromide and silver nitrate ts descrtbed. The resulting colorless compound dtstills at 66°C (2 mm), has an n_D^{20} 1.4321 – 1.4323, and is completely soluble in aqueous alkali. It ts polnted out that 1-nitrooctane has been prepared previously from 1-todooctane and silver nitrtte; from octane by botling wtth nitric actd; from 1-nttrooctylene by catalytic hydrogenation; and from n-octyl p-toluene-sulfonate and sodtum nitrtte.

PUR. 05:004

Purdue U. [School of Chemical and Metallurgical Engineertng] Lafayette, Ind.

SYNTHESIS OF TERTIARY NITROPARAFFINS, by N. Kornblum and R. J. Clutter. Aug. 1954, 3p. ([AF]OSR-TN-54-199) (AF 18(600)310) AD 53150 Unclassifted

Also published in Jour. Amer. Chem. Soc., v. 76: 4494-4495, Sept. 5, 1954.

litgh ytelds of tertiary (t) nitroparafftns and nitroso-paraffins were obtained by the oxidatton of t-carbamtnes using potasstum permanganate as oxidtzer. Oxidatton of t-butyl amtne produced t-nitrobutane; that of t-amyl amtne, t-nitropentane; that of 1-octyl amtne, t-nitro-octane; and that of 1,8-diamtno-p-methane, the cor-responding dtnitro compound. The process has been examtned more closely for t-butyl amtne.

PUR. 05:005

Purdue U. [School of Chemical and Metallurgical Engineertng] Lafayette, Ind.

THE REACTION OF SILVER NITRITE WITH SECONDARY AND TERTIARY ALKYL HALIDES, by N. Kornblum, R. A. Smiley and others. Aug. 1954, 15p. tncl. tables, refs. (Paper no. 6) [AFOSR-TN-54-229] (AF 18(600)310) Unclassifled

Published in Jour. Amer. Chem. Soc., v. 77: 5528-5533, Nov. 5, 1955.

A deftnttive study has been made of the reaction of secondary and tertiary alkyl halides with silver nitrite Treatment of secondary halides with silver nitrite gives nitroparafftns tn about 15% yields. The reaction of tertiary halides with silver nitrtte ts even less useful as a means of preparing nitroparafftns (0 to 5% yields). The complex mixtures produced have been shown to contain, in addition to the antictpated nitroparafftns and nttrtte esters, olefins, nitrate esters and adducts of olefins wtth oxides of nitrogen. (Contractor's abstract)

PUR. 05:006

Purdue U. [School of Chemical and Metallurgical Engineertng] Lafayette, Ind.

THE STEREOCHEMISTRY OF THE REACTION OF ALKYL HALIDES WITH SILVER NITRITE, by N. Kornblum, L. Fishbetn, and R. A. Smiley. Aug. 1954, 31p. tncl. tables, refs. (Paper no. 7) ([AF]OSR-TN-54-230) (AF 18(600)310) AD 101759 Unclassifted

Also published tn Jour. Amer. Chem. Soc., v. 77: 6261-6266, Dec. 5, 1955.

When optically active 2-bromooctane ts treated wtth stiver nttrtte, the 2-nitrooctane and 2-octyl nitrtte produced both have the tnverted conftguration and both are optically pure or very nearly so. The same result ts obtained wtth active 2-todooctane. In con-trast, the reaction of optically active α-phenylethyl chlortde with silver nitrtte yields α-phenylethyl nttrtte of the same conftguration as the chlortde and α-phenylnitroethane of the opposite conftguration from the halide; furthermore, the α-phenylethyl nitrtte and α-phenylnttroethane are far from optically pure. The stereochemical relationshtps between alcohols and nttrtte esters tn the α-phenylethyl and tn the 2-octyl systems have been estabtlshed. (Contractor's abstract)

PUR. 05:007

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE REDUCTION OF OPTICALLY ACTIVE 2-NITROOCTANE AND α-PHENYL NITROETHANE, by N. Kornblum and L. Fishbetn. Aug. 1954, 11p. incl. table, refs. (Paper no. 8) ([AF]OSR-TN-54-231) (AF 18(600)310) AD 101758 Unclassifted

Also published in Jour. Amer. Chem. Soc., v. 77: 6266-6269, Dec. 5, 1955.

Conditions are described for reducing optically active nitro compounds to active amines. In this way, the conftgurational relationship of 2-nitrooctane and of

α-phenylnitroethane to other compounds of the 2-octyl- and α-phenylethyl series is established. Not all reducing agents give optically active amines, and the implications of this fact are discussed briefly. (Contractor's abstract)

PUR. 05:008

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE MECHANISM OF THE REACTION OF SILVER NITRITE WITH ALKYL HALIDES. THE CONTRASTING REACTIONS OF SILVER AND ALKALI METAL SALTS WITH ALKYL HALIDES. THE ALKYLATION OF AMBIDENT ANIONS, by N. Kornblum, R. A. Smiley and others. Oct. 1954, 1v. incl. diagrs. tables, refs. (Paper no. 9) ([AF]OSR-TN-54-300) (AF 18(600)310)
AD 50673 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 6269-6280, Dec. 5, 1955.

A study of the reaction of $AgNO_2$ with alkyl halides showed that it proceeds via a transition state which has S_N1 and S_N2 character in proportions that vary gradually with the structure of the halide. The reaction products reflect this variation in character; the greater the carbonium contribution to the transition state, the greater is the yield of nitrite ester and smaller is the yield of nitroparaffin. The reason for the divergent reactions of Ag and alkali metal salts with alkyl halides was established. The electrophilic attack of Ag on the halogen of the alkyl halide greatly enhanced the carbonium contribution to the transition state. This resulted in a preference for covalency formation to the most electronegative atom of the anion. The nature of the transition state was affected by changes in the reaction medium and in the structure of the alkylating agent. The generalization was made that the greater the S_N1 character of the transition state, the greater is the preference for covalency formation with the atom of the highest electronegativity, and conversely, the greater the S_N2 contribution, the greater the preference for bond formation to the atom of lowest electronegativity.

PUR. 05:009

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

LABORATORY VACUUM FURNACE, by A. S. Yue and A. G. Guy. Jan. 29, 1955 [5]p. incl. diagr. (PRF rept. no. 1) ([AF]OSR-TN-55-49) (AF 18(600)310)
AD 57549 Unclassified

A vacuum furnace, fabricated not only for diffusion experiments but also for general laboratory purposes, is described and illustrated. Its design features and operating characteristics are given, including data on the fore-pump section, diffusion pump, baffle, piping, cold trap, syphon bellows, feed-through seals, leak detection, furnace tube, and pump-down time. It is pointed out that the performance of this laboratory furnace has been very satisfactory from the standpoint of both attained vacuum and freedom from leaks.

PUR. 05:010

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE REACTION OF SILVER NITRITE WITH α-HALOESTERS, by N. Kornblum, M. E. Chalmers, and R. Daniels. Aug. 12, 1955 [1]p. incl. tables. (Paper no. 10) [AFOSR-TN-55-101] (AF 18(600)310)
AD 101760 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 6654-6655, Dec. 20, 1955.

A study has been made of the reaction of silver nitrite with α-haloesters to determine its usefulness for the preparation of α-nitroesters, and also to test the mechanism proposed for the reaction of silver nitrite with organic halides. It is pointed out that the reaction of α-bromoesters with silver nitrite is extremely slow, e.g., after 6.5 days at room temperature ethyl bromoacetate and ethyl-α-bromopropionate had only reacted to the extent of 12-15%. In contrast, the reaction of α-iodoesters proceeds to completion in several days, giving yields of the pure α-nitroesters of 75-84%. The theoretical implications of these facts are discussed briefly, the reaction of silver nitrite with organic halides being described as a "pull-push" process involving the development of an electron deficiency at the carbon atom undergoing substitution.

PUR. 05:011

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

A NEW REACTION OF α-NITROESTERS, by N. Kornblum and J. H. Eicher. Apr. 1956 [4]p. incl. table, refs. ([AF]OSR-TN-55-240) (AF 18(600)310)
AD 101757 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1494-1497, Apr. 5, 1956.

α-Nitroesters react with a solution of sodium nitrite in aqueous ethanol at room temperature, giving α-oximinoesters in 70-78% yields. Ethyl nitroacetate reacts vigorously to give a mixture of nitrous oxide, nitrogen, and carbon dioxide. If the α-nitroester does not have a hydrogen atom on the carbon holding the nitro group, it is quantitatively recovered. The mechanism of this new reaction is discussed. (Contractor's abstract)

PUR. 05:012 - PUR. 05:016

PUR. 05:012

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

NEOPENTYL IODIDE, by N. Kornblum and D. C. Iffland. Dec. 1955 [1]p. ([AF]OSR-TN-55-241) (AF 18(600)310) AD 101756 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 6653-6654, Dec. 20, 1955.

A method for preparing neopentyl iodide (I), a modification of the Landauer and Rydon procedure, is described. Neopentyl alcohol is treated with a mixture of methyl iodide and triphenyl phosphite to give pure I (bp 71°C (100 mm, n_D^{20} 1.4888) in 53-57% yield.

PUR. 05:013

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

ETHYL α-NITROBUTYRATE, by N. Kornblum and R. K. Blackwood. [1955] [3]p. [AFOSR-TN-55-379] (AF 18(600)310) Unclassified

Published in Org. Syntheses, v. 37: 44-46, 1957.

A procedure is described for preparing ethyl α-nitrobutyrate (I). Ethyl α-bromobutyrate is poured into a mixture of N, N-dimethylformamide (DMF), sodium nitrate, and anhydrous phloroglucinol, reacting as follows: $CH_3CH_2\underset{\underset{Br}{|}}{C}HCO_2C_2H_5 + NaNO_2 \xrightarrow[\text{Phloroglucinol}]{DMF}$

$CH_3CH_2\underset{\underset{NO_2}{|}}{C}HCO_2C_2H_5$(l) + NaBr. The reaction gives a 68-75% yield of colorless (I), having a bp of 71°C/1 mm and an n_D^{20} 1.4233. It is pointed out that (I) may also be prepared in 75% yield by the reaction of silver nitrite with ethyl α-iodobutyrate (Jour. Amer. Chem. Soc., v. 77: 6654, 1955). An 18% yield has been obtained by nitration and subsequent decarboxylation of diethyl ethylmalonate (Eicher, Thesis. Purdue U., 1950). The present method offers the advantage of a direct preparation using sodium nitrate.

PUR. 05:014

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

A NEW METHOD FOR THE SYNTHESIS OF ALIPHATIC NITRO COMPOUNDS, by N. Kornblum, H. O. Larson and others. Sept. 8, 1955 [5]p. incl. tables, refs. [AFOSR-TN-55-380] (AF 18(600)310) AD 101754 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1497-1501, Apr. 5, 1956.

A description is given of a simple, new method for preparing primary and secondary aliphatic nitro compounds. Alkyl halides are treated with sodium nitrite in dimethylformamide, giving 55-62% yields of pure organic nitro compounds.

PUR. 05:015

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE REACTION OF ALIPHATIC NITRO COMPOUNDS WITH NITRITE ESTERS, by N. Kornblum, R. K. Blackwood, and D. D. Mooberry. Apr. 1956 [4]p. incl. tables, refs. ([AF]OSR-TN-55-446) (AF 18-(600)310) AD 101753 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1501-1504, Apr. 5, 1956.

Although primary nitroparaffins, secondary nitroparaffins, and α-nitroesters are inert toward nitrite esters, the joint action of a nitrite ester and sodium destroys the nitro compound. Primary nitro compounds give the carboxylic acid, secondary nitroparaffins yield ketones and α-nitroesters are converted to α-oximinoesters. The course of these reactions is described. (Contractor's abstract)

PUR. 05:016

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

A NEW METHOD FOR THE SYNTHESIS OF ALIPHATIC NITRO COMPOUNDS, by N. Kornblum, H. O. Larson and others. [1955] [1]p. [AF 18(600)310] Unclassified

Published in Chem. and Indus. (London), v. 16: 443, Apr. 16, 1955.

The reactions employing 1- and 2-bromo-octane were found to be first order in halide and first order in nitrite ion. Clearly this is an S_N2 process. Consequently, it is not surprising that tertiary halides and cycloheryl halides, instead of giving nitro compounds, yield olefins.

Reaction of halides with sodium nitrite

Halide	Reaction time (hr)	Yield (%) Nitro compound	Alkyl nitrite
1-Bromo-octane	3	60	29
1-Iodoheptane	1	61	31
1-Iodo-3-phenylpropane	1	59	26
Benzyl bromide	5[a]	52	35
2-Bromo-octane	45[b]	58	c
2-Iodo-octane	4	60	28
cyclo Pentyl iodide	5[b]	55	–
Ethyl 2-bromopropionate	4[b,d]	63	–
Ethyl 2-bromocaproate	6[b,d]	64	–

([a]This experiment was carried out at −30° to −15°; all others at room temperature. [b] Anhydrous phloroglucinol, equimolar with the halide, is added initially. [c]Octan-2-ol isolated in 38% yield. [d]Urea not present.) The following preparation of 2-nitro-octane typifies the general procedure: 2-Iodo-octane (72 g) was added rapidly to dry sodium nitrite (36 g) and urea (40 g) in dry DMF (600 ml). After stirring for four hours at room temperature the mixture was poured into ice-water (1.5 l), extracted with light petroleum (b.p. 35–37°), dried and rectified. This gave 13.0 g (28% yield) of 2-octyl nitrite, b.p. 41-42°/6 mm, which, after a small interfraction, was followed by 28.4 g (60% yield) of pure 2-nitro-octane, b.p. 60°/1 mm, n_D^{20} 1.4280.

PUR. 05:017

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE REACTION OF NITRIC OXIDE WITH 2-OCTANE, by N. Kornblum and E. P. Oliveto. [1955] [2]p. (AF 18(600)310) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 5173-5175, Oct. 5, 1955.

After eight days at 100° 2-octanol did not react appreciably with nitric oxide. A mixture of 2-octanol and 2-octanone, heated together at 100° for a week (under nitrogen) also remained essentially unchanged. In contrast when 2-octanone was heated to 100° in the presence of nitric oxide (in the absence of light) 60% of the ketone reacted in eight days to give a number of products. Although acetic and heptanoic acids were isolated, neither formic acid nor caproic acid could be detected. And while capronitrile ($C_5H_{11}CN$) is present, acetonitrile could not be found. A substantial amount of a nitrogen-containing tar, not volatile with steam, was also obtained. The nitric oxide which reacted was converted to nitrous oxide and nitrogen; in addition, water and hydrogen cyanide were found.

PRODUCTS FORMED IN THE REACTION BETWEEN NITRIC OXIDE AND 2-OCTANONE

	grams	mmoles
original amounts of ketone	14.6	114
ketone reacting	8.6	67
heptanoic acid produced	1.0	7.7
acetic acid produced	1.2	19.6
capronitrile produced	ca 1.8	ca 18
nitrous oxide produced	1.5	33
nitrogen	3.1	110

(Contractor's abstract)

PUR. 05:018

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE INTERACTION OF ALKYL HALIDES WITH DIMETHYLFORMAMIDE, by N. Kornblum and R. K. Blackwood. [Oct. 21, 1955] 7p. incl. diagrs. tables. [AFOSR-TN-56-65] (AF 18(600)310) AD 81057 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 4037-4039, Aug. 20, 1956.

Solutions of alkyl halides in dimethylformamide (DMF) undergo dehydrohalogenation and salt formation on standing at room temperature (25°-30°C). Results of the interaction of the following alkyl halides with DMF are presented:

Halide	Concentration (mol/l)	Reaction (% complete)
methyl iodide	0.2	10%, 12 days
1-iodobutane	0.100	41%, 17 days
2-iodobutane	0.100	69%, 19 days
benzyl bromide	0.2	10%, 19 days
1-bromooctane	0.200	64%, 324 days
2-methyl-1-bromo-propane	0.200	25%, 280 days
2-bromooctane	0.200	79%, 304 days
t-butyl bromide	0.100	75%, 7 days

The kinetics of the reaction of 3 of the above compounds in DMF solutions 1-iodobutane, 2-iodobutane, and t-butyl bromide, were studied, and the data obtained are presented in tables.

PUR. 05:019

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE INFRARED ABSORPTION SPECTRA OF NITROPARAFFINS AND ALKYL NITRATES, by N. Kornblum, H. E. Ungnade, and R. A. Smiley. Feb. 1956 [7]p. incl. tables, refs. (Paper no. 14) (AFOSR-TN-56-88) (AF 18(600)310) AD 82002 Unclassified

Also published in Jour. Org. Chem., v. 21: 377-378, 1956.

The infrared spectra of a large number of aliphatic nitro compounds and nitrate esters are presented. Comparisons are made between the data obtained and infrared absorption bands previously ascribed to the aliphatic nitro group.

PUR. 05:020 - PUR. 06:001

PUR. 05:020

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

THE SYNTHESIS OF TERTIARY NITROPARAFFINS, by N. Kornblum, R. J. Clutter and W. J. Jones. July 1956, 8p. incl. tables. (AFOSR-TN-56-197) (AF 18(600)310) AD 87070 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 4003-4004, Aug. 20, 1956.

A simple and reliable procedure is described for oxidizing teri-carbinamines, RR'R"C-NH_2, to the corresponding tert-nitro compounds with $KMnO_4$ at 25° to 30°C. The procedure is applicable, without alieration, to a wide variety of amines, and gives 70 to 80% yields of the tert-nitro compounds.

PUR. 05:021

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

ULTRAVIOLET ABSORPTION SPECTRA OF NITROPARAFFINS, ALKYL NITRATES AND ALKYL NITRITES, by H. E. Ungnade and R. A. Smiley. [June 1956] 14p. incl. diagrs. tables, refs. [Technical note no. 18] (AFOSR-TN-56-252) (AF 18(600)310) AD 88972 Unclassified

Also published in Jour. Org. Chem., v. 21: 993-996, Sept. 1956.

In this study, UV absorption spectra have been determined for a series of nitroparaffins, alkyl nitrates, and alkyl nitrites. The spectra for the nitro compounds and alkyl nitrates were obtained in 95% ethanol, while those for the alkyl nitrites were obtained in anhydrous ether to avoid ester interchange reactions with alcohol. The measurements were made in 1-cm cells at 25°C with a Cary recording spectrophotometer, the data being presented in tables. The relationship between structure and absorption structure is discussed. It is concluded that since the UV spectra of the compounds studied differ sufficiently, they can be utilized in identifying these compounds.

PUR. 05:022

Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

A NEW SYNTHESIS OF α-NITROESTERS, by N. Kornblum, R. K. Blackwood, and J. W. Powers. [Sept. 17, 1956] [13]p. incl. tables, refs. (AFOSR-TN-56-431) (Sponsored jointly by E. I. du Pont de Nemours and Co. and Air Force Office of Scientific Research under AF 18(600)310; continued by AF 18(600)-1463) AD 96514 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 2507-2509, May 20, 1957.

In this chemical study, α-nitroesters were prepared at room temperature by treating α-haloesters with $NaNO_2$ in the presence of phloroglucinol (I). By adding I to the reaction mixture, the formation of oximinoesters is prevented and pure α-nitroesters in the yields indicated below are obtained:

Ethyl α-nitroester	Reaction time (hr) in dimethyl-formamide (DMF)	Reaction time (hr) in dimethyl-sulfoxide (DMSO)	Yield (%) in DMF	Yield (%) DMSO
propionate	1.5	2	66	62
butyrate	1.5	2.5	83	70-75
valerate	1.5	...	87	...
caproate	1	5	76	74
isobutyrate	5	44	91	78
isovalerate	75	150	75	67
α-phenyl-α-nitroacetate	...	2.5	...	70

PUR. 06:001

Purdue U. School of Chemical and Metallurgical Engineering, Lafayette, Ind.

PRECISION MEASURING METALLURGICAL MICROSCOPE, by A. G. Guy and A. S. Yue. Dec. 12, 1955 [3]p. incl. illus. (Rept. no. PRF-3) ([AF]-OSR-TN-56-34) (AF 18(600)1463; continuation of AF 18(600)310) AD 80545 Unclassified

Also published in Rev. Scient. Instruments, v. 27: 239-240, Apr. 1956.

A description and an illustration of this instrument are given. It incorporates the precision-measuring aspect of the Cooke nuclear research microscope no. M4005. The framework of the microscope is made up of a 1.5-by 2.5-in. brass post mounted on a 1-in. thick brass base plate, which is supported on 3 legs. The stage is a Cooke no. [M]4005 ball-bearing micrometer stage with hardened ways. It has a travel of 25 mm and a unit reading of 0.005 mm on the micrometers, allowing estimations to be made to the nearest 0.0005 mm. The microscope body is Baush and Lomb no. 31-29-03-01 with vertical illuminator no. 31-24-90-11. The eyepiece is fitted with a micrometer disc, ruled with 1 horizontal cross hair, and 2 vertical cross hairs between which the point to be measured is centered. A 20 x eyepiece and a 50 x, 0.85 N.A. objective were used in test readings made on a glass slide ruled with 2 lines separated by 0.2500 in. No blacklash was found in the micrometers. The separation distance was duplicated to ± 0.0005 mm.

PUR. 06:002

Purdue U. School of Chemical and Metallurgical Engineering, Lafayette, Ind.

UNSTEADY-STATE DIFFUSION THROUGH THIN SHEETS, by A. S. Yue and A. G. Guy. Dec. 6, 1955 [26]p. incl. diagrs. (Rept. no. PRF-2) ([AF]OSR-TN-56-35) (AF 18(600)1463) AD 80546 Unclassified

A theoretical formulation is proposed for treating the process of steady-state diffusion in substitutional solid solutions. Equations governing steady-state diffusion and the approach to the steady-state are derived. A proposed experimental arrangement for attaining steady-state diffusion of Zn through α brass is illustrated and analyzed. (Contractor's abstract, modified)

PUR. 06:003

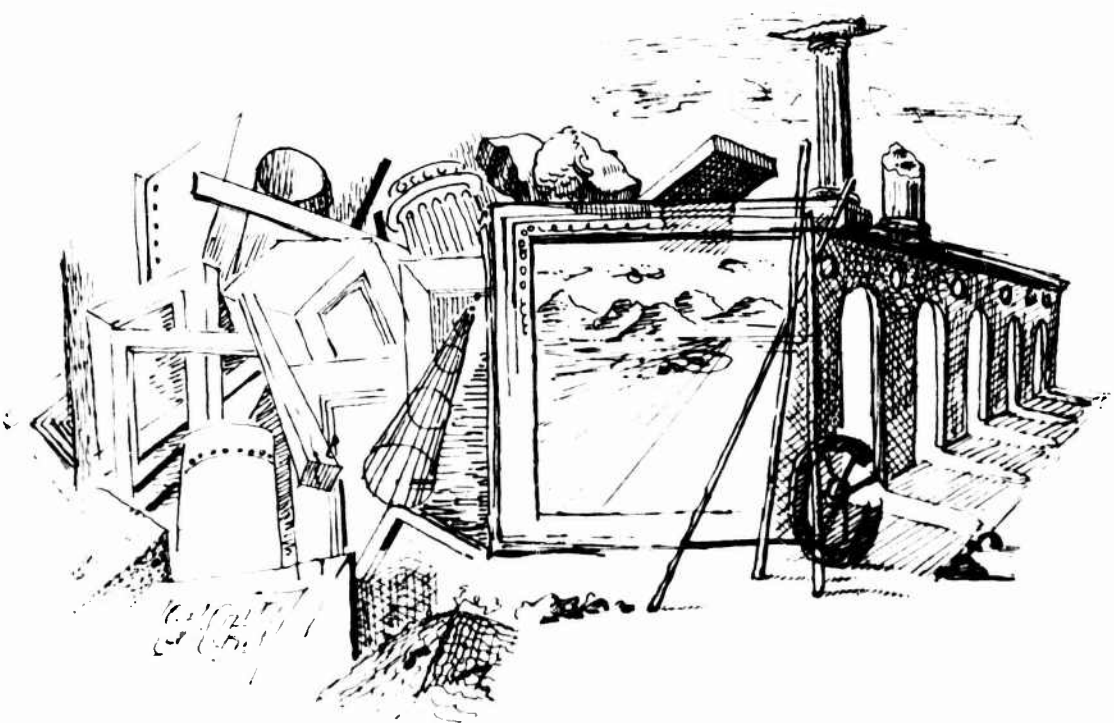
Purdue U. [School of Chemical and Metallurgical Engineering] Lafayette, Ind.

APPROXIMATE METHOD FOR CALCULATIONS USING CONCENTRATION-DEPENDENT DIFFUSION COEFFICIENTS, by A. G. Guy, M. Golomb, and incl. diagrs. tables. (PRF rept. no. 4) (AFOSR-TN-56-194) (AF 18(600)1463) AD 87067 Unclassified

Presented at meeting of the National Metal Congress, Chicago, Ill., Nov. 1957.

Also published in Jour. Metals, v. 9: 1204-1206, Oct. 1957.

The diffusion equation is modified to account for variations in the value of the diffusion coefficient with concentration by the use of a special coordinate system x_0, such that for every elementary region dx there is a corresponding region dx_0 of such thickness that $dx/\sqrt{D} = dx_0/\sqrt{D_0}$, where D_0 is some constant reference value of the diffusion coefficient. Illustrative calculations are given for the semi-infinite and finite solid conditions for the diffusion of Zn into Cu. (ASTIA abstract)



RCA. 01:001 - RRI. 01:003

RCA. 01:001

Radio Corp. of Amertca. [Davtd Sarnoff Research Center] Princeton, N. J.

DISCHARGE MECHANISM OF MERCURY POOL ARCS, by K. G. Hernqvist. Feb. 23, 1956, 16p. incl. tllus. diagrs. refs. (Rept. no. RB-34) (AFOSR-TN-56-18) [AF 18(600)1239] Unclassified

In this study, a model for the discharge mechantsm of Hg pool arcs ts proposed, and tt is shown to be in agreement with experiment. The following subjects are discussed in connection wtth the model: (1) schemattc dtagrams showing tube structure; (2) potential distrtbutions; (3) arc-energy balance; (4) current-denstty dtstrtbutton; (5) motton of arc cathode spot; (6) transtent behavtor of the Hg pool arc; (7) emission mechanism of Hg pool arcs; and (8) comparison between the Hg pool arc and thermtonic arcs (e. g., carbon arc). It is concluded that: (a) Hg pool arcs operate in the ball-of-ftre mode of dtscharge, and (b) the electron emission mechantsm is nonthermtonic. Emitted electrons from the cathode arrtve wtth only thermal energies in a plasma adjacent to the cathode. The potential of this plasma is equal to or slightly htgher than that of the Fermi level of the cathode. The emisston may result from etther a large electrtc field at the cathode (tunnel effect) or from an effecttve lowering of the cathode work functton. This lowering of the work functton may be caused by a vapor or plasma of high density adjacent to the cathode surface.

RCA. 01:002

Radio Corp. of America. David Sarnoff Research Center, Princeton, N. J.

RESEARCH IN GASEOUS ELECTRONICS, by K. G. Hernqvist, R. W. Peter, and A. D. Sutherland. Final rept. Sept. 23, 1954-June 23, 1956, 48p. tllus. diagrs. refs. (AFOSR-TN-56-34) (AF 18(600)1239) AD 96229 Unclasstfied

A general classificatton of arcs based on the emission mechanism is made. A summary of characteristic properties of nonthermiontc arcs is presented based on a litterature survey. A study of retrograde motion done at these laboratories mainly before the activation of this contract is described. Based on the analogy between the ball-of-fire mode of hot cathode discharge and the Hg pool arc, a model for the discharge mechanism of the latter is proposed. Studies of discharge behavior after arc extinguishing indicate that the electron to ion current ratio of the arc is not less than about 50. A comparison between the power consumption for the Hg pool arc and that of thermionic arcs is made. Studies of the low current density mode of the Hg pool arc are described. These include the procedure to establish and maintain this mode of discharge and ultra-high-speed photographic studies of the cathode surface. These studies indicate that the time average of the emission current density is very low. Some previously proposed mechanisms of emission are discussed in view of the new experimental results obtained under this contract. It is indicated that a modified version of the field emisston mechantsm or a conttnuous cathode to plasma transition offers the most promising approach towards an understanding of the emisston mechanism. (Contractor's abstract, modified)

RRI. 01:001

Reed Research, Inc., Washington, D. C.

FORCED VIBRATION OF A VISCO-ELASTIC RECTANGULAR PLATE IN FLUID MEDIA, 1, by G. C. K. Yeh and J. Martinek. Dec. 1955, 17p. refs. (Technical note no. 1) ([AF]OSR-TN-55-469) (AF 18(600)-1382) AD 128340 Unclassified

Presented at Ninth Internattonal Congress of Applied Mechanics, Brussels (Belgtum), Sept. 5-13, 1956.

Forced vibratton of a thin rectangular plate stmply supported tn a rtgtd infinite baffle is analyzed. The plate is assumed to separate 2 dtfferent flutd media, and the vibration is excited by a simple plane wave of high frequency (as compared with $c/2\sqrt{\pi ab}$) normally incident from 1 side of the plate. The equatton of motion is derived for such a plate of Maxwell's viscoelastic material, and is solved by means of Galerkin's method. The solutton of the equatton renders expresstons for the plate deflectton, and an energy transmtsston coefftctent. In the limiting case of a visco-rtgid material, the expresstons reduce to those for a purely elastic plate prevtously obtained. (Contractor's abstract)

RRI. 01:002

Reed Research, Inc., Washington, D. C.

FORCED VIBRATION OF A CLAMPED RECTANGULAR PLATE IN FLUID MEDIA, by G. C. K. Yeh and J. Martinek. [1955] 5p. [18(600)1382] Unclassified

Published in Jour. Appl. Mech., v. 22: 568-572, Dec. 1955.

The plate is clamped in a rigid infinite baffle which separates 2 different fluid media, and is excited by a plane wave normally incident from 1 side. The wavelengths in both media are assumed to be of small order compared with the edge lengths of the plate. The deflection of the plate is expressed in a double series, and Ritz method is used in shape of Lagrange calculus. Numerical results about the energy transmission are presented based on a 4-term series. (Contractor's abstract)

RRI. 01:003

Reed Research, Inc., Washington, D. C.

ON THE NONLINEAR OSCILLATIONS OF

VISCO-ELASTIC PLATES, by J. Martinek. Dec. 1955, 8p. (Technical note no. 2) ([AF]OSR-TN-56-47) (AF 18(600)1382) AD 80559 Unclassified

Some of the reasons why a material as defined by Maxwell as compared to a Jeffreys-Voigt material is more realistic are presented. For the case of small oscillations of visco-elastic plates, the differential equation of motion can then be solved by classical methods if a Maxwell material is used. (Contractor's abstract)

RRI. 01:004

Reed Research, Inc., Washington, D. C.

A SURVEY AND ANALYSIS OF VISCO-ELASTIC MATERIALS WITH PARTICULAR REFERENCE TO PLATES AND BEAMS, by G. C. K. Yeh, J. Martinek, and C. Torre. June 27, 1956, 30p. (Rept. no. RR-1054-B-TN-3) (AFOSR-TN-56-292) (AF 18(600)1382) AD 90004 Unclassified

Fundamental formulations for Maxwell solid (visco-elastic material) and Kelvin-Voigt solid (firmo-viscous material are summarized and analyzed. Equations of motion for plates and beams consisting of such materials are derived. Several recent publications along this line are discussed. (Contractor's abstract)

RRI. 01:005

Reed Research, Inc., Washington, D. C.

FORCED VIBRATION OF A VISCO-ELASTIC RECTANGULAR PLATE IN FLUID MEDIA, II, by J. Martinek and G. C. K. Yeh. July 23, 1956, 12p. (Technical note no. 4) (AFOSR-TN-56-327) (AF 18(600)1382) AD 95203 Unclassified

Presented at Ninth International Congress of Applied Mechanics, Brussels (Belgium), Sept. 5-13, 1956.

The forced vibration of a thin rectangular plate clamped in a rigid infinite baffle is analyzed. This plate is assumed to separate 2 different media, and the vibration is excited by a simple plane wave of high frequency (as compared with $c/2\sqrt{\pi ab}$) normally incident from one side of the plate. The equation of motion derived for such a plate of Maxwell's viscoelastic material is solved by means of Galerkin's method. The solution of the equation renders expressions for the plate deflection and an energy transmission coefficient. In the limiting case of a viscorigid material, the expressions reduce to those for a purely elastic plate obtained previously. Numerical computations based on the resulting expressions of the present analysis will provide information of practical interest, particularly on the effects of the internal (material)damping. (Contractor's abstract)

RRI. 01:006

Reed Research, Inc., Washington, D. C.

POTENTIAL AND STREAM FUNCTION OF A VORTEX DISK IN THE PRESENCE OF A RIGID SPHERE, by J. Martinek, G. C. K. Yeh, and H. Zorn. [1956] [11]p. [AF 18(600)1382] Unclassified

Published in Proc. Cambridge Philos. Soc. (England), v. 53: 717-727, July 1957.

The potential and stream functions of a vortex disk in the presence of a sphere have been derived in closed forms. By means of an elliptic integral presentation of the disk and the application of the sphere theorems (of Weiss, Butler, Ludford, Martinek, and Yeh), the analysis has been successfully accomplished.

RPI. 01:001

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

THE APPLICATION OF THE ELECTRIC ANALOGY TO TWO-DIMENSIONAL PROBLEMS IN AERONAUTICS, by W. B. Brower, Jr. Nov. 1, 1953, 102p. incl. illus. diagrs. refs. (Rept. no. TR-AE-5406) (In cooperation with Institute Blaise Pascal, Seine (France)) [AFOSR-TN-54-196] (AF 18(600)499) AD 37288 Unclassified

The theoretical basis was reviewed for the rheoelectric analogy (an electric analogy which employs continuous conductors). In the case of plane and axial flows, the possibility of the presence of 2 analogies was demonstrated. Expressions were derived which related the electrical and aerodynamic potential functions for uniform and circulatory flows. Problems were solved for each of these flows around a cylinder, as well as for several basic experiments for an airfoil. Examples are given for the application of the electric analogy to practical aerodynamic problems. (Contractor's abstract)

RPI. 01:002

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

THE TECHNIQUE OF ELECTRIC ANALOGIES [CHAPTER XV], by L. [C.] Malavard, tr. by J. Begue and W. B. Brower, [Jr.]. 77p. incl. illus. (Rept. no. TR-AE-5301) (In cooperation with Centre Nationale de la Recherche Scientifique (France)) ([AF]OSR-TN-54-299) [AF 18(600)499] AD 63325 Unclassified

This translation describes research work conducted by L. Malavard, Director of Research at the Centre Nationale de la Recherche Scientifique. The following is taken from the table of contents: Generalities of the Method (principles; three-dimensional conductor; plane conductor; surface conductor; boundary conductions; various generalizations). Ordinary Problems; Experimental Investigation of Fields (definition of a typical model; nature of the conductor; electrical tanks; methods and apparatus for determination of the equipotentials; mechanical apparatus - tracing of the field). Special

RPI. 01:003 - RPI. 01:007

Problems and Corresponding Models (supply with several electrodes; representatton of the boundary condtttons of the Dtrtchlet, Neumann, and Fourter types; tank wtth slowly varying depth; tanks of discontinuous depth — ftelds having unequal resisttvtty; representatton of singularttte s). General Remarks on the Application of the Method (utilization of symmetry; change of model scale; superpostttion of ftelds; experimental errors).

RPI. 01:003

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

ON VARIATIONAL PRINCIPLES FOR REAL FLUIDS, by P. Lteber, O. Anderson, and K. S. Wan. Oct. 1955, 35p. incl. dtagrs. ([AF]OSR-TN-55-370) (AF 18(600)-499) AD 75078 Unclassifted

A theory of lift was developed for bodies, such as bodtes of revolutton, for whtch the Kutta condttions do not apply. The dissipation function was minimized mathematically and the assoctated Euler equations of condttion were developed based on the calculus of variation. In 2 dimensions the Euler condttions reduced to the biharmonic equattonfor the stream function. A principle to determine the real flow path under general conditions was formulated as a principle of virtual displacement for real fluids. According to this formulation, it is required that the virtual velocities associated with the actual flow path minimize the work done by traction applied at the surface enclosing the fluid. Using the energy conservation principle, the work done by these forces is then expressed in terms of the kinetic and dissipation energy of the flow enclosed by these surfaces. In performing the vartattons on the generating functions thus obtained, only the velocities were subjected to the vartation. The inertia and pressure forces corresponding to the real path were held constant with respect to the vartation. This yielded the Navier-Stokes equations as the Euler equations of the generating function. The minimum principle is applied to the calculation of a real flow between parallel plates and to the development of a boundary layer theory. (ASTIA abstract)

RPI. 01:004

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

THE DESIGN OF A BASIC ELECTRIC-TANK ANALOGY INSTALLATION, by W. B. Brower, Jr. and P. DeRienzo. Sept. 1, 1955, 9p. incl. illus. diagrs. (Rept. no. TR-AE-5505) [AFOSR-TN-55-424] (AF 18(600)-499) AD 75450 Unclassified

A descriptton is gtven of the mechanical and electrtcal equtpment used in an electric-tank analogy installation for the study of 2-dimenstonal flows. Metallic parts of the traversing system were machined from Al or stainless steel to prevent corrosion. Use of Al and special attention to the design resulted in a lightweight superstructure which may be readtly adapted to other tanks.

RPI. 01:005

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

THE APPLICATION OF THE ELECTRIC-TANK ANALOGY TO TWO AND THREE-DIMENSIONAL PROBLEMS IN LINEARIZED AERODYNAMIC THEORY, by W. B. Brower, Jr. Dec. 15, 1955, 103p. incl. illus. diagrs. tables, refs. (Rept. no. TR-AE-5506) (AF-OSR-TN-55-471) (AF 18(600)499) AD 83384 Unclassified

The basic princtples of an electric-analogy calculator whtch solves the integral equattonfor 2- and 3-dimensional linearized lifting theory are presented. Included are typical computattons and compartsons wtth exact solttons, when available. The calculator is simple in constructton, requiring only a semiskilled operator. It provides rapid and accurate solttons, and may be classed as inexpensive compared to other modern computing equipment. (Contractor's abstract)

RPI. 01:006

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

A LINEARIZED THEORY FOR THE NORMAL FORCE ON CLOSED BODIES OF REVOLUTION, by W. B. Brower [Jr.]. [1956] [10]p. incl. diagrs. (AF 18-(600)499) Unclassified

Published in Proc. Ninth International Congress Appl. Mech., Brussels (Belgium) (Sept. 5-13, 1956) v. 1: 439-448, 1957.

A theory is presented for the normal force on slender, closed bodies of revolution (i.e., bodies pointed at both ends) inclined slightly to the main flow. The theory embodies a mathematical model related to that employed by von Kármán in an unpublished work. In this model, a vortex sheet is assumed to emanate from the zero-meridian line aft of the section of maximum diameter. The strength and distribution of vorticity in the modified theory is determined by a boundary condition placed on the transverse flow. The theory is applied to the case of a paraboloid of revolution of fineness ratio 5. The actual computation is carried out by means of an electric-tank analogy. Comparison of results with theory are presented for the slope of the normal-force curve and the normal-force distribution. The theory with the new boundary condition yields results which are in close agreement with those of von Kármán. A few comparisons with wind-tunnel results are included. (Contractor's summary)

RPI. 01:007

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

THE USE OF RHEOELECTRICAL ANALOGIES IN AERODYNAMICS, by L. C. Malavard. Aug. 1956, 173p. incl. illus. diagrs. refs. (NATO AGARDograph

rept. no. 18) [AF 18(600)499] Unclassified

The rheoelectric analogy method is based on the identity between the equations which govern certain fluid flows and those for the distribution of electric potential in a continuous conducting medium (electric tank, conducting paper, etc.). After a review of the principle of this method, the study describes the equipment and experimental techniques used in model construction, in the physical realization of the given problem data, in the exploration of the potential fields, and in carrying out the necessary adjustments and measurements. Next the different aerodynamic applications are examined: representations of plane flows, studies of airfoil sections and turbine blade lattices, practical accomplishment of conformal mappings, and studies of axially symmetric and three-dimensional flows. Detailed descriptions are given of the analog methods and set-ups used for the solution of lifting line, propeller, lifting surface, and compressible flow problems.

RPI. 02:001

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

VORTEX STRUCTURES IN PIPE FLOW, by W. H. Webb and R. P. Harrington. Mar. 3, 1956, 3p. incl. illus. [AF 18(600)681] Unclassified

Published in Jour. Aeronaut. Sciences, v. 23: 792-794, Aug. 1956.

Apparatus is briefly described, and a method is presented for visualizing the dynamical properties of artificially produced vortex systems in order to shed light on the characteristics of vortices which may be observed in future studies of natural transition. The apparatus consists principally of two large steel water tanks connected by a long straight 1.25-in. id plastic pipe, flow being induced in the pipe by opening valves on the downstream tank. The maximum Reynolds number obtainable, based on pipe radius and mean velocity, was about 10,000. For visualization of the flow, dye was injected either through a rake inserted in the front of the entrance nozzle or through a thin slit in the pipe located some distance downstream of the inlet. Velocity profiles were measured by means of a micrometer pitot tube connected to a bifluid manometer, and mean flow measurements were made by use of a sight glass on the upstream tank. Many disturbance elements of widely varying shapes, e.g., 3/16 and 1/8-in. machine screws, and a 0.0038-in. diam wire, were utilized to produce a velocity perturbation normal to the mean parallel flow. Typical vortex sequences observed for all varieties of disturbances are shown. The vortices are of the horseshoe type as discussed by Theodorsen (Mechanism of Turbulence, Proceedings of the Second Midwestern Conference on Fluid Mechanics, 1952). An attempt was also made to measure the disturbance magnitude necessary to produce the last stage of flow for various Reynolds numbers. The results are presented on a graph. A sequence of slow-motion photographs (1000 frames/sec) is included showing the turbulent burst which occurred naturally, without an obstruction, in the pipe at a Reynolds number of 5000. The vortex-like motions which are seen at the wall are not clearly defined; it is felt, however, that photographic refinements will eventually allow detailed analyses to be made of the unique transition vortex configuration for pipe flow.

RPI. 03:001

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

ON THE LAMINAR MIXING OF A TWO-DIMENSIONAL COMPRESSIBLE JET, by K.-T. Yen. Mar. 18, 1954 [17] p. incl. diagr. (Rept. no. TR-AE-5404) ([AF]OSR-TN-54-129) (AF 18(600)992) AD 40025 Unclassified

The 2-dimensional problem is considered of laminar mixing and induction by injection of a high-speed jet into a stationary fluid. By means of an asymptotic expansion and a change of independent variables, the usual boundary-layer-type differential equations are reduced to a single ordinary differential equation as a first approximation. The transformation of the independent variables is chosen such that it relates the compressible mixing problem to its associated incompressible one for which the solution is already known. The solution for the compressible case can then be readily obtained. The effect of compressibility on the divergence of the jet, the mass flow rate, and the velocity field is given. The method is equivalent to the technique suggested by Stewartson (Proc. Roy. Soc. London A., v. 200: 84, 1949), and is applicable to the turbulent case by suitable modification of the coefficient of viscosity.

RPI. 03:002

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

AN INVESTIGATION OF THE COANDA EFFECT FOR SUPERSONIC FLOWS, by K.-T. Yen. Mar. 18, 1954 [30] p. incl. diagrs. (Rept. no. TR-AE-5405) ([AF]OSR-TN-54-130) (AF 18(600)992) AD 45023 Unclassified

The purpose of this work is to study the feasibility of utilizing the Coanda effect to improve the mixing and induction of supersonic flows. The problem studied here is the flow phenomenon of two supersonic streams as the result of inserting a curved surface into the primary stream. An approximate theory based on the Prandtl-Meyer flow is developed for the determination of the contact discontinuity between the two streams. The laminar mixing along the contact discontinuity is then studied. It is shown that the mixing of the two streams can be improved appreciably provided certain temperature and Mach number conditions for these two streams are satisfied. (Contractor's abstract)

RPI. 03:003 - RPI. 05:001

RPI. 03:003

Rensselaer Polytechntc Inst. Dept. of Aeronauttcal Engineering, Troy, N. Y.

A THEORETICAL EVALUATION OF THE COANDA NOZZLE, by K.-T. Yen. July 5, t955 [29]p. tncl. dtagrs. (Rept. no. TR-AE-550t) ([AF]OSR-TN-55-253) (AF 18(600)992) AD 84518 Unclassifted

An tnvesttgatton of the Coanda effect as applted to a 2-dtmenstonal nozzle (Coanda nozzle) wtth a bend attached to 1 stde of tts exit ts made. By constdertng a perfect fluid, theorettcal analysis shows that an apprectable mass flow rate tncrease ts obtatned when the flow follows the bend and ts deflected. Theorettcally, the sharper the corner at the bend, the longer the bend attached to the nozzle, and the longer the overhang, the larger the mass flow rate whtch can be obtatned. In partttcular, the best theorettcal result ts obtatned when the bend ts sharp-edged. If the vtscous effect of the flutd ts constdered, the Coanda phenomenon, although theorettcally sound, ts dtfftcult to put tnto practtcal use. Unless effecttve and posttttve boundary layer control can be devtsed and applted, the "Coanda nozzle," tn tts present form, seems to be ltmtted tn tts practtcal value. (Contractor's abstract)

RPI. 03:004

Rensselaer Polytechntc Inst. [Dept. of Aeronauttcal Engineering] Troy, N. Y.

ON THE ENERGY BALANCE IN A COMPRESSIBLE BOUNDARY LAYER, by K.-T. Yen. Sept. 3, 1955, 3p. tncl. tllus. [AF t8(600)992] Unclasstfted

Published in Jour. Aeronaut. Sciences, v. 23: 274-276, Mar. 1956.

The energy balance tn the compresstble boundary layer over a flat plate ts constdered. The energy equatton ts stmplifted by compartng the order of magnttude of vartous terms present tn the equatton. Some stmple relattons, expressing the energy balance between the mean flow and the turbulent fluctuatton, are gtven for the partttcular case of the Prandtl number of untty. If, tn addttton, the plate ts tnsulated, tt ts shown that the sum of the total temperature of the mean flow and that of the turbulent fluctuatton is constant tn the boundary layer. (Contractor's abstract)

RPI. 04:001

Rensselaer Polytechntc Inst. Dept. of Aeronauttcal Engtneering, Troy, N. Y.

EXPLORATORY INVESTIGATION OF MIXING IN BENDS, by S. H. Lam. Sept. 1954, 6p. dtagrs. refs. (Rept. no. TR-AE-5502) ([AF]OSR-TN-55-t22) (AF 18(600)-t339) AD 63960 Unclasstfted

A summary is presented of present knowledge on the problem of flow in curved ducts. The information whtch is available currently on the effects of duct curvature on flow pattern transttton and pressure drop ts brtefly revtewed, and an account is gtven of exploratory work whtch was carrted out on thts subject at Rensselaer Polytechnic Insttttute. (Contractor's abstract)

RPI. 04:002

Rensselaer Polytechntc Inst. Dept. of Aeronauttcal Engineering, Troy, N. Y.

AN INVESTIGATION OF MIXING IN BENDS, by I. Stern, S. H. Lam, and O. J. Akel. Dec. 1955 [42]p. incl. tllus. diagrs. refs. (Rept. no. TR-AE-5508) ([AF]OSR-TR-56-1) (AF 18(600)I339) AD 8t574 Unclassifted

An expertmental study was made of the behavtor of double-flow systems tn 90° elbows by measuring the effects of primary to secondary temperature, area and stagnation pressure rattos, and of the curvature ratto on the ratto of tnduced to primary mass flows. The expertmental results do not bear out the expectatton that the secondary flow resulting from the curvature of the duct tn the presence of a nonunlformtty of tnttttal energy distrtbutton mtght promote mixing. The extstence of an optttmum curvature ratto is tndlcated for those cases tn whtch mixing of 2 flows is requtred to occur stmultaneously wtth a prescrtbed change of thetr average dtrectton. When the prescrtbed change of dtrectton ts not requtred to take place stmultaneously wtth mixing, the mtntmum losses are obtatned when the 2 flows are completely mixed tn a stralght duct before being deflected in the curved passage. Theorettcal arguments suggest a stmple expertmental technique for the measurement of mixing losses tn multiple flow systems tn bends, and thts technique ts descrtbed tn some detatl.

RPI. 05:00t

Rensselaer Polytechnic Inst. Dept. of Aeronauttcal Engineering, Troy, N. Y.

AN INVERSE PROBLEM IN HYPERSONIC VISCOUS FLOW, by T.-Y. Li. July t3, t956, 35p. tncl. dtagrs. (Rept. no. TR-AE-5603) (AFOSR-TN-56-308) (AF 18-(600)159t) AD 94842 Unclasstfted

Also published in Proc. Ftfth Mtdwestern Conference on Flutd Mechantcs, Mtchtgan U., Ann Arbor (Apr. t-2, 1957), Ann Arbor, Untv. of Mtch. Press, 1957, p. 201-223.

This mathematical study deals wtth an "inverse" problem tn hypersontc vtscous flow, the problem of determtntng the body shape assoctated wtth a prescrtbed pressure fteld. Tangent-wedge approxtmatton is used to provtde an explctt relatton between the pressure inside the boundary layer and the local effective body tncltnatton. Moment integral method ts used in the analysis of the boundary layer growth. For a

prescribed pressure field, an iterative scheme is devised to compute the necessary body shape. Numerical examples are computed for a specific pressure field at $M_\infty = 10$ for a range of Reynolds numbers in 3 different cases: (1) a heated surface; (2) a cooled surface; and (3) a supercooled surface. Results show that the iterative scheme converges rapidly, at least in the present set of examples. Significance of the results and limitations of the method are discussed. (Contractor's abstract)

RPI. 05:002

Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.

DETERMINATION OF A CONSTANT-PRESSURE SURFACE IN TWO-DIMENSIONAL HYPERSONIC VISCOUS FLOW, by R. A. Harris and T.-Y. Li. Aug. 24, 1956 [15]p. incl. diagrs. (Rept. no. TR-AE-5604) (AFOSR-TN-56-484) (AF 18(600)1591) AD 97368 Unclassified

A method is developed for determining that body shape which will maintain a constant pressure distribution on its surface in a 2-dimenstonal steady hypersonic flow. The tangent-wedge approximation is used inversely so that the pressure distribution is assumed and the body which will give this distribution is determined. Two numerical examples are computed: (1) $p/p_\infty = 1$ and (2) $p/p_\infty = 4$, in which p is the static pressure and ∞ denotes a free-stream condition. The calculations show a decrease in Reynolds number, based on an arbitrary reference length, and an increase in surface temperature; both of these tend to increase the viscous interaction effects. Boundary-layer thickness decreases as the pressure within the boundary layer increases. To maintain a constant pressure distribution on a body surface in hypersonic flow, the surface must be concave rather than plane. The degree of concavity is determined by the value of p/p_∞.

RPI. 05:003

Rensselaer Polytechnic Inst. [Dept. of Aeronautical Engineering] Troy, N. Y.

EFFECTS OF FREE STREAM VORTICITY ON THE BEHAVIOR OF A VISCOUS BOUNDARY LAYER, by T.-Y. Li. Aug. 2, 1956 [1]p. (AF 18(600)1591) AD 143926 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 23: 1128-1129, Dec. 1956.

The hypersonic boundary layer on a flat plate is associated with a region of inviscid rotational flow behind a curved shock wave from the plate leading edge. In earlier studies (Li, T.-Y., Jour. Aeronaut. Sciences, v. 22: 651-652, 1955; Li, T.-Y., Ibid., v. 22: 724-725, 1955), a simple example of a viscous boundary layer in a free stream of constant vorticity was treated, providing an understanding of the effects of free-stream vorticity on the behavior of a viscous boundary layer. The present study briefly gives a reformulation of the problem in which the pressure gradient induced by the displacement effect of the boundary layer is considered. The highlights of the analysis can be most simply presented in the case of steady, incompressible two-dimensional flow. It is demonstrated that neither the free-stream vorticity nor the boundary-layer displacement effect contributes any change on the viscous boundary layer; however, the free-stream vorticity effects may become significant as soon as the boundary-layer displacement effects become important, e.g., as in some hypersonic boundary-layer investigations. Generally, it can be stated that one of the effects of free-stream vorticity is the introduction of a modified pressure field. It follows that the skin friction, heat transfer, boundary-layer separation, and laminar stability characteristics are all affected, their effects becoming important as soon as the displacement effects become significant.

RPI. 06:001

Rensselaer Polytechnic Inst. [Dept. of Chemistry] Troy, N. Y.

THE SILVER-SILVER HALIDE ELECTRODES. PREPARATION, STABILITY, REPRODUCIBILITY, AND STANDARD POTENTIALS IN AQUEOUS AND NON-AQUEOUS MEDIA, by G. J. Janz and H. Taniguchi. Dec. 1953, iv. incl. illus. tables, refs. (Technical note no. 1) ([AF]OSR-TN-54-51) (AF 18(600)333) AD 37385 Unclassified

Also published in Chem. Rev., v. 53: 397-437, Dec. 1953.

The preparation and the properties of silver-silver halide electrodes are described, with particular reference to silver-silver chloride electrodes. Three types of the latter are distinguished, the electrolytic, thermal, and thermal-electrolytic types. Their reproductibility and stability are discussed. The standard potentials of three electrodes (silver-silver chloride, silver-silver bromide, and silver-silver iodide) in various media and at various temperatures were established.

RPI. 06:002

Rensselaer Polytechnic Inst. Dept. of Chemistry, Troy, N. Y.

AN ANHYDROUS HYDROGEN CHLORIDE GENERATOR, by H. Taniguchi and G. J. Janz. Aug. 1955 [4]p. incl. diagr. (Technical note no. 2) ([AF]OSR-TN-55-318) (AF 18(600)333) AD 77228 Unclassified

Also published in Anal. Chem., v. 28: 287-288, Feb. 1956.

An all-glass (Pyrex) apparatus has been constructed

RPI. 06:003 - RPI. 06:006

for the generation of pure anhydrous HCl; thus, any danger of HCl contact with rubber is completely eltmi-nated. The apparatus is designed to handle NaCl charges of 5 to 50 g. The spent reaction mixture can be siphoned from the reaction chamber. It is pointed out that the generator operates equally well with HCl charges or with solid chloride. A schematic diagram of the apparatus is included.

RPI. 06:003

Rensselaer Polytechnic Inst. Dept. of Chemistry, Troy, N. Y.

THE PREPARATION AND REPRODUCIBILITY OF THE THERMAL-ELECTROLYTIC TYPE SILVER-SILVER CHLORIDE ELECTRODES, by H. Tantguchi and G. J. Janz. Dec. 1955 [25] p. incl. diagrs. tables. (Technical note no. 3) ([AF]OSR-TN-55-476) (AF 18(600)-333) AD 80796 Unclassified

A procedure is described in detail for the preparation of the thermal-electrolytic Ag-AgCl electrodes for precision use. A reproducibility of the electrodes by this procedure of only ±0.1 mv can be expected unless the freshly prepared electrodes are evaluated relative to equilibrated Ag-AgCl electrodes selected as reference standards. With care, reference standards corresponding to an electrode in the ground energy state, and of constant potential (±0.005 mv) for periods of several months can be attained. It is suggested that the difference in the values of the standard potential of this electrode may be attributed in part to the limited reproducibility of these electrodes. The importance of the factors of porosity, amount of silver chloride, and color, relative to the attainment of stable electrodes that equilibrate rapidly are considered. (Contractor's abstract)

RPI. 06:004

Rensselaer Polytechnic Inst. Dept. of Chemistry, Troy, N. Y.

THE CONCEPT OF THE ABSOLUTE ELECTRODE POTENTIAL, by H. Mendelsohn and G. J. Janz. June 1956, 45p. incl. diagrs. tables, refs. (Technical note no. 4) (AFOSR-TN-56-253) (AF 18(600)333) AD 88973 Unclassified

Theoretical and experimental attempts were made to determine an absolute electrode potential. Theoretical attempts were based on the determination of partial molar free energy. Experimental determinations depend on the attainment of a null electrode to measure the absolute emf of a reference electrode. Thermodynamic reasoning indicated that attainment of an absolute emf is impossible. A nonthermodynamic arithmetical device was derived for splitting up molar quantities between the respective ions in order to evaluate partial molar ionic values in the application of the Born-Haber cycle to the problem. Theoretical values obtained by means of the Born-Haber cycle are actually approximations of the absolute emf resulting from numerous assumptions of the absolute emf of an electrode are achieved but the indisputable value of this measurement has not been obtained. The Lippman, Billiter, and Andauer potentials are included in a discussion of experimental attempts to prepare a null electrode.

RPI. 06:005

Rensselaer Polytechnic Inst. Dept. of Chemistry, Troy, N. Y.

COMPARISON OF THE ELECTROMOTIVE FORCE SERIES IN VARIOUS SOLVENTS, by H. Strehlow, tr. by G. J. Janz. Nov. 1953 [26] p. incl. diagrs. tables, refs. (Technical note no. 5) (AFOSR-TN-56-549) (AF 18(600)333) AD 110368 Unclassified

Also published in Zeitschr. Elektrochemie, v. 56: 827-833, 1952.

A critical discussion is made of the basis for the arrangement of the elements in the order of their normal potentials to form the electromotive force series. It is questioned whether the emf series in the various solvents form quite isolated systems or whether a relation exists between them. The desirability of another independent method from which the emf series can be studied by comparison is stated and two possible methods are discussed. Firstly, the difference in the free energy of solvation of the Rb ion can be calculated approximately in various solvents from theoretical molecular concept. Secondly, the order of the electromotive force series gained can be tested through the acidity measurements of solutions of strong acids in the specific solvents. Calculation results and experimental data are compared.

RPI. 06:006

Rensselaer Polytechnic Inst. Dept. of Chemistry, Troy, N. Y.

CONDUCTANCE OF HYDROGEN CHLORIDE IN ACETONITRILE, by S. S. Danyluk and G. J. Janz. Nov. 24, 1956, iv. incl. diagrs. tables, refs. (Technical note no. 6) (AFOSR-TN-56-600) (AF 18(600)333) AD 115029 Unclassified

The conductance of a freshly prepared solution is not constant, but increases with time to a maximum or "stabilized" value. In the light of the present investigations, the conductance-time effect may be attributed to a slow attainment of ionization equilibrium for hydrogen chloride, the effect being attributed in part to the weak proton-acceptor properties of acetonitrile. The equivalent conductance of "stabilized" solutions of hydrogen chloride has been studied as a function of concentration over the range 0.0009 to 0.6 equiv/litre. Interpretation of the results in the light of the Bjerrum ion-pair formation and Fuoss-Kraus triple-ion formation theories in solvents of low dielectric constant is discussed. The low values of the equivalent conductance are in accord with ionic association processes in

hydrogen chloride-acetonitrile solutions. A crystalline solid of analysis corresponding to $CH_3CN \cdot 2HCl$ can be separated by chilling a saturated solution of hydrogen chloride in acetonitrile. The infrared spectra of these solutions are in accord with such molecular type hydrogen chloride addition compounds being present. Both the formation of a mixture of electrolyte and nonelectrolyte species by the solute, i.e.: (1) $CH_3CN \cdot HCl \rightleftharpoons CH_3CN + HCl$, and (2) $CH_3CNH^+ \cdot Cl^- \rightleftharpoons CH_3CNH^+ + Cl^-$ must be considered in the ultimate interpretation of the properties of hydrogen chloride in anhydrous acetonitrile. (Contractor's abstract)

RPI. 07:001

Rensselaer Polytechnic Inst. Dept. of Mathematics, Troy, N. Y.

ON THE EFFECTS OF THE ADDITION OF MASS TO VIBRATING SYSTEMS, by G. H. Handelman and H. Cohen. Sept. 1, 1956 [13]p. incl. diagrs. (Math. rept. no. 4) (AFOSR-TN-56-387) (AF 18(600)1586) AD 96045 Unclassified

Presented at Ninth International Congress of Applied Mechanics, Brussels (Belgium), Sept. 5-13, 1956.

The characteristic frequencies of a circular plate carrying a rigidly attached, rigid, concentric, circular mass of finite area and vibrating symmetrically are studied. The main problem is that of determining the ranges of the parameters for which the frequencies will always be above and always be below those of the unloaded case. The results obtained are compared with those previously found for longitudinal and transverse vibrations of bars and transverse vibrations of membranes. It is seen that critical values of the parameters depend on the specific system under study. The first term in the asymptotic expansion of the higher frequencies is obtained. It is found that the density ratios do not enter this term and the plate behaves like a beam. This is similar to the case of the membrane which behaves like a bar under longitudinal motion. (Contractor's abstract)

RPI. 07:002

Rensselaer Polytechnic Inst. Dept. of Mathematics, Troy, N. Y.

ON THE ANTI-SYMMETRIC VIBRATIONS OF A BEAM CARRYING A DISTRIBUTED ADDED MASS, by G. H. Handelman and Y.-O. Tu. July 31, 1956 [4]p. incl. diagr. (Math. rept. no. 2) (AFOSR-TN-56-398) (AF 18(600)1586) AD 96056 Unclassified

An investigation was carried out to determine the effects on the antisymmetric vibration characteristics of specific elastic systems when rigid masses occupying a finite area are attached. If a uniform beam has a symmetric rigid mass attached about an axis perpendicular to the plane of bending through a point which is referred to as the modal point, the system is assumed to execute antisymmetric vibrations about this point. Various parameters are considered and equations are derived.

RPI. 07:003

Rensselaer Polytechnic Inst. Dept. of Mathematics, Troy, N. Y.

ON THE VIBRATION OF A CIRCULAR MEMBRANE WITH ADDED MASS, by H. Cohen and G. H. Handelman. July 31, 1956 [16]p. incl. diagrs. (Math. rept. no. 1) (AFOSR-TN-56-403) (AF 18(600)-1586) AD 96211 Unclassified

The characteristic frequencies of a circular membrane carrying a rigidly attached concentric circular mass of finite area and vibrating symmetrically are studied. The main problem is that of determining the ranges of the parameters for which the frequencies will always be above or always be below those of the unloaded case. One of the chief tools is the minimum principle appropriate to the problem. The first term in the asymptotic expansion of the higher frequencies is obtained. (Contractor's summary)

RIC. 01:001

Rice Inst. Dept. of Mathematics, Houston, Tex.

LIMITS OF RATIONAL FUNCTIONS, by G. R. MacLane. Aug. 9, 1954, 9p. (Technical note no. 1) ([AF]OSR-TN-54-206) (AF 18(600)1135) AD 54609 Unclassified

Also published in Pacific Jour. Math., v. 6: 111-116, 1956.

The principal results are given in 2 theorems. Theorem 1. Let D be a simply connected domain contained in $I(Z) > 0$ and let D^* be the reflection of D in $I(Z) = 0$. Let $f(Z)$ be an arbitrary holomorphic function in D, $f \neq 0$ in D. Let $f^*(Z) = f(Z)$; $f^*(Z)$ is holomorphic and nonzero in D^*. Then there exists a sequence of rational functions $R_n(Z)$ such that: (1) all zeros and poles of $R_n(Z)$ are real; (2) $R_n(Z) \rightarrow f(Z)$ uniformly in every compact subset of D and $R_n(Z)$ $c f^*(Z)$ uniformly in every compact subset of D^*, where c is a constant of modulus 1; and (3) the sequence $R_n(Z)$ is non-normal at every point of the complement of $D \cup D^*$. Theorem 2. Let D be a simply connected domain in the Z-plane, symmetric with respect to the real axis and containing no points of the interval $x \leq 0$ of the real axis. Let $f(Z)$ be holomorphic and nonzero in D, and let $f(x)$ be real on the single interval γ common to D and the real axis. Then there exists a sequence of rational functions $R_n(Z)$ such that (1) all zeros and poles of $R_n(Z)$ are real and negative; (2) $R_n(Z) \rightarrow f(Z)$ uniformly in every compact subset of D; and (3) the sequence $R_n(Z)$ is non-normal at every point of the complement of D.

RIC. 01:002 - ROC. 01:004

RIC. 01:002

Rice Inst. Dept. of Mathematics, Houston, Tex.

ON THE ZEROS OF THE DERIVATIVES OF AN ENTIRE FUNCTION, PART I. MEROMORPHIC FUNCTIONS WITH SPECIFIED ASYMPTOTIC BEHAVIOR, PART II, by G. R. MacLane. July 19, 1955, 46p. (Technical note no. 2) ([AF]OSR-TN-55-223) (AF 18(600)1135) AD 73188 Unclassified

Also published in Proc. Amer. Math. Soc., v. 8: 702-706, Aug. 1957.

The following theorem is proved: if K is any compact subset of the z-sphere and $\omega \in K$, then there exists an entire function f(z) such that the set of all the zeros of all the functions $f^{(n)}(z)$ condenses exactly on K. An investigation is made of the existence of a meromorphic function asymptotic to several given meromorphic functions in disjoint domains stretching to ω. Emphasis is placed on the rapidity of approach in terms of $|z|$.

ROC. 01:001

Rochester U. Dept. of Chemistry, N. Y.

THE ACTION OF HEAT ON S-CROTYLTHIOSALICYLIC ACID AND RELATED COMPOUNDS, by J. C. Peiropoulos, M. A. McCall, and D. S. Tarbell. [1953] [5]p. [AF 18(600)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 1130-1134, Mar. 5, 1953.

The behavior of allyl and crotyl aryl sulfides on heating is very different from that of the oxygen analogs. S-Allyl-3,5-dichlorothiosalicylic acid is converted in part to dichlorothiosalicylic acid and to bis-(carboxydichlorophenyl) sulfide by heating to 275°. S-crotylthiosalicylic acid yields 2-ethyl-2,3-dihydrobenzothiophene (I) and the 7-carboxy derivative of this compound (II) when heated at 260°. The structures were proved by degradation and synthesis. The decarboxylation involved is simultaneous with the rearrangement and the crotyl group must rearrange without inversion, followed by cyclization to form II and I. The following new compounds, isomeric with I, have been synthesized during the identification of I: 4-methylthiochroman; 3-ethyl-2,3-dihydrobenzothiophene-1,1-dioxide; 2-methylthiochroman; and 3-methylthiochroman. (Contractor's abstract)

ROC. 01:002

Rochester U. Dept. of Chemistry, N. Y.

STUDIES ON MODEL COMPOUNDS FOR COENZYME A. A KINETIC STUDY OF AMINOLYSIS AND HYDROLYSIS OF ETHYL THIOACETATE AND β-ACETAMINOETHYL THIOACETATE IN AQUEOUS SOLUTION, by P. J. Hawkins and D. S. Tarbell. [1953] [4]p. incl. diagrs. tables, refs. [AF 18(600)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 2982-2985, June 20, 1953.

A kinetic study of the reaction of n-butylamine with ethyl thioacetate and with β-acetamidoethyl thioacetate in aqueous solution showed the rate of hydrolysis of the thioesters in aqueous amine solution to be appreciable. The rate of disappearance of ester by aminolysis and hydrolysis was in agreement with the following rate equation: $-d([Ester]/dt) = k_4[Ester][RNH_2][OH^-] + k_5[Ester][OH^-]$. The rate of reaction of the ethyl thioacetate is similar to that of β-acetamidoethyl thioacetate, indicating little effect on the reaction rate of the amide group in the β-position. Bis-(β-acetaminoethyl) disulfide and N-n-butylacetamide have been isolated in high yield from the action of n-butylamine on β-acetaminoethyl thioacetate in aqueous solution. (Contractor's abstract)

ROC. 01:003

Rochester U. Dept. of Chemistry, N. Y.

CLEAVAGE OF THE CARBON-SULFUR BOND. KINETICS OF THE REACTION OF THIOBENZOIC ACID WITH ANILINE, by P. J. Hawkins, D. S. Tarbell, and P. Noble, Jr. [1953] [4]p. incl. tables, refs. [AF 18(600)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 4462-4465, Sept. 20, 1953.

The kinetics of the reaction between thiobenzoic acid and aniline has been studied. In chlorobenzene solution, the rate is given by $k(C_6H_5COSH)(C_6H_5NH_2)$; variations in k between different samples of thiobenzoic acid are probably due to the presence of small amounts of benzoic acid as impurity. The effect of other substances on the rate has been measured. In aqueous acetic acid, the kinetics vary, depending on the composition of the solution, but most runs follow the above kinetics in the initial stage. In aniline solution, the kinetics follow the equation, rate = $k(C_6H_5COSH)^2$. The much greater rate of acylation of aniline by thiobenzoic acid, compared to benzoic acid, is discussed. (Contractor's abstract)

ROC. 01:004

Rochester U. Dept. of Chemistry, N. Y.

A NEW METHOD OF PREPARING SUBSTITUTED THIOPHENOLS, by A. H. Herz and D. S. Tarbell. [1953] [4]p. [AF 18(600)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 4657-4660, Oct. 5, 1953.

Attempts to carry out Friedel-Crafts acylations of diphenyl disulfide or formaldehyde diphenyl mercaptal were unsuccessful; however, it was shown that the readily formed addition product of a thiophenol and 3-nitrobenzalacetophenone is amenable to electrophilic substitution, and that this substituted addition product may be nearly quantitatively converted to the corresponding substituted thiophenol. It was demonstrated

by the preparation of acetylated, brominated and nitrated thiophenols that this scheme constitutes a general method for the preparation of electrophilically substituted thiophenols. (Contractor's abstract)

ROC. 01:005

Rochester U. Dept. of Chemistry, N. Y.

THE KINETICS OF BASIC HYDROLYSIS OF SOME γ-LACTONES AND γ-THIOLACTONES IN AQUEOUS ACETONE, by C. M. Stevens and D. S. Tarbell. Aug. 1, 1954 [8]p. incl. tables, refs. (Technical note no. 1) ([AF]OSR-TN-54-207) (AF 18(600)482) Unclassified

Also published in Jour. Org. Chem., v. 19: 1996-2003, Dec. 1954.

Rates of alkaline hydrolysis for 3 γ-lactones and 3 γ-thiolactones in 43% acetone - 57% H_2O have been measured conductometrically. The lactones and thiolactones show much smaller effects on the rates from increasing alkyl substitution around O_2 (or S) than do the open chain acetates and thioacetates. Methods of synthesizing γ-isocaprolactone and the corresponding thiolactone have been evaluated. The addition of thioacetic acid to 4-methyl-3-pentenoic acid is antiMarkownikoff, yielding 4-methyl-3-acetylmercaptopentanoic acid, which is also obtained from 4-methyl-2-pentenoic acid. (Contractor's abstract)

ROC. 01:006

Rochester U. Dept. of Chemistry, N. Y.

AN INFRARED STUDY OF HYDROGEN BONDING INVOLVING THE THIOL GROUP, by D. S. Tarbell, D. Plant, and C. Whiteman. Aug. 1, 1954, 4p. incl. tables, refs. (Technical note no. 2) ([AF]OSR-TN-54-208) (AF 18(600)482) AD 89077 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 1572-1575, Mar. 20, 1955.

A study of the infrared spectra of a series of aminothiols of the type $R_2N(CH_2)_nSH$ (n = 3 or 4) has given no indication of hydrogen bonding involving the -S-H group. Further studies on mixtures of sulfoxides and thiol compounds, and on thiobenzoic acid alone, indicate that hydrogen bonding through the -S-H group is negligible. The -S-D stretching frequency in thiophenol-d and n-hexanethiol-d has been found to occur at 1839 and 1870 cm^{-1}, respectively. The synthesis of several new aminothiols and aminoalcohols is reported. Thiol compounds are found to react with carbon tetrachloride in the presence of tertiary bases at room temperature to yield mainly the disulfide and the amine hydrochloride; the reaction presumably involves a displacement with the formation of $-SCCl_3$ compounds, which then react further. (Contractor's abstract)

ROC. 01:007

Rochester U. Dept. of Chemistry, N. Y.

A STUDY OF THE SCHÖNBERG REARRANGEMENT OF DIARYL THIONCARBONATES TO DIARYL THIOLCARBONATES, by H. R. Al-Kazimi, D. S. Tarbell, and D. Plant. Sept. 11, 1954 [4]p. incl. tables, refs. (Technical note no. 3) ([AF]OSR-TN-54-243) (AF 18(600)482) AD 82243 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 2479-2482, May 5, 1955.

A study of twelve examples of the Schönberg rearrangement of diaryl thioncarbonates to diaryl thiolcarbonates has shown that the reaction is favored by electron-withdrawing groups in the o and p positions. It is suggested that the reaction involves a cyclic transition state, with a nucleophilic attack of the thion sulfur on the aromatic nucleus. The similarity of this rearrangement to the Smiles, Chapman and Stevens rearrangements, and to reactions involving a shift from oxygen to sulfur, is discussed. (Contractor's abstract)

ROC. 01:008

Rochester U. Dept. of Chemistry, N. Y.

THE INFRARED SPECTRA OF SOME 1,4-THIAPYRONE DERIVATIVES, by D. S. Tarbell and P. Hoffman. [1954] [3]p. incl. table. [AF 18(600)-482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 2451-2453, May 5, 1954.

A study was made of the infrared spectra of 1,4-thiapyrone, its hydrochloride, 3-carboxy-1,4-thiapyrone, the corresponding ester and the amide. There was no evidence of normal carbonyl absorption. The spectrum of 1,4-thiapyrone hydrochloride was shifted toward lower frequencies compared to the thiapyrone itself. These results are in agreement with numerous other lines of evidence in indicating that the thiapyrone nucleus, and the thiapyrylium salts especially, are numerous hybrids with little or no contributions from forms with a carbon-oxygen double bond. The infrared spectrum of 1,4-thiapyrone sulfone, on the other hand, showed the absorption expected from a conjugated carbonyl group and carbon-carbon double bonds. The preparation of 3-carboxy-1,4-thiapyrone and its derivatives from 3-carbomethoxytetrahydro-1,4-thiapyrone is described. (Contractor's abstract)

ROC. 01:009

Rochester U. Dept. of Chemistry, N. Y.

THE SCHÖNBERG REARRANGEMENT. KINETICS OF THE REARRANGEMENT OF BIS-(4-CHLOROPHENYL) THIONCARBONATE TO THE THIOLCARBONATE, by

ROC. 01:010 - ROC. 02:001

D. H. Powers and D. S. Tarbell. July 1, 1955 [9]p. incf. iables, refs. (Technical note no. 4) ([AF]OSR-TN-55-204) (AF 18(600)482) Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 70-71, Jan. 5, 1956.

The rale of the rearrangemenl of bis-(4-chforophenyl) thioncarbonate to bis-(4-chforophenyf) thiolcarbonate without solvent has heen measured af a number of temperatures around 250°C. The reaction is first-order, ihe energy of activation is 38.2 kcal/mof, and the entropy of activatioń at 263.8°C is -12.6 cal/°/mof. fsolation experimenls show that the reaclion is essentially quantiiative. The kinetics are in agreement with the idea that the reaction involves a 4-memoered cyclic iransiiion state. (Contracior's abstract)

ROC. 01:010

Rochester U. Dept. of Chemistry, N. Y.

FREE RADfCAL SUBSTfTUTfON fN 3, 4-BENZPYRENE, by W. Conway and D. S. Tarbell. [1956] [6]p. incl. diagr. refs. [AF 18(6C0)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 2228-2233, May 20, 1956.

frradiation of 3, 4-benzpyrene and thioglycolic acid with a mercury arc in quariz vessels gives a 43% yield of 5-benzpyrenylacetic acid, whose structure is proved by decarboxylaiion to 5-methylbenzpyrene. 5-Mercapiobenzpyrene appears to be formed also. 5-Benzpyrenylmercaptoacetic acid has been synthesized, and irradiation of its methyl ester decomposes it to yield some methyl 5-benzpyrenylacelate. Azoisobutyronfirile and benzpyrene yield a small amount of a monocyanopropyl produci, and an appreciahle amount of f, 2-bis-(cyanopropyl)-1, 2-dihydrohenzpyrene. The significance of these results for the theoretical calcufations of reactivity of benzpyrene is discussed. An improved paper chromatographic technique for benzpyrene and its derivatives is described. Numerous experiments show that benzpyrene is not rapidly attacked by RS radicals. (Contractor's abstract)

ROC. 01:011

Rochester U. Dept. of Chemistry, N. Y.

THE ISOMERfZATION BY BASE OF ALKYL ALLYL SULFIDES TO ALKYL PROPENYL SULFIDES. THE MECHANISM OF THE REACTION, by D. S. Tarbell and W. E. Lovett. [1956] [6.p. incl. refs. [AF 18-(600)482] Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 2259-2264, May 20, 1956.

Allyl n-hexyl sulfide is isomerized to n-hexyl propenyl sulfide by refluxing with 3.7 M afcoholic sodium ethoxide; affyl-t-butyl sulfide behaves similarfy. Allyl n-hexyl eiher is recovered after similar treatment. Diallyl sulfide is isomerized to dipropenyl sulfide, and is also converted in part to an unsaturated mercaptan, 3-mercapto-1, 5-hexadiene, by a rearrangement of an allyl group. It has been found that N-sodiochloro-p-bromobenzenesulfonamide is superior to chloramine-T for characierization of sulfides by formation of sulfilimines. Isomerization of allyl n-hexyl sulfide by sodium ethoxide is deuteroethanol gives n-hexyfpropenyl sulfide containing (by mass spectrometric analysis) considerable quantities of mono- and dideuterated products, indicating that the isomerization proceeds through a carbanion which can exchange with the sofvent. The resufts of the siudy emphasize the ability of sulfide sulfur, not aitached io an aromatic ring, to stabilize a negaiive charge on the adjacent carbon, presumably through contributions from resonance forms with a decet of elecirons around sulfur. (Contractor's abstract)

ROC. 01:012

Rochester U. Dept. of Chemistry, N. Y.

STUDfES ON THIOESTERS RELATED TO COENZYME A. A DINETIC STUDY OF AMINOLYSIS AND HYDROLYSIS OF β -(N-METHYLACETAMINO)-ETHYL THIOACETATE, N, S-DIACETYLALETHEINE AnD γ – ACETAMINOPROPYL THIOACETATE, by D. S. Tarbeff and D. P. Cameron. [1956] [5]p. incf. [AF 18 (600)-482] Uncfassified

Published in Jour. Amer. Chem. Soc., v. 78: 2731-2735, June 20, 1956.

The synihesis of β-(N-methylacetamino)-ethyl thioacetate and γ-acetaminopropyl thioacetate is described. Rates of alkaline hydrolysis and of aminolysis by n-buiylamine of these ihioesters and of N, S-diacetylaletheine in aqueous solution at 0° have been measured; the kinetics of the reactions have been discussed. The above thioesters, containing some of the structural features of coenzyme A, do not differ greatly among themselves or with ethyl thioacetate and β-acetaminoethyl thioacetate, with respect to the thioester grouping under the conditions specified. (Contractor's abstract)

ROC. 02:001

Rochester U. Dept. of Chemistry, N. Y.

THE PfROTOLYSIS OF KETENE AT LOW PRESSURE, by G. B. Porter. [July 31, 1956] [2.p. incl. tables. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600) 1582.]) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 827-828, Feb. 20, 1957.

Apparent quantum yields of carbon monoxide and of ethylene have been determined at wave length 3650 Å

as functions of temperature and of concentration of ketene. At the lowest concentrations studied the yield of ethylene decreases, probably because of heterogeneous disappearance of methylene radicals. Apparent quantum yields of carbon monoxide, based on a Beer's law extrapolation, are constant at concentrations below 5×10^{-5} mole/liter. The significance of this constancy is discussed in terms of a detailed mechanism including an internal conversion process. (Contractor's abstract)

ROC. 02:002

Rochester U. Dept. of Chemistry, N. Y.

THE RELATIVE INTENSITIES OF FLUORESCENCE AND PHOSPHORESCENCE IN BIACETYL VAPOR, by H. Okabe and W. A Noyes, Jr. Aug. 20, 1956 [6] p. incl. diagrs. table. refs. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)1528]) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 801-806, Feb. 20, 1957.

A technique is described for measuring the relative intensities of emission from biacetyl vapor in the blue (fluorescence) and in the green (phosphorescence) parts of the spectrum when exciting wave lengths are around 4358 and 3650 Å, respectively. In pure biacetyl at 26° and 42 mm pressure the integrated ratio of green to blue is 58 (±8):1. This ratio is unaffected by change in wave length and by the addition of acetone, benzene or methyl chloride. The ratio decreases as the temperature is raised and decreased rapidly to zero upon addition of oxygen. The state from which phosphorescence occurs by a step which parallels and is independent of fluorescence. Both rates must apparently be collision independent under the conditions studied. Dissociation must occur from upper vibration levels of the singlet state although the data do not provide conclusions about details of this process. Biacetyl emission in biacetylacetone mixtures irradiated at 3130 Å (absorbed mainly by the acetone) leads at room temperature to a preferential excitation of phosphorescence rather that fluorescence. The previously proposed mechanism can account for these facts.

ROC. 02:003

Rochester U. Dept. of Chemistry, N. Y.

PHOTOCHEMICAL STUDIES. LII. THE NITROUS OXIDE-ETHANE SYSTEM, by G. A. Castellion and W. A. Noyes, Jr. Aug. 27, 1956 [4] p. incl. tables, refs. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)1528]) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 290-293, Jan. 20, 1957.

The ratio of nitrogen formed photochemically at about 1900 Å in pure nitrous oxide to that formed under identical conditions in a nitrous oxide-ethane mixture is 1.4. This indicates that the primary photochemical process is probably $N_2O = N_2 + O$ and that oxygen atoms react much more rapidly with ethane than with nitrous oxide. Several products are formed including ethylene, butane, carbon monoxide, hydrogen, methane and probably ethanol and acetaldehyde. A complete elucidation of the mechanism is not possible, due to the fact that oxygen atoms seem to react more rapidly with one or more of the products than they do with ethane itself. More ethylene is formed than one would expect from the amount of butane. Due to secondary reactions which must involve the initially formed products it has not been possible to obtain precise information about the reactions of oxygen atoms and of hydroxyl radicals.

ROC. 02:004

Rochester U. Dept. of Chemistry, N. Y.

THE PHOTOOXIDATION OF DIETHYL KETONE, by J. E. Jolley. Oct. 4, 1956 [6] p. incl. tables, refs. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)-1528]) Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 1537-1542, Apr. 5, 1957.

The photochemical reaction between diethyl ketone and oxygen has been studied at temperatures from 35 to 150° at several oxygen pressures and over a wide range of intensities. At all temperatures the carbon monoxide yield becomes small at high oxygen pressures, thus indicating that the propionyl radical reacts with oxygen without producing carbon monoxide. All yields pass through maxima (except possibly carbon monoxide at 35°), and oxygen acts as an inhibitor at high oxygen pressures. At room temperature quantum yields are independent of intensity, but at 150° they are in inverse linear function of the square root of the intensity. Oxygen at very low pressures strongly suppresses the formation of C_2 hydrocarbons so that the reaction between ethyl radicals and oxygen must be very rapid. A fairly complete mechanism for the reaction can be suggested and the relative values of several rate constants estimated. Chains must be propagated mainly by ethoxy and pentanonyl radicals. Since rates of formation of acetaldehyde and carbon dioxide are closely parallel to each other, possibly pentanonyl radicals react with oxygen to give acetaldehyde, carbon dioxide and ethyl radicals. (Contractor's abstract)

ROC. 02:005

Rochester U. Dept. of Chemistry, N. Y.

THE PHOTOLYSIS OF KETENE AT 3650 A° IN THE PRESENCE OF OXYGEN, by G. [illegible]. Porter. [Dec. 21, 1956.] 3 p. incl. diagr. table. (Sponsored jointly

ROC. 03:001 - ROC. 03:002

by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)1528])
Unclassified

Published in Jour. Amer. Chem. Soc., v. 79: 1878-1880, Apr. 20, 1957.

The photolysis of ketene at 3650 A° was investigated in the presence of oxygen. Even at low concentrations, oxygen virtually eliminates the dissociation of ketene into carbon monoxide and methylene radicals at room temperature. There is a direct reaction of oxygen with excited ketene molecules which leads to carbon monoxide and carbon dioxide among the products, but which gives very little ethylene. Within experimental error, the quantum yield of formation of carbon monoxide is equal to that of oxygen consumption. All quantum yields are small and the principal reaction of oxygen is deactivation of excited ketene molecules. At low oxygen concentrations, the quantum yields, with exception of that of ethylene, show maxima at about 5×10^{-6} mole of oxygen/liter (about 0.1 mm pressure). At 160°, there is an intensity dependent chain reaction with oxygen. (Contractor's abstract)

ROC. 03:00f

Rochester U. Dept. of Physics, N. Y.

HIGH ENERGY COSMIC-RAY INTERACTIONS IN PHOTOGRAPHIC EMULSION AND LEAD (Abstract), by D. M. Ritson, M. F. Kaplon, and W. D. Walker. Jan. 23, 1953 [2]p. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Cambridge, Mass., Jan. 22-24, 1953.

Published in Phys. Rev., v. 90: 360-361, Apr. 15, 1953.

In a flight at White Sands, N. M., in Apr. 1952, an arrangement consisting of a 750-cc "Block" of photographic emulsion on top of an "emulsion cloud chamber" was flown at 90,000 ft for several hr. The block consisted of ninety-two 400 μ G-5 stripped emulsions piled one above the other, and the emulsion cloud chamber contained twenty-five 3-mm lead plates separated by 250 μ photographic plates. Six proton induced interactions and one secondary interaction with energies of the $\sim 10^{13}$ ev have been observed in the emulsion with multiplicities of the ~ 15 and N_h values of 0, 0, 2, 4, 6 and 15 (secondary interaction had an N_h of 2). Thus, low N_h values are characteristic of high energy primary, as well as secondary, interactions in emulsion. The events found in lead ($\sim 310^{12}$ ev) show a strong increase in apparent multiplicity with increasing distance of the interaction back in the first lead plate setting a limit on the lifetime τ of the π^0 meson, $\tau \leq 10^{-14}$ sec. The multiplicity is similar to that observed previously for interactions in brass and for the interactions observed in emulsion, indicating a very weak dependence of multiplicity in a nucleus on the number of nucleons struck by the primary. (Contractor's abstract)

ROC. 03:002

Rochester U. [Dept. of Physics] N. Y.

HIGH ENERGY NUCLEAR INTERACTIONS IN LEAD AND LIGHT ELEMENTS, by M. F. Kaplon, D. M. Ritson, and W. D. Walker. Mar. 31, 1953, 4p. incl. diagr. table, refs. (AF 18(600)380) AD 10875
Unclassified

Also published in Phys. Rev., v. 90: 716-717, May 15, 1953.

Previous measurements (Phys. Rev., v. 88: 386, 1952) were extended on nuclear interactions in the energy region 10^{12}-10^{14} ev, in a 6-hr flight at White Sands using an emulsion cloud chamber made up of a 6" x 4" x 2" "block" of 92 G-5 stripped emulsions, 6" x 4" x 400 μ, placed on top of an emulsion cloud chamber of 25 alternate 3 mm lead plates and 250 μ G-5 emulsion. The stripped emulsions of the "block" were separated after the flight and processed with emulsions attached to glass backing before development. Results are graphed and tabulated. The initial multiplicity of charged particles, observed on the plate directly below a lead absorber in which an interaction occurred, appeared to be about 20 in the majority of showers; the median energy of this group of interactions was estimated to be about 2×10^{12} ev. Seven primary interactions were found in emulsion; the average number of shower particles (N_s) about 16 appears to be independent of the number of evaporation prongs (N_h) which had a median energy of $\sim 10^{13}$ ev. If the interaction cross section for primaries of these energies is geometric, approximately half the collisions in emulsion would occur in Ag or Br and the rest in C, N, O, and H. Though the division of interactions on the basis of the number of star prongs is not certain, it seems likely that the cases with $N_h = 0$ occur in light elements, and the case with $N_h = 15$ must have arisen from an interaction in an Ag or Br nucleus. If the dividing line between the light and heavy elements is taken to be $N_h \approx 4$ or 5, then our data are consistent with half the interactions occurring in light elements and half in heavy elements. It is seen that the mean number of shower particles for interactions with $N_h < 4$ and $N_h > 4$ is 16 for both cases. Use of prior findings and corrections for the differences in median energies on the assumption that the multiplicity varies as $E^{1/4}$, permits the comparison of multiplicities of shower particles in various elements for primary energies of $\sim 5 \times 10^{12}$ ev. For lead the multiplicity is ~ 24, brass ~ 18, Ag and Br ~ 14, and light elements ~ 14. It would appear that the multiplicity in this energy region is almost independent of the target nucleus. There have been cases found in which the multiplicity of shower particles is much higher than those considered above. The possible multiple production of particles in initial interactions is briefly discussed as an explanation of experimental results. The occurrence of both high and low energy pairs of charged particles produced by neutral radiation, in observing the passage of the high energy showers through the block of stripped emulsions has

also been noted. The most reasonable assumption is that these pairs are electron-positron pairs produced by photons; though the present statistics are too low to draw any definite conclusion, the contribution of bremsstrahlung according to Schiff's theory seems to be too low to account for the low energy pairs.

ROC. 03:003

Rochester U. Dept. of Physics, N. Y.

THE ABSORPTION MEAN PATH OF THE HIGH-ENERGY NUCLEONIC COMPONENT OF COSMIC RADIATION, by M. F. Kaplon, J. Z. Klose and others. July 3, 1953, 4p. incl. diagr. (AF 18(600)380) Unclassified

Also published in Phys. Rev., v. 91: 1573, Sept. 15, 1953.

Two similar emulsion cloud chambers consisting of 24 alternate 3-mm lead plates and 250μ G-5 emulsions were exposed to cosmic radiation. One stack was exposed for 30 days at 10,700 ft with the planes of the emulsions and lead plates at an angle of 45° with the vertical. The other was exposed for 6 hr at 90,000 ft with the planes of the emulsions and lead plates horizontal. The two emulsion cloud chambers were used to obtain flux measurements of the nuclear interacting component of the cosmic radiation for energies $\gtrsim 10^{12}$ ev. The data obtained was used to determine the absorption mean path in the atmosphere (λ) for this energy region. Data is evaluated by means of a Gross transformation since the emulsion cloud chamber is not a unidirectional detector. Results show $\lambda = 129 \pm 15$ gm/cm^2 with a mean value not less than about 115 gm/cm^2, which is in agreement with the majority of previous results obtained at lower energies, and indicates it to be independent of energy from $\sim 10^9$ ev to $\sim 10^{12}$ ev. The calculated value of the primary nucleonic flux at the top of the atmosphere, $N_0 = 0.22 \pm 0.0075$/meter^2/sec/steradian, is in good agreement with a previous determination for a somewhat higher energy. For a distribution of nucleons $\alpha \cos^6 \theta$, the integral primary flux of nucleons at mountain altitude was found to be $N_0 = 0.0009 \pm 0.000$ 0.0004/meter^2/sec/steradian. For comparison the integral primary flux of nucleons determined at mountain altitude assuming an isotropic distribution of nucleons was $N_0 = 0.0004 \pm 0.0002$/meter^2/sec/steradian, representing a lower limit on N_0 at mountain altitude.

ROC. 03:004

Rochester U. Dept. of Physics, N. Y.

SOME K-PARTICLE MASS MEASUREMENTS, by D. M. Ritson. 1953. 1 p. (AF 18(600)380) Unclassified

Published in Phys. Rev., v. 91: 1572, Sept. 15, 1953.

Description is given of K-particle mass measurements determined with a new technique of measuring gap density as a function of residual range in electron-sensitive photographic emulsion. Mass values are obtained by assuming that singly charged particles of the same velocity, but different mass, produce emulsion tracks of identical gap density; then the ratio of the masses equals the ratio of the ranges where velocities are equal. Mass values ($\pm$ 100 m_e) of three K particles observed in balloon flight exposures were thus determined to be respectively 970, 1020, and 870. These results are consistent with assumption of a single mass value 950 $\pm$ 60 m_e and support the conclusions that masses of the majority of K particles observed in balloon flights are about 950 m_e and are within the accuracy of the experiments indistinguishable from the mass of the τ meson.

ROC. 03:005

Rochester U. Dept. of Physics, N. Y.

EMULSION CLOUD-CHAMBER STUDY OF HIGH ENERGY RADIATION AT MOUNTAIN ALTITUDE (Abstract), by J. Z. Klose, M. F. Kaplon and others. June 20, 1953 [1]p. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Rochester, N. Y., June 18-20, 1953.

Published in Phys. Rev., v. 92: 855, Nov. 1, 1953.

An emulsion cloud chamber consisting of 24 alternate 6 in. x 4 in. 3.13-mm Pb plates and 250 μ Ilford G-5 emulsions was exposed for one month at Echo Lake, Colo. High energy nuclear interactions and electronic showers were detected and studied. From the analysis of the nuclear showers (median energy $\sim 10^{12}$ ev) an absorption mean free path in atmosphere of the high energy interacting component is derived. The value obtained, $\lambda_A \sim 120$ g/cm^2, is appreciably longer than the geometric mean free path. The flux and zenith angle distribution of the electronic showers are discussed. (Contractor's abstract, modified)

ROC. 03:006

Rochester U. Dept. of Physics, N. Y.

INTERACTIONS OF HEAVY PRIMARIES OF THE COSMIC RADIATION (Abstract), by M. F. Kaplon, J. H. Noon, and D. M. Ritson. June 20, 1953. [1]p. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Rochester, N. Y., June 18-20, 1953.

Published in Phys. Rev., v. 92: 855, Nov. 1, 1953.

In tracing 300 heavy primaries, 90 interactions were found with nuclei of a photographic emulsion "block." The emulsion "block" was composed of ninety-two 400μ stripped emulsions (6 in. x 4 in.) piled above each other. The block was flown for 6 hr at White Sands (41° geomagnetic). Eight of the 90 interactions found

ROC. 03:007 - ROC. 03:010

appeared to be with the hydrogen of the emulsion. These can be used for charge calibration. Out of the 90 interactions 22 fragments with Z = 3, 4, or 5 were found to emerge, confirming previously published values. Thus it does not seem possible to account for an apparently observed primary flux of these nuclei in terms of secondaries produced in the atmosphere. A detailed discussion of mean free paths and mechanism of the interactions is presented. (Contractor's abstract, modified)

ROC. 03:007

Rochester U. Dept. of Physics, N. Y.

PRODUCTION OF FAST LITHIUM, BERYLLIUM, BORON FRAGMENTS FROM INTERACTIONS OF PRIMARY COSMIC-RAY NUCLEI, by J. H. Noon, M. F. Kaplon, and D. M. Ritson. [1953] 3p. incl. diagrs. (AF 18(600)380) Unclassified

Also published in Phys. Rev., v. 92: 1585-1586, Dec. 15, 1953.

Study was made of the interactions of heavy cosmic ray nuclei in a stack of ninety-two 400μ Ilford G-5 stripped emulsions flown at White Sands, N. M. (41° geomagnetic). Two hundred and seventy heavy primary nuclei were traced through the stack. Charge determination both for the primary and collision fragments was based on delta-ray counting. The primary nuclei were divided into two groups; medium nuclei (M)$6 \leq Z \leq 10$, and heavy nuclei (H)$Z > 10$. From a study of 87 interactions occurring in emulsion, the proportion of the light elements lithium, beryllium, and boron (L nuclei) produced as fast fragments in these interactions were determined.

ROC. 03:008

Rochester U. Dept. of Physics, N. Y.

OBSERVATION OF A NEW DECAY MODE OF A HEAVY MESON, by J. Crussard, M. F. Kaplon and others. [1954] [1]p. incl. diagrs. refs. [AF 18-(600)380] Unclassified

Published in Phys. Rev., v. 93: 253, Jan. 1, 1954.

The trajectories of stopping π mesons were traced back in a stack of stripped emulsions to detect unstable heavy particles giving rise to π mesons as decay products. The technique of microscopic examination is given of the stripped emulsions, which were flown vertically at an altitude of 102,000 ft for 9 hr at geomagnetic latitude $\lambda = 55°$. Of the 299 π mesons traced, 150 were positive and 149 negative (the sign being determined since either $\pi \to \mu$ decay or σ star were observed). Of these, 116 π^+ and 103 π^- originated outside the stack, of those originating in the stack, 32 π^+ and 44 π^- came from stars having 3 or more prongs while 2 π^+ and 2 π^- originated from 2-prong stars. One π^+ meson of 4.3-mm range originates from the end of a stopping tracks (diagrammed), there is no indication of any recoil. Since the π^+ undergoes a large angle scattering, its energy lies between 13.8 and 15 mev. The stopping track has been traced through 14 emulsions and leaves the stack at a residual range of 1.6 cm. A weighted mean value of $950 \neq 85\ m_e$ was obtained for all mass measurements made on the primary particle by scattering-range and ionization-range methods. Interpretations of the event favor the decay at rest of a positively-charged heavy particle into a slow π^+ meson and one or more neutral particles.

ROC. 03:009

Rochester U. [Dept. of Physics] N. Y.

THE LIGHT ELEMENTS OF THE COSMIC RADIATION — EXPERIMENTAL (Abstract), by G. W. Racette, M. F. Kaplon, and D. M. Ritson. [1954] [1]p. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago Chicago, Ill., Nov. 27-28, 1953.

Published in Phys. Rev., v. 93: 914, Feb. 15, 1954.

A stack of 27 250μ Ilford emulsions on glass was flown with vertical orientation for 8 hr at White Sands, N. M. ($\lambda = 41°$) at a mean depth of 20 g; the 27 plates consisted of 9 triads of G-5, C-2, and D-1 emulsions. The G-5 emulsions were scanned for all tracks with $1 > 61$ min and with projected length $> 725\mu$. All tracks obtained were traced as far as possible through the stack, the variation of I with range being used to differentiate tracks with $Z \geq 3$ from nonrelativistic α particles, slow protons, and deuterons. Charge determination was made by gap density and grain count in the insensitive emulsions. In a survey of 15 cm^2 of emulsion, 21 particles were found with $3 \leq Z \leq 5$ (L nuclei), 26 with $6 \leq Z \leq 10$ (M nuclei), and 8 with $Z > 10$ (H nuclei). The primary flux values obtained for M and H nuclei are in accord with values previously reported. (Contractor's abstract)

ROC. 03:010

Rochester U. [Dept. of Physics] N. Y.

THE LIGHT ELEMENTS OF THE PRIMARY COSMIC RADIATION—INTERPRETATION (Abstract), by M. F. Kaplon, G. W. Racette, and D. M. Ritson. [1954] [1]p. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago, Ill. Nov. 27-28, 1953.

Published in Phys. Rev., v. 93: 914-915, Feb. 15, 1954.

Also published in Bull. Amer. Phys. Soc., v. 28: 10-11, Nov. 27, 1953.

To analyze the preceding data we have considered the diffusion equation for the three charge groups (L, M, H). Besides the depth of observation, the solutions depend upon λ_I (interaction mean free path) and P_{I-J} (probability of J-type production when an I type interacts) which are not well known for atmosphere (particularly P_{I-J}). It is necessary in the experiment to sum over all zenith angles consistent with our scanning criteria. Letting α be the calculated ratio of observable L nuclei emerging from collisions in the residual atmosphere to observable M nuclei with our scanning criteria, it was found that $\alpha = 0.35; 0.61$ for $P_{ML} = 0.23; 0.40$, respectively; if, for $P_{ML} = 0.40$, λ_L is increased by 10 percent, $\alpha = 0.69$. Thus, the interpretation of the observed ratio L/M = 21/16 = 0.81 depends on the λ_I and P_I. Though the observations differ markedly with those of Bradt and Peters and tend to confirm those of the Bristol Group, it is believed that a primary flux value of L nuclei derived by extrapolation cannot yet be unequivocally given, though at present the evidence favors the existence of some primary flux of the light elements. ($0.10 \lesssim L_0/M_0 \lesssim 0.5$). (Contractor's abstract)

ROC. 03:011

Rochester U. [Dept. of Physics] N. Y.

NEUTRAL-TO-CHARGE RATIO IN HIGH-ENERGY INTERACTIONS, by M. F. Kaplon, W. D. Walker, and M. Koshiba. [1954] [2]p. incl. table (AF 18(600)-380) Unclassified

Published in Phys. Rev., v. 93: 1424-1425, Mar. 15, 1954.

A group of very high energy interactions ($E = \geq 10^{12}$ev/nucleon) were examined in stripped emulsion. The ratio of π^0 mesons to charged shower particles was 0.46 ± 0.09. The ratio of other charged shower particles to $\pi^{\pm}$ - mesons was 0.09 ± 0.25. Data are tabulated for the individual interactions.

ROC. 03:012

Rochester U. Dept. of Physics, N. Y.

FRAGMENTATION OF HEAVY PRIMARY NUCLEI OF THE COSMIC RADIATION INTO LIGHT ELEMENTS (Abstract), by J. H. Noon and M. F. Kaplon. [1954] [1]p. (AF 18(600)380) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, May 1, 1954.

Published in Phys. Rev., v. 95: 647, July 15, 1954.

Interactions of heavy primary nuclei with carbon, oxygen, and hydrogen nuclei of plastic (cellulose acetate) have been studied to determine the proportion of light elements (Li, Be, B) produced as fast fragments. A vertical stack of stripped emulsions and plastic sheets was flown at Minnesota (55° geomagnetic) for 9 hr at 102,000 ft. Twelve 400 μ Ilford G-5 emulsions (6" x 4"), 11,200 μ G-5-200 μ G-0 emulsions and 11 plastic sheets were arranged in 11 sets of triads. In tracing 800 heavy primaries ($Z \geq 6$) through the stack, 15 interactions were found to occur in the plastic and in 8 cases light elements were produced as fast fragments. The probability for fragmentation into light elements thus obtained agrees with a previous calculation on the basis of a simple geometrical model using data from heavy primary interactions with nuclei of photographic emulsion. This information is important in estimating what proportion of the observed flux of light elements at a given depth in the atmosphere comes from interaction of heavy primaries with nitrogen and oxygen of the residual atmosphere. (Contractor's abstract)

ROC. 03:013

Rochester U. [Dept. of Physics] N. Y.

HEAVY UNSTABLE PARTICLES IN STRIPPED EMULSIONS, by J. Crussard, M. F. Kaplon and others. [1954] [1]p. incl. table. (AF 18(600)380) Unclassified

Published in Phys. Rev., v. 95: 584, July 15, 1954.

Seven particles and their masses are: K_{π}^{+}, 1060 ± 100 m_e; K_{μ}^{+}, 980 ± 130 m_e; K_1, 1020 ± 300 m_e; K_2, 968 ± 220 m_e; τ, 870 ± 215 m_e; $\Lambda^{\pm}$, 2390 ± 490 m_e; and an excited fragment, $4 \leq Z \leq 6$. The origin, primary range, and the secondaries of each particle are tabulated.

ROC. 03:014

Rochester U. Dept. of Physics, N. Y.

OBSERVATIONS ON THE HIGH-ENERGY SOFT CASCADE (Abstract), by M. Koshiba and M. F. Kaplon. [1954] [1]p. (AF 18(600)380) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, May 1, 1954.

Published in Phys. Rev., v. 95: 647, July 15, 1954.

The use of stripped emulsion stacks affords an excellent opportunity to study the soft cascade process in detail. In order to specify with some certainty the initial conditions of the cascade and to introduce no selection bias, it is appropriate to study the soft showers originating from the decay photons of neutral π mesons emitted in high energy nuclear interactions. Soft showers which appear to originate from a single electron or photon in the emulsion may be accompanied by one or more photons; further for these showers there may be a detection bias favoring those showers with the largest fluctuations. The soft cascades initiated by the decay π^0 photons of a very high energy nuclear interaction has been studied. For the showers of low initial energy the cascade seems

ROC. 03:015 - ROC. 03:018

to develop in accord with the predictions of shower theory; on the other hand for showers of very high initial energy (≳100 bev), the trident process seems to play an important role in the initial development. Detailed shower developments will be presented and the trident process discussed. (Contractor's abstract)

ROC. 03:015

Rochester U. Dept. of Physics, N. Y.

OBSERVATIONS ON UNSTABLE PARTICLES IN PHOTOGRAPHIC EMULSION (Abstract), by J. Crussard, M. F. Kaplon and others. [1954] [1]p. (AF 18(600)380) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, May 1, 1954.

Published in Phys. Rev., v. 95: 660, July 15, 1954.

Also published in Bull. Amer. Phys. Soc., v. 29: 72-73, Apr. 29, 1954.

Further evidence is presented for the existence of the alternate decay mode of the τ meson. A particle with a mass value of 1060 ± 100 m_e, originating from a star classified as either 2 + 1_0 or 2 + 0_p, is observed to decay into a π^+ meson of 15.2 mev energy. Two cases of normal 3 charged π decay of the τ meson are observed, one of which gives a precise Q value of 73.85 ± 1 mev; it is noted that the τ meson mass is identical within experimental errors to that of the θ° meson. A K meson is observed to be produced from a star with a total visible prong energy of 850 mev; this may suggest a low production threshold. Another K meson is observed to suffer large angle inelastic scattering at low energy (~40 mev) implying a direct nuclear interaction of this particle. Q values for 2 prong stars consisting of π^- mesons and protons will be reported; among these is a value of 37.8 ± .6 mev, corresponding to a Λ_0 decay. (Contractor's abstract)

ROC. 03:016

Rochester U. [Dept. of Physics] N. Y.

ANOMALOUS EVENT OBSERVED IN PHOTOGRAPHIC EMULSION, by J. H. Noon, M. F. Kaplon, and J. Crussard. [1954] [2]p. incl. diagr. tables. (AF 18-(600)380) Unclassified

Published in Phys. Rev., v. 95: 1103-1104, Aug. 15, 1954.

In a stack of 400-μ G-5 stripped emulsions flown at high altitude an anomalous interaction of a fast heavy nucleus was observed. A fast Be nucleus (a) interacts producing a 6 + 1 $_{Be}$ star. Two of the prongs are relativistic particles of charge 3 and 2, each making an angle ~ 0.002 radian with the primary. The triply charged particle (b) interacts after 5.09 cm, giving a 0 + $6_{1.1}$ star. The doubly charged particle (c) travels 1.37 cm, then splits into 2 fast singly charged particles (d and e); there is no observational evidence of nuclear interaction and the event c→d + e is coplanar. Since it is resonable to assume in interaction of fast heavy nuclei that the fast heavy fragments observed originate from the incident nucleus, the charge of the fragments should not exceed that of the parent. The violation of this aspect of charge conservation provides the anomaly. Possible explanations are discussed. (C.A., 1954:11955e)

ROC. 03:017

Rochester U. [Dept. of Physics] N. Y.

ABUNDANCE OF LITHIUM, BERYLLIUM, AND BORON IN THE PRIMARY COSMIC RADIATION, by M. F. Kaplon, J. H. Noon, and G. W. Racette. [1954] 29p. incl. diagrs. tables, refs. (AF 18(600)380) Unclassified

Also published in Phys. Rev., v. 96: 1408-1416, Dec. 1, 1954.

The flux of nuclei of charge greater than two of the primary cosmic radiation has been measured at 41° and 55° geomagnetic latitudes with photographic emulsions flown in "Sky Hook" balloons. The technique used at the lower latitude is similar in principle to that employed originally by Bradt and Peters, while that used at the higher latitude is the method of Dainton, Fowler, and Kent. The different experimental methods are discussed and the latter is found more satisfactory for the light element problem. Primary flux values are reported for the medium nuclei ($6 \leq Z \leq 10$) and the heavy nuclei ($Z > 10$) at the two latitudes. It is concluded that there exists a finite primary flux of the light nuclei ($3 \leq Z \leq 5$) and the most reliable value from these experiments of the ratio of the primary light-nuclei flux N_L° to the primary medium-nuclei flux N_M° at the top of the atmosphere is found to be 0.46 ± 0.15. (Contractor's abstract)

ROC. 03:018

Rochester U. [Dept. of Physics, N. Y.

ANALYSIS OF A HIGH-ENERGY COSMIC-RAY SHOWER. I. SOFT COMPONENT AND TRIDENT PROCESS, by M. Koshiba and M. F. Kaplon. [1954] 20 p. incl. diagrs. tables, refs. [AF 18(600)380] Unclassified

Published in Phys. Rev., v. 97: 193-200, Jan. 1, 1955.

An analysis is presented of the soft component arising from a high energy nuclear shower (~3 x 10^{13} ev) observed in stripped emulsion. The chief results obtained are: (1) The production ratio of neutral π mesons to charged shower particles is 0.50 ± 0.11; (2) the lifetime of the neutral π meson is found to be $(1^{+1}_{-0.5})$ x 10^{-14} sec; (3) the mean free path for direct electron

patr production by htgh-energy electrons is found to be 4.4 and 1.1 radiation untts for electrons in the energy tntervals 1 to 10 bev and t0 to 100 bev, respectively. (Contractors abstract)

ROC.03:019

Rochester U. [Dept. of Phystcs] N. Y.

INTERACTIONS OF THE HEAVY NUCLEI OF THE COSMIC RADIATION, by J. H. Noon and M. F. Kaplon. [1954] 23p. incl. diagrs. tables, refs. [AF 18(600)-380] Unclassified

Published in Phys. Rev., v. 97: 769-779, Feb. 1, 1955.

Fragmentation probabilitties have been obtained for the tnteractions of heavy nuclei wtth target nuclei of photographic emulston and a ltght element absorber (gelatin and cellulose acetate). The predictions of a stmple geometrical model for the fragmentatton probabtlitties tn ltght elements dertved from those observed tn emulsion are tn agreement wtth experimental observations. Measurements of the interaction mean free paths of heavy nuclet at dtfferent latitudes indtcate that the tnteractton cross section is energy tnsenstttve and is smaller than geometrtc. Curves are presented showing the ratto of the secondary ltght element (Lt, Be, B) flux relative to the medium element ($6 \leq Z \leq 10$) flux as a functton of atmospheric depth. (Contractor's abstract)

ROC.03:020

Rochester U. [Dept. of Phystcs] N. Y.

β^--DECAY OF K-MESONS (Abstract), by G. Yekuttelt, M. F. Kaplon, and J. Klarmann. [t955] [1]p. [AF t8(600)380] Unclasstfted

Presented at meeting of the Amer. Phys. Soc., Washtngton, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 64t, July t5, t955.

Two events in emulsion have been observed interpretable as the decay of the K-meson tnto an electron and two neutral partticles. In the first the decay track ts emitted at mtnimum tonization with E = 260 mev; identification rests upon the fact that it loses t10 mev in 4.6 cm with no change in tonization, an abnormal loss for a π or μ meson but not for an electron. In the second the secondary is emitted with 20 mev at mintmum tontzation; tn terms of known particles it must be an electron. For both particles the primary mass is ~ t000 M_e. In view of this and other recent observations on the K electron decay, it now seems conclusive that a K-meson exists and decays into an electron and two neutral massless partticles (this is implied by first event above). It is thus interesting to inquire as to whether the K decays giving a continuous electron and μ meson spectra may not be alternate modes via a Fermi tnteractton. The branching ratto is of order unity and the life time $\sim 10^{-9}$ seconds assuming a Universal Fermt Interaction. A survey of the observattons on K meson decay tn emulston shows the data does not contradtct this hypothesis. (Contractor's abstract)

ROC.03:021

Rochester U. [Dept. of Phystcs] N. Y.

HIGH-ENERGY COSMIC-RAY SOFT SHOWERS IN NUCLEAR EMULSION (Abstract), by M. Koshiba and M. F. Kaplon. [1955] [1]p. [AF 18(600)380] Unclasstfied

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 641, July 15, 1955.

A stack of stripped emulsion flown tn Sky Hook Balloons at 41° geomagnetic latitude has been scanned for high energy soft showers. More than 20 cases of pure electron showers whose apparent ortgin consists of a single electron pair in emulston have been observed and analyzed. The nature of these showers (initial pair energy in the regton of 10 bev) as well as the tnttial cascade development has been tnvestigated, wtth special attention to the trident process in the early development. Most of these showers are conststent with the assumptton that they ortgtnate from the conversion of the decay photons from locally produced π^0 mesons. However, there are a few anamolous cases not eastly reconcileable wtth our present knowledge. (Contractor's abstract)

ROC.03:022

Rochester U. [Dept. of Physics] N. Y.

"V"-PARTICLES IN NUCLEAR EMULSION, by J. Klarmann, M. F. Kaplon, and G. Yekutieit. [1955] [1]p. [AF t8(600)380] Unclassifted

Presented at meetting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, t955.

Published in Phys. Rev., v. 99: 64t, July 15, 1955.

Emulston stacks are well sutted for precise energy determtnattons and tdentiftcattons of relattvely energetic charged particles (effective energy ltmtt determined by stack size) stnce they can be stopped and their energy limit determined by range measurement, whtle tdentiftcation ts assisted by the characteristics of the track termtnus. Emulsion stacks should thus afford the most precise Q-value determinations for unstable partticles if they can be detected and their decay fragments stop. We have searched for "V-particles" by tracing back trajectories of π-mesons; for those events in which the meson ortginates from a 2 prong star, the other prong being an endtng proton, a Q-value was calculated as sumtng decay of a neutral particle into a proton and

ROC. 03:023 - ROC. 03:027

π^-meson. Very precise Q-values are reported for the Λ° decay in this way. At present 12 "V-particles" selected this way in the laboratory give a spectrum of Q-values including 3 between 36.6 and 37 mev and two with 30.3 and 30.5 mev respectively. The latter two (having no counterpart in Cloud Chamber investigations) suggest a possible background of simulated V-particles in emulsion coincding with the Λ°. An attempt to assess this is made by studying stars of the type $(\pi^+)_o$, $(\pi^+)_p$, $(\pi^+ + p)_p$, $(\pi^- + 2p)_o$ and $(\pi^- + 2p)_p$ which, with the simulated V-particle stars $(\pi^- + p)_o$, represent the two possibilities of single $\pi^\pm$ meson production in photo-nucleon interaction and the four possibilities in nucleon-nucleon interactions. (Contractor's abstract)

ROC. 03:023

Rochester U. [Dept. of Physics] N. Y.

β-DECAY OF K-MESONS AND THE CLASSIFICATION OF K-MESON DECAYS, by M. F. Kaplon, J. Klarmann, and G. Yekutieli. May 5, 1955, 20p. incl. diagrs. tables, refs. [AF 18(600)380] Unclassified

Also published in Phys. Rev., v. 99: 1528-1533, Sept. 1, 1955.

Three well-identified cases of K-electron decay were observed. The secondary electrons have energies of 20-261 mev. This shows that the decay involves at least 3 particles. The available data on K-meson decays observed in nuclear emulsion is analyzed by determining how many of the secondaries are consistent with the assumption that they are μ-mesons from the $K_{\mu 3}$ decay or electrons from the Ke_3 decay. An appreciable fraction ($\sim$1/3 to 1/2) of the observed decays are consistent with this assignment. The observed branching ratio is consistent with that deduced from a Fermi interaction, but the lifetime predicted on the basis of a universal Fermi interaction is shorter than that suggested by the observations in emulsion. The existing data on K-mesons are consistent with the assumption that there are at least 5 separate decay schemes, and that in each case the parent K-meson has integral spin. (C. A., 1955:15532h)

ROC. 03:024

Rochester U. [Dept. of Physics] N. Y.

HIGH-ENERGY ELECTROMAGNETIC PHENOMENA IN COSMIC RADIATION, by M. Koshiba and M. F. Kaplon. [1955] 1 v. incl. diagrs. tables, refs. [AF 18(600)-380] Unclassified

Also published in Phys. Rev., v. 100: 327-339, Oct. 1, 1955.

Isolated high-energy electron showers in photographic emulsion have been investigated and have yielded the following conclusions: (1) out of 16 cases of isolated electron showers observed to originate from single electron pairs of energy greater than 1 bev, 2 cases have been found to be anomalous in the sense that they seem to have been initiated by more than 2 photons; one of the two has been analyzed in detail. (2) The discrepancy between the experimental observations and theoretical predictions on the trident process found in a previous work has been obtained again with the additional experimental data of this experiment. (Contractor's abstract)

ROC. 03:025

Rochester U. Dept. of Physics, N. Y.

NATURE OF THE NEUTRAL PARTICLES IN THE $K_{\mu 3}$ DECAY, by G. Yekutieli, M. F. Kaplon, and T. F. Hoang. [1956] [2]p. incl. diagr. (Sponsored jointly by Atomic Energy Commission and Air Force Office of Scientific Research under AF 18(600)380) Unclassified

Published in Phys. Rev., v. 101: 506-507, Jan. 1, 1956.

The reaction $K^+ \rightarrow e^+ + e^- + \mu^+$ was identified. The $e^- - e^+$ pair had p βc values of 21 ± 6 and 74 ± 9 mev. The μ^+ kinetic energy at emission was 17.93 mev. The K^+ mass was 1060 ± 200 m_e. A theoretical treatment of the $K_{\mu 3}{}^+$ decay is given.

ROC. 03:026

Rochester U. Dept. of Physics, N. Y.

FURTHER EVIDENCE ON THE NATURE OF THE NEUTRAL PARTICLES IN THE DECAY SCHEME OF $K_{\mu 3}$, by T. F. Hoang, M. F. Kaplon, and G. Yekutieli. [1956] [2]p. incl. diagr. (Sponsored jointly by Atomic Energy Commission and Air Force Office of Scientific Research under AF 18(600)380) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 15, Jan. 30, 1956.

Published in Phys. Rev., v. 101: 1834-1835, Mar. 15, 1956.

The decay $K_{\mu 3} \rightarrow \mu^+ + \pi^\circ + X^\circ$ (X° is a neutral particle with mass < 217 mev; it can be a π° meson, γ-ray, or a neutrino) was demonstrated previously. In a new $K_{\mu 3}$ decay, it was found that X° is massless, and that it is either a photon or a neutrino. (C. A., 1956:9903d)

ROC. 03:027

Rochester U. Dept. of Physics, N. Y.

METHODS FOR THE DETERMINATION OF GAP LENGTH DISTRIBUTION OF NUCLEAR EMULSION

TRACKS (Abstract), by J. Klarmann and R. A. Bryan. [1956] [1]p. (AF 18(600)380) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 230, Apr. 26, 1956.

Two different methods, using a multiple channel analyzer, have been employed to measure the gap length distribution for tracks of low Z components of the primary cosmic radiation. In previous methods the observer measured and recorded the length of each gap individually, but here the recording is automatic. At the end of a measurement the number of gaps longer than s microns for 8 adjustable values of s can be read off directly from the channel analyzer. In the first method the stage is driven at uniform speed along the track while in the second the observer moves at hairline along the track. In both methods the observer does not have to remove his eyes from the microscope for duration of the measurement. Thus these methods seem to be more expedient than others previously described. Data indicating the sensitivity and range of application of both methods are presented.

ROC. 03:028

Rochester U. Dept. of Physics, N. Y.

RATIOS OF DECAY MODES OF K^+ MESONS PRODUCED BY THE COSMOTRON, by T. F. Hoang, M. F. Kaplon, and G. Yekutieli. [1956] [3]p. incl. diagrs. tables. (Sponsored jointly by Atomic Energy Commission and Air Force Office of Scientific Research under AF 18(600)380) Unclassified

Published in Phys. Rev., v. 102: 1185-1187, May 15, 1956.

A beam of K^+ mesons, 270 ± 10 mev/c, was produced by 2.9 - bev protons on Cu. The occurrence of the modes of decay was: $K_{\mu 2}$, $59 \pm \frac{6}{5}\%$; $K_{\pi 2}$, 21 ± 3%; τ, 5.2%; $K_{\pi 3}$, 3.5%; $K_{\mu 3}$, $6 \pm \frac{3}{2}\%$; K_{e3}, $5 \pm \frac{6}{2.7}\%$. The results are compared with those of Ritson, et al. (Chem. Abstracts, v. 50: 6965i, 1956) and of Crussard, et al. (C.A., 1956:14404f)

ROC. 03:029

Rochester U. Dept. of Physics, N. Y.

TWO EXAMPLES OF RARE K^+ - DECAYS IN EMULSION, by R. Cester, T. F. Hoang and others. [1956] [3]p. incl. diagrs. (Sponsored jointly by Atomic Energy Commission and Air Force Office of Scientific Research under [AF 18(600)380]) Unclassified

Published in Nuovo Cimento, Series X, v. 3: 1471-1473, June 1, 1956.

A decay at rest, $K^+ \pi_2 - \pi^+ + \pi^\circ (- e^+ + e^- + \lambda)$ and a decay in flight, $\tau^+ - 2_{\pi^+} + \pi^-$, are observed. (C.A., 1958:18007e)

ROC. 03:030

Rochester U. Dept. of Physics, N. Y.

CONTROLLED DEVELOPMENT FOR NUCLEAR EMULSIONS, by J. M. Blum. [May 28, 1956; rev. July 17, 1956] [2]p. incl. diagrs. [AF 18(600)380] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 219, Apr. 26, 1956.

Published in Rev. Scient. Instruments, v. 27: 938-939, Nov. 1956.

A method consisting of separating the active phase of the development of nuclear emulsions into two or more stages is presented here. The purpose of this procedure is to obtain a reproducible degree of development of these emulsions at some prefixed level of sensitivity. The preliminary results reported indicate the feasibility of this procedure. (Contractor's abstract)

ROC. 04:001

Rochester U. Inst. of Optics, N. Y.

INVESTIGATION OF LEAD SULFIDE PHOTOCONDUCTIVITY BY OPTICAL SCANNING TECHNIQUE, by E. P. Woodruff and H. D. Polster. Technical rept. Nov. 1953, 7p. (AF 18(600)193) AD 28941 Unclassified

The photoconductive sensitivity of microscopic regions of PbS surfaces was investigated with a microbeam apparatus which produced a spot of light of a magnitude of 2 to 15μ on the photoconductor. PbS surfaces, chemically deposited onto glass with gold electrodes evaporated onto the ends, were examined. Electron photomicrographs indicated a crystallite size of 0.5 to 2.0 μ. All work was carried out at room temperature. In a number of parallel scans, it was found that few points varied by as much as a factor of 10 from the normal. Some of the localized spots of high sensitivity occurred near the ends of threadlike breaks. Several phenomena were found that involved changes in sensitivity over periods of hours. Ion migration is discussed with respect to these phenomena. Noise of an order of magnitude greater than normal followed a reversal of the polarity after continuous running in one polarity for days. The noise subsided to normal in about ½ hr. (ASTIA abstract)

ROC.04:002 - ROC.04:006

ROC.04:002

Rochester U. Inst. of Optics, N. Y.

FINE-SPOT SCANNING OF LEAD SULFIDE FILMS, by D. Dutton. Oct. 1954 [19]p. incl. diagrs. refs. ([AF]OSR-TN-54-288) (AF 18(600)193) AD 50329 Unclassified

High resolution optical scanning and potential probe measurements have been made on chemically deposited lead sulfide layers. Photoconductivity is localized to a high degree in regions at least as small as the optical resolution limit of 2 μ. These regions might be identified with potential barriers of the type proposed by Smith (Proceedings of the Reading Conference on Semiconducting Materials, 1951, p.198) and Gibson (Proc. Phys. Soc. London, v. 64B: 603, 1951) with the stipulations that: (a) diffusion of minority carriers is effectively limited by grain boundaries; and (b) those grain boundaries associated with important potential barriers are relatively infrequent. The films may show high optical sensitivity associated with large potential gradients near the electrodes. This is apparently a polarization effect absent in new cells. The high gradient develops near the cathode over a period of several hr, at room temperature, with an applied field of the order of 5v/mm. (Contractor's abstract)

ROC.04:003

Rochester U. Inst. of Optics, N. Y.

LOCALIZATION OF PHOTOCONDUCTIVITY IN PbS FILMS, by D. Dutton. Aug. 1955 [11]p. incl. diagrs. (Technical note no. 3) ([AF]OSR-TN-55-279) (AF 18-(600)193) AD 77487 Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

A test for the degree of localization of photoconductivity in thin films, first used by Müser (Zeitschr. physik. Chemie (Leipzig), v. 198: 52, 1951) and consisting of the comparison of the photocurrents produced by 2 orientations of a long narrow beam, parallel to and perpendicular to the applied field, has been applied to samples of lead sulfide photoconducting layers. The results are consistent with a localized-photoconductivity model. Because of inherent experimental difficulties, the method does not appear suitable for placing a small upper limit on the range of minority carriers. On the basis of the present measurements, the limit may be placed at from 0.1 to 0.3 mm. The limit suggested by fine-spot scanning observations is less than 2 x 10^{-3}mm. (Contractor's abstract)

ROC.04:004

Rochester U. Inst. of Optics, N. Y.

LUMINESCENCE OF POTASSIUM IODIDE, by K. Teegarden. June 1956 [21]p. incl. diagrs. (Rept. no. 7) (AFOSR-TN-56-275) (AF 18(600)193) AD 89485 Unclassified

Also published in Phys. Rev., v. 105: 1222-1227, Feb. 15, 1957.

Single crystals of KI luminesced with a quantum yield between 0.5 and 1 when cooled to -160°C and illuminated with light absorbed in the first fundamental band. Emission occurred mainly in a single band with its peak at 3.3 ev. The results obtained indicated that lattice defects which broaden or add to the tail of the fundamental band also caused a shift of the emission band to longer wavelengths. With a single crystal containing a small amount of Th impurity, indirect excitation of Th luminescence apparently resulted from the absorption of light in the first fundamental band of the crystal at -160°C. It was indicated that a systematic study of the luminescence as a function of Th concentration may give a measurement of the so-called "exciton" diffusion length.

ROC.04:005

Rochester U. Inst. of Optics, N. Y.

NEW DATA ON ALKALI HALIDE FILMS CONTAINING EXCESS HALOGEN, by K. Teegarden. June 1956 [9]p. incl. diagrs. (Rept. no. 6) (AFOSR-TN-56-276) (AF 18(600)193) AD 89486 Unclassified

The optical densities of thin films of KI and KBr containing Cl_2 and of KCl containing excess I_2, Br_2, and Cl_2 were measured at -183°C. The films were formed by simultaneously evaporating an alkali halide and the halogen onto a fused quartz substrate. The absorption spectrum of a large crystal of KBr and the optical density of single KCl crystals were obtained after x-irradiation at -140° and -80°, respectively. The optical absorption bands of films of KI or KBr formed by excess I_2, Br_2, or Cl_2 were the same as the V-absorption bands found in additively colored or x-rayed crystals. Different absorption bands were produced by the thin KCl films with excess I_2, Br_2 or Cl_2.

ROC.04:006

Rochester U. Inst. of Optics, N. Y.

OPTICAL ABSORPTION BY SILVER HALIDES, by S. Tutthast. Oct. 1956 [13]p. incl. diagrs. refs. (AFOSR-TN-56-543) (Rept. no. 15 under AF 18(600)688 and rept. no. 8 under AF 18(600)193) AD 110362 Unclassified

Also published in Phys. Rev., v. 105: 882-884, Feb. 1957.

The absorption spectra of AgCl, AgBr and AgI films evaporated on quartz plates have been measured at room temperature and liquid nitrogen temperature. It has been found that the "exciton peaks," which have been believed to depend very little upon temperature, become sharper and shift toward the shorter wave-length side

as the films are cooled down to liquid nitrogen temperature. Attempts are made to combine the present data with some published data to give absorption curves for AgCl and AgBr over a large range of absorption spectrum at room and low temperatures. (Contractor's abstract)

ROC. 05:001

Rochester U. Inst. of Optics, N. Y.

F-CENTER WAVE FUNCTIONS IN ALKALI HALIDES, by D. L. Dexter. [1953] 5p. incl. refs. (Rept. no. R355-20-7) (AF 18(600)688) AD 42588
Unclassified

Also published in Phys. Rev., v. 93: 244-245, Jan. 1, 1954.

The discussion considers the conclusions of Kittel et al that the natural model for the F-center wave function is that corresponding to a linear combination of atomic orbitals (LCAO) centered on the 6 positive ions closest to the negative-ion vacancy. An attempt is made to show that previous experiments are consistent with the common alternative model of the F-center, based on a radial field directed at the negative-ion vacancy, when the model is properly applied. The LCAO model was capable of explaining the observed probability densities at the K nuclei, in agreement with previous conclusions, although in this simple form it predicts nothing about the density at the nearest Cl^- ions empirically found to be 0.12×10^{24} cm^{-3}. With the use of Tibbs' functions (Trans. Faraday Soc., v. 35: 1471, 1939), the probability density of the F-center electron at one of the 6 nearest Na nuclei was estimated to be 0.61×10^{24} cm^{-3}. The value for the density at one of the 12 nearest Cl nuclei was computed and found to be 0.45×10^{24} cm^{-3}. The relatively large value at the Cl nuclei is a result of the larger nuclear charge in Cl, which gives a large amplitude to the 4s-like function at the Cl nucleus. The width of the absorption peak for NaCl was measured as 162 oersteds, but with the estimated probability densities was calculated to be 265 oersteds. The next nearest shell of Na ions contributed only 1% to the mean square width. There is no obvious advantage to either type of wave function, except that the function $f(|r|)g(r)$ is simpler, and gives a more accurate description at larger r than does a LCAO containing only a few terms. (ASTIA abstract)

ROC. 05:002

Rochester U. Inst. of Optics, N. Y.

X RAY COLORATION OF ALKALI HALIDES, by D. L. Dexter. Nov. 23, 1953 [8] p. incl. illus. refs. (In cooperation with Naval Research Lab., Washington, D. C.) (AFOSR-TN-54-22) (AF 18(600)688) AD 42587
Unclassified

Also published in Phys. Rev., v. 93: 985-992, Mar. 1, 1954.

Processes of importance in the coloration of solids by x-radiation are discussed on the basis of Seitz's hypothesis that vacancies are created at jogs on dislocations or at other imperfections. The interaction between F centers and dislocations is calculated, and it is shown that F centers located within about 50Å of edge-type dislocations would experience measurable broadening and perhaps shifting of their absorption peaks, in contradiction of experiment. From the available energy in the form of point thermal pulses, it is shown that most vacancies freed from jogs or other sources probably make less than a thousand atomic jumps during x-irradiation at He temperatures and hence are unable to diffuse more than about 100Å from their sources. The tunneling of F-center electrons to positive-hole centers is calculated, and it is concluded that tunneling can occur with high probability over a distance of ~30Å by an electron in its ground state, ~40Å in its first excited state. Such tunneling is important in limiting local F- and V-center concentrations even at He temperature in the dark. Crystals achieving macroscopic concentrations of the order 10^{18} cm^{-3}, it is concluded, must contain very high densities of vacancy sources to be consistent with the requirements of both the large tunneling range and the small diffusion distance. (Contractor's abstract)

ROC. 05:003

Rochester U. Inst. of Optics, N. Y.

THEORY OF CONCENTRATION QUENCHING IN INORGANIC PHOSPHORS, by D. L. Dexter and J. H. Schulman. Feb. 8, 1954 [8] p. incl. illus. refs. (In cooperation with Naval Research Lab., Washington, D. C.) (AFOSR-TN-54-23A) (AF 18(600)688) AD 42586
Unclassified

Also published in Jour. Chem. Phys., v. 22: 1063-1070, June 1954.

A theory is presented for concentration quenching in solid systems, based on the migration of excitation energy from one activator center to another and eventually to an imperfection which may act as an energy sink. Calculations are made on the dependence of the fluorescence yield on concentration, and to indicate typical activator concentrations at which appreciable quenching may be expected to occur. If the transition in the activator is of the electric dipole or electric quadrupole type, appreciable quenching may arise when the activator concentration is 10^{-3} to 10^{-2}; if it is a magnetic dipole transition, transfer will occur by exchange, rather than by overlapping of magnetic dipole fields, and the critical concentration will be of the order of a few percent. The implications of transfer phenomena upon the observed absence of luminescence in most "pure" inorganic crystals are discussed, and it is concluded that transfer rates are so high in strongly absorbing crystals that the energy can easily migrate to a very few sinks dispersed throughout the lattice. (Contractor's abstract)

ROC. 05:004 - ROC. 05:008

ROC. 05:004

Rochester U. Inst. of Optics, N. Y.

RECIPROCITY LAW FAILURE IN DESENSITIZED EMULSIONS, by S. Tutihasi. June 1954 [22]p. incl. diagrs. tables. ([AF]OSR-TN-54-154) (AF 18(600)-688) AD 46175 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 45: 15-18, Jan. 1955.

The reciprocity law failure of desenstlized emulsions has been siudied in the range of the moderaie and extremely high intensity exposures. It is shown ihai the desensitized emulsion increases iis sensitivity in the high tniensity range relative to the non-desensitized, basic emulston. Two of the three dyes siudied have shown two sieps of low iniensiiy reciprocity failure: a strong, prtmary low tntensity failure and a weak, secondary failure. Speculations on the mechanisms of these two failures are given. (Contractor's abstract)

ROC. 05:005

Rochester U. Insi. of Optics, N. Y.

ON THE SHAPES OF ABSORPTION AND EMISSION LINES OF IMPURITIES IN SOLIDS, by D. L. Dexter. Aug. 1954, 5p. (In cooperation with Naval Research Lab. Solid State Div., Washington, D. C.) ([AF]OSR-TN-54-192) (AF 19(600)688) AD 46175 Unclassified

Also published in Phys. Rev., v. 96: 615-616, Nov. 1, 1954.

Existing ireatments of band shapes in solids, for the simplest impurity centers, predict Gaussian shape functions. These trealmenis assume for simplicity that the electronic matrix element is independent of the nuclear wave functions, and that the energy width of the band is negligible compared with ihe energy of the mtdpoint of the band. We estimate here the expected magnitude of the effect of correciing these assumptions in iypical cases, and find ihai the emtssion or absorption band may deviate from a Gausstan by iwenty per cent or more on the wings. (Contractor's abstract)

ROC. 05:006

Rochester U. Inst. of Optics, N. Y.

THE EFFECT OF DISLOCATIONS ON THE OPTICAL ABSORPTION EDGE IN NONMETALS, by R. M. Blakney and D. L. Dexter. Aug. 1954 [31]p. incl. diagrs. table, refs. ([AF]OSR-TN-54-193) (AF 18(600)688) AD 46120 Unclassified

Also published in Defects in Crystalline Solids—Report of 1954 Bristol Conference, p. 108-120.

Also published in Phys. Rev., v. 96: 227-228, Oct. 1, 1954.

Calculaitons are presenied whtch show the exieni io which dislocations may be expected to tnfluence the fundamenial electronic absorption specira of tnsulaiors and semiconductors. An absorption coefficieni of the order of 10^2/cm may be expected for several 100 Å the long-wavelength side of the absorption edge in a heavily cold-worked crystal for several types of band siructure. This value ts smaller than ihai estimated by considering only the magniiude of the mairix element for forbidden iransitions (Rev. Modern Phys., v. 23: 328, 1951).

ROC. 05:007

Rochester U. Inst. of Optics, N. Y.

ABSORPTION NEAR THE EDGE IN INSULATORS, by D. L. Dexter. Oct. 1954 [44]p. incl. dtagrs. refs. (Technical note no. 6) ([AF]OSR-TN-54-277) (AF 18-(600)688) AD 45028 Unclassifted

The shape of the absorpiion coefficieni io be expected in perfect insulating crysials is reviewed, and the influences of various types of imperfection upon the absorption specirum are discussed. In poor crysials, an absorption coefficieni of 10^2 - 10^3 may be expecied up to one ev towards lower energy from the edge, and in ihin flims surface-effeci may cause an apparent value of 10^4 or perhaps even higher. A few experimenis are suggesied which may help to add to an understanding of absorpiion phenomena. (Contractor's abstract)

ROC. 05:008

Rochester U. Insi. of Optics, N. Y.

TUNNELING OF ELECTRONS IN ALKALI HALIDES (Abstract), by D. L. Dexter. [1954] 1p. (AF 18(600)-688) Unclassifted

Presented at meeting of ihe Amer. Phys. Soc., Columbia U., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 771, May 1, 1954.

The tunneling of electrons from F-centers to hole-centers is calculated for the ground and excited states, and the accompanying bleaching is discussed. Tunneling ranges of 30 and 40 Å are found, corresponding to saturation concentrations of about 10^{19} per cm^3 if the F- and V-center distributions interpenetrate. The effect of an electric field is examined, and applications of the theory are made to experiments by Maurer and coworkers on optical and thermal bleaching in the presence of a field. Implications are discussed of tunneling phenomena on the x-ray coloration of crystals at low temperatures, and it is concluded that tunneling represents an important back-reaction for limiting local color-center concentrations. (Contractor's abstract)

ROC. 05:009

Rochester U. Inst. of Optics, N. Y.

NOTE ON THE RESISTIVITY OF DILUTE ALLOYS, by D. L. Dexter. Dec. 1953, 3p. (Technical note no. 7) ([AF]OSR-TN-55-5) (AF 18(600)688) AD 84530 Unclassifted

Also publtshed in Phys. Rev., v. 98: 543, Apr. 15, 1955.

It is shown that the temperature-independent component to the electrical resistivity of dilute alloys, associated with and proportional to the tmpurity concentration, should not, even in ideal cases, be expected to obey an even power series in the valence difference between host and impurity atom, as expressed by Linde's Rule. In the simplest cases the odd terms may be considered as artstng from interference between (shielded) coulomb and lattice distortion scattering. (Contractor's abstract)

ROC. 05:010

Rochester U. Inst. of Optics, N. Y.

CRITERION FOR THE OCCURRENCE OF LUMINESCENCE, by D. L. Dexter, C. C. Klick, and G. A. Russell. May 1955, 4p. incl. diagrs. refs. (Technical rept. no. 9) (AFOSR-TN-55-174) (AF 18(600)688) AD 81839 Unclassifled

Also publtshed in Phys. Rev., v. 100: 603-605, Oct. 15, 1955.

A mechanism is suggested for the non-radiative quenching of excited states of simple impurity centers, namely, a cross-over to the ground electronic state of the center tmmedtately after excitation and before thermal equilibrium has had time to come about. It is proposed that this mechanism is responsible for the absence of strong luminescence in some impurity and color centers, e.g., the F-center in alkali halide crystals. The quenching process proposed here is applicable only for certain geometries of the configuration coordinate diagram, which are discussed with a view to a criterion for strong luminescence. The quenching mechanism is consistent with known configuration coordinate curves, and leads to a prediction which is experimentally verified, to the effect that the wavelength of emitted radiation is not more than twice that of the light absorbed by the center The same mechanism shows the possibility of photoconductivity arising from absorption in discrete lines even at low temperatures. (Contractor's abstract)

ROC. 05:011

Rochester U. Inst. of Optics, N. Y.

ON THE ABSORPTION OF LIGHT BY ATOMS IN SOLIDS, by D. L. Dexter. May 1955, 28p. incl. refs. (Technical note no. 8) (AFOSR-TN-55-175) (AF 18(600)688) AD 70984 Unclassifled

Also published in Phys. Rev., v. 101: 48-55, Jan. 1, 1956.

The interactions of an atom with its neighbors in an idealized solid are taken into account explicitly in treating the absorption of light, as contrasted with the usual introduction of an "effective" field and mass. In the discussion of the magnitude of the absorption coefficient, 2 cases are treated: (1) the absorption by an impurity atom, in which case we are led to an equation similar to Smakula's; and (2) the absorption by 1 of the atoms of the perfect crystal. The computations are based on a simple idealized model whose validity is discussed for existing systems. (Contractor's abstract)

ROC. 05:012

Rochester U. Inst. of Optics, N. Y.

QUENCHING OF PHOTOCONDUCTIVITY IN CADMIUM SULFIDE, by S. Tutihasi. Sept. 1955 [24]p. incl. diagrs. refs. ([AF]OSR-TN-55-239) (Technical note no. 10 under AF 18(600)688 and technical note no. 4 under AF 18(600)193) AD 77488 Unclassifted

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series tt, v. 1: 110-111, Mar. 15, 1956.

Also published in Jour. Opt. Soc. Amer., v. 46: 443-448, June 1956.

An tnvestigation was made of the spectral distrtbution in CdS crystals and the temperature dependence on the quenching of the photoconductivity in the crystals. Of the 2 quenching bands which are resolved at room temperature in pure crystals, the 1.4-μ band was no longer resolved at -75°C and lower, although some quenching was observed at -185°C. In Cu-doped crystals, only 1 quenching band was observed at 1.4μ, and this completely disappeared at temperatures below -80°C. Results implied that the quenching process at 1.4μ involves the excitation of trapped holes and the thermal ionization of excited holes. The quenching peak at 0.9μ remained at -185°C in pure crystals, and the quenching efficiency was reduced to some extent. The addition of tR radiation to green light on CdS crystals caused an initial transient increase in photoconductivity in the crystals followed by a decay. Data showed that the transient increase in photoconductivity on the application of IR radiation was caused hy the temporary increase of conduction electrons created by IR light which ejects trapped electrons from traps into the conduction band. (Contractor's abstract, modified)

ROC. 05:013

Rochester U. tnst. of Optics, N. Y.

V-CENTERS IN EVAPORATED ALKALI HALIDE FILMS, by K. Teegarden. Nov. 1955 [5]p. inct. diagrs.

ROC. 05:014 - ROC. 05:017

([AF]OSR-TN-55-402) (Technical note no. 11 under AF 18(600)688 and technical note no. 5 under AF 18(600)-193) AD 79513 Unclassified

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 113, Mar. 15, 1956.

Also published in Jour. Chem. Phys., v. 24: 161, Jan. 1956.

V-centers have been produced in thin films (300 Å to 600 Å) of KI and KBr by evaporating the alkali halide and a halogen simultaneously onto a quartz substrate held at low temperature. The concentration of these centers was of the order of $10^{20}/cm^3$. A study of the films shows that the V-bands depend only on the alkali halide, not on the halogen. As a result, KI + I_2 has the same band structure as KI + Br_2. This fact tends to support the vacancy models of the V-centers suggested by Seitz and others. (Contractor's abstract)

ROC. 05:014

Rochester U. [Inst. of Optics] N. Y.

ABSORPTION CROSS SECTION FOR LIGHT IN PERFECT SOLIDS (Abstract), by D. L. Dexter. [1955] [1]p. [AF 18(600)688] Unclassified

Presented at meeting of the Amer. Phys. Soc., Mexico City (Mexico), Aug. 29-31, 1955.

Published in Phys. Rev., v. 100: 964, Nov. 1, 1955.

The interactions of an atom with its neighbors in an idealized solid are taken into account explicitly in treating the absorption of light, as contrasted with the usual introduction of an "effective" field and mass. It will be shown that in simple cases the total cross section of an atom in a given absorption line j is uninfluenced by the dipole coupling with the same transition in neighboring atoms of density n, although the transition probability per atom is increased by the factor

$$[1 + (\pi n/3)2e^2 \langle r_j \rangle^2 / e_j]^2.$$

Thus the "effective fields" for polarization, for absorption cross section, and for transition probability are all different. Additional correction terms arise from transitions $I \neq j$ in the neighbors, from exchange and overlap effects, and from higher multipole effects. These additional effects are in general important.

ROC. 05:015

Rochester U. Inst. of Optics, N. Y.

SCATTERING OF ELECTRONS FROM CLUSTERED VACANCIES IN COPPER, by D. L. Dexter. Jan. 1956 [19]p. incl. table, refs. (Technical note no. 12) ([AF OSR-TN-56-12) (AF 18(600)688) AD 82242 Unclassified

Also published in Phys. Rev., v. 103: 107-110, July 1, 1956.

The excess resistivity, ρ, and resistivity /unit stored energy, q, associated with dislocations, vacancies, and interstitials are briefly reviewed, and the same quantities are calculated for clustered vacancies. For clusters of more than 100 vacancies, which seem to exist at room temperature in cold-worked or bombarded Cu, q is larger by factors of about 3, 8, and several hundred than the corresponding ratios for vacancies, interstitials, and dislocations. (Contractor's abstract)

ROC. 05:016

Rochester U. Inst. of Optics, N. Y.

BITTER MAGNETS IN GRAPHITE SINGLE CRYSTALS, by N. N. Axelrod. Apr. 1956 [11]p. incl. diagrs. (Technical note no. 13) (AFOSR-TN-56-180) (AF 18-(600)688) AD 87053 Unclassified

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 119, Mar. 15, 1956.

A discussion is presented on the presence of screw dislocations, in single graphite crystals, with their axes along the direction of high resistivity. This anisotropy provides low resistivity paths in the c direction of these crystals. The magnetic field arising from a helical current flow was calculated by making use of a theorem by O. Bottema (Physica v. 8: 703, 1941) for the radial and vertical components of the magnetic field associated with currents in finite solenoids. A suggestion was made that it may be feasible to detect the magnetic field by using suspensions of ferromagnetic powders.

ROC. 05:017

Rochester U. Inst. of Optics, N. Y.

SOLID STATE LUMINESCENCE THEORY AND OSCILLATOR STRENGTHS IN KCl:Tl, by R. S. Knox and D. L. Dexter. June 1956 [32]p. incl. diagrs. tables, refs. (Technical note no. 14) (AFOSR-TN-56-405) (AF 18(600)688) AD 96213 Unclassified

Also published in Phys. Rev., v. 104: 1245-1262, Dec. 1, 1956.

The existing quantitative treatment by Williams (Jour. Chem. Phys. v. 19: 457, 1951) of the Seitz model (Jour. Chem. Phys., v. 6: 150, 1938) for the KCl:Tl luminescent system has been extended to include a prediction of the oscillator strengths of the 1960Å and 2475Å absorption lines. These f values are simply related to those of the associated free-ion transitions. In the course of the computations, it is found that the best available Tl+ wave functions are inaccurate for the free ion and are therefore not of great value for the KCl:Tl center. Free-ion oscillator strengths are (a) computed with these

functions, and are (b) estimated by analysis of experimental spectra. The results of both methods, when modified for KCl:Tl, are in poor agreement with experimental f values in the solid. A review and critique are given for the present Williams dynamical treatment of the Seitz-Williams model. It is concluded that a sensitive test for the model would be its successful prediction of the ratio of these (1960 and 2475Å) oscillator strengths in KCl:Tl. The observed values are from 3 to 5 times as large as the predicted value. It is decided that the KCl:Tl problem is not as well understood as it has been believed, since the existing quantitative theory: (a) is subject to considerable arbitrariness in the construction of excited-state configurational coordinate curves, (b) appears to be in fortuitous agreement with experiment insofar as its quantitative predictions depend on Tl^+ wave functions, and (c) does not, in this sample extension, predict the observed ratio of oscillator strengths corresponding to the electronic transitions assumed responsible for the behavior of the center. (Contractor's abstract)

ROC. 05:018

Rochester U. Inst. of Optics, N. Y.

OSCILLATOR STRENGTHS IN THE KCl:Tl PHOSPHOR, (Abstract), by R. S. Knox and D. L. Dexter. [1956] 1p. (AF 18(600)688) Unclassified

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 112, Mar. 15, 1956.

Wave functions calculated by Hartree without exchange are used to compute energy levels and oscillator strengths in the $^{1,3}P_1 - {}^1S_0$ transitions in free Tl^+. The results will be compared with measured f values in the iso-electronic Hg atom and those of the corresponding transitions in the KCl:Tl luminescent center. In our perturbation approximation the ratio g of f(forbidden) to f(allowed) is independent of the dipole matrix element and is simply related to the spin-orbit matrix element H_1. Values of H_1 and f in Hg indicate that for the free ion the wave functions are too diffuse, i.e., too small at small distances and too large at distances of importance in luminescence theory ($\sim 3a_0$). Implications of the lack of agreement between calculated and observed values of f and g will be discussed with a view to assessing the validity of the usual model for the KCl:Tl center. (Contractor's abstract)

ROC. 05:019

Rochester U. Inst. of Optics, N. Y.

RESISTIVITY FROM CLUSTERED VACANCIES IN COPPER (Abstract), by D. L. Dexter. [1956] 1 p. (AF 18(600)688) Unclassified

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 114, Mar. 15, 1956.

The excess resistivity and stored energy associated with clusters of vacancies, i.e., cavities, are calculated for copper on the basis of a simple model; the cavities are assumed spherical and shielding effects are neglected so that the results are valid only for clusters of more than 10^2 vacancies. The evidence for the existence of cavities, the results of the present calculations, and comparison with other scattering entities will be presented, and the implications discussed. It appears probable that, in copper heavily cold worked at nitrogen temperatures, a large fraction, of the order one-half, of the energy expended is stored in the form of vacancies, many of which cluster into cavities upon warming to room temperature. Vacancies formed by radiation damage seem to behave similarly. (Contractor's abstract)

ROM. 01:001

Rome U. School of Aeronautical Engineering (Italy).

BALANCE METHOD IN ENGINEERING SCIENCE, by L. Broglio. July 1954, 246p. incl. diagrs. tables. (Technical rept. SIARgraph no. 1) (AF 61(514)422) AD 93261 Unclassified

An explanation is presented of the basic ideas governing the Balance Method (B. M.), as applied to the problems of applied mechanics, with particular emphasis being placed on structural problems. The report is divided into 4 parts. In Part I, the B. M. is presented in a general form. Part II contains detailed practical applications of the B. M. to some typical structures. Part III develops further the work of Part II, giving some numerical examples for the structures already considered. Part IV compares the B. M. with other methods of solution. (Contractor's abstract, modified)

ROM. 01:002

Rome U. School of Aeronautical Engineering (Italy).

BALANCE METHOD IN ADVANCED AERONAUTICAL STRUCTURES ANALYSIS, by L. Broglio. Feb. 1955, 169p. incl. diagrs. tables. (Technical rept. SIARgraph no. 2) (AF 61(514)422) AD 93762 Unclassified

In this 5-part report, the Balance Method (B. M.) is applied to advanced problems concerning aeronautical structures. Part I contains general information on shell structures. Part II applies the B. M. to the 4-stringer shell for the most general condition of structure and of loading. In Part III, the B. M. is applied to the rectangular shell with 4 main stringers, the top and bottom panels being reinforced by n secondary

ROM. 01:003 - ROS. 01:001

stringers having 2 axes of symmetry. Both the cases of symmetric (bending) and antisymmetric (torsion) load distribution are treated. Part IV is devoted to the B. M. analysis of the rectangular unsymmetric shell, with the only top-panel being reinforced by n secondary stringers. Finally, Part V contains some examples of application of the solutions of Part II and III to numerical cases. Tables and graphs are included. (Contractor's abstract, modified)

ROM. 01:003

Rome U. School of Aeronautical Engineering (Italy).

STATIC ANALYSIS OF SWEPT WING BY THE BALANCE METHOD, by L. Broglio. Nov. 1955, 88p. incl. illus. (Technical rept. no. 3; SIARgraph no. 4) (AF 61(514)422) AD 113286 Unclassified

In this paper some results are presented on the problem of constant and variable cross-section swept-wings, reinforced by many stringers, with elastic ribs and with covering sheets working also in tension or compression. In Part I the fundamental relationships are deduced, that lead to the mathematical statement of the problem. In Part II the solution of the problem is obtained by the application of the Balance Method. In Part III the solution, given in the foregoing Part II, is applied to some particular load conditions for the constant cross-section swept-wing, and the general solution is also given for the variable cross-section swept-wing. In Part IV some numerical results are given in order to complete the theoretical results. (Contractor's abstract)

ROM. 01:004

Rome U. School of Aeronautical Engineering (Italy).

THE BALANCE METHOD APPLIED TO SWEPT-WING STRESS ANALYSIS, by L. Broglio. [1956] [8]p. incl. diagrs. table. (AF 61(514)433; continued by AF 61(514)888) Unclassified

Presented at Structures Session, Twenty-third annual meeting, Inst. Aeronaut. Sciences, New York, Jan. 24-27, 1955.

Published in Jour. Aeronaut. Sciences, v. 24: 363-370, May 1957.

Preliminary results are presented of an investigation dealing with the stress analysis of the variable cross-section swept wing, reinforced by many stringers, having elastic ribs, and with cover sheets carrying also tension or compression. Attention was focused on problems such as the stress concentration in the rear spar and the bending-torsion interaction. This permitted a reduction in the numbers of parameters which are assumed to define satisfactorily the motion of the various points belonging to the same wing-section. (Contractor's abstract, modified)

ROM. 02:001

Rome U. School of Aeronautical Engineering (Italy).

A METHOD FOR SOLVING DYNAMIC PROBLEMS OF MODERN TRANSONIC AND SUPERSONIC WINGS, by L. Broglio. [1956] [25]p. incl. diagrs. (NATO AGARDograph rept. no. 38) [AF 61(514)888; continuation of AF 61(514)422] Unclassified

Presented at Third meeting of the Structures and Materials Panel, Washington, D. C., Apr. 10-17, 1956.

A method is presented for the general solution of dynamic problems of delta, swept or crescent wings, or those of a more general type. The first part gives a method for the determination of frequencies and modes of vibration, with the influence coefficients and mass distribution assumed known. In the second part the calculation of the influence functions is discussed and, in the third, the methods of the previous two parts are applied to determine the influence functions in specific simplified cases. (Contractor's abstract)

ROM. 03:001

Rome U. School of Aeronautical Engineering (Italy).

METHOD OF INTEGRATION FOR SUPERSONIC FLOW BEHIND AN ATTACHED SHOCK-WAVE, by L. Broglio. Mar. 1955, 114p. incl. diagrs. tables. (Technical rept. no. 1; SIARgraph no. 3) [AFOSR-TN-55-450] (AF 61(514)431) AD 80172 Unclassified

The fluid field behind a shock wave attached to the sharp nose of a body of whatsoever form is analyzed. The solution is expanded into a series of powers r^n of the distance r from the apex: every term of the series is shown to be independent of the successive ones, and the solution results from the superposition, to a non-linear field (field around a cone), of successive linear fields (Part I). In particular, attention is devoted to a body little different from one of revolution, and the procedure is shown in this case to reduce to the step-by-step integration of a certain number of ordinary differential equations of the 2nd order (Part II). In Part III, the rules and the explicit formulas are given for the step-by-step integration of the equations that result from the analysis of Parts I and II. Finally, in Part IV, numerical examples are developed. Tables and graphs are included, (Contractor's abstract, modified)

Rosemount Aeronautical Labs., Minneapolis, Minn.
see Minnesota U. Rosemount Aeronautical Labs., Minneapolis, Minn.

ROS. 01:001

Ross, Chandler C., West Covina, Calif.

A NOMOGRAPH ON THE PROBLEM OF COMBUSTION INSTABILITY IN LIQUID-PROPELLANT ROCKET MOTORS, by C. C. Ross and P. P. Datner. Final

rept. June 4-Dec. 31, 1953, 66p. incl. illus. diagrs. tables, refs. ([AF]OSR-TR-54-2) (AF 18(600)799) Unclassified

Published in part in Selected Combustion Problems, Cambridge U. (England) (Dec. 7-11, 1953), London, Butterworths Scientific Publications, 1954, p. 352-402.

Three different types of combustion instability in liquid-propellant rocket engines – the low-frequency "chugging," the high-frequency "screaming," and the low-frequency "divergent" type – are briefly described. The pertinent information available in the literature is reviewed, and the problems encountered in securing reliable experimental data on the phenomena, using conventional instrumentation, are discussed. A discussion of low-frequency instability, resulting from the interaction of propellant feed system oscillations and combustion gas vibrations, is given, based on available test results. Some data on high-frequency combustion oscillations are presented, indicating that the vibrations of the combustion gases correspond to the propagation of finite pressure disturbances in the combustion chamber, which appear to originate in the combustion zone. The modes of combustion gas oscillations of both high and low frequencies are described as similar to those of acoustic oscillations taking place in cavity resonators, and as maintained by the interaction between the rates at which propellants are consumed and fluctuations in combustion chamber pressure, resulting in strong reactive shock waves. It is noted that combustion oscillations may be excited by disturbances of the random noise type, inherent in the combustion, or by a shock such as a "hard start." It is pointed out that all published theories on the phenomena agree on two principles. (1) The oscillations of combustion gases are maintained by periodic variations in the propellant consumption rate, resulting in a periodicity in the rate of heat release. All theories are based on Rayleigh's principle that vibration in a confined mass of gas can be maintained by periodic heat release if variations in heat release and in pressure oscillations are in phase, but that the oscillations will be impeded if the fluctuations in heat release and pressure are out of phase. (2) The significance of the combustion time lag with respect to combustion instability is generally recognized, and the rocket engines under discussion are considered to be dynamic systems with delay reaction because of this inherent time lag. It is shown that the Nyquist criterion of stability could be applied successfully for predicting the dynamic behavior of rocket systems if sufficient data were available concerning the physical and chemical kinetics of the conversion of propellants into burned gases in the combustion chamber. (Contractor's summary)

ROS. 01:002

[Itoss, Chandler C., West Covina, Calif.]

COMBUSTION PROBLEMS IN LIQUID-FUEL ROCKET ENGINES, by S. S. Penner and P. P. Datner. [1955] [19]p. incl. diagrs. table, refs. (AF 18(18(700)799) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 11-29.

Brief discussions of theoretical estimates for motor performance based on thermodynamics, the relation between nozzle flow characteristics and performance, and general rocket engines introduce a review of fundamental studies investigating the burning characteristics of simple heterogeneous systems. Engineering problems in rocket engine combustion are then reviewed. The consideration of basic work on heterogeneous combustion discusses the burning of single droplets, of fuel sprays and of monopropellants in tubes, carbon formation, and laboratory measurements of ignition delay. The review of engineering problems treats the following: design difficulties associated with ignition failure, shutdown and flame-out problems regarding peak pressures during transient operation, combustion chamber volume requirements and their relation to possible rate-controlling reaction steps, combustion oscillations, as well as motor scaling and similarity analysis.

ROY. 01:001

[Royal Inst. of Tech., Stockholm (Sweden).]

ON THE INFLUENCE OF THE GEOMETRY OF SLENDER BODIES OF REVOLUTION AND DELTA WINGS ON THEIR DRAG AND PRESSURE DISTRIBUTION AT TRANSONIC SPEEDS, by F. Keune and K. Oswatitsch. 1955, 34p. incl. diagrs. tables, refs. (Technical rept.) ([AF]OSR-TN-55-364) (AF 61(514)-811) AD 80178 Unclassified

A theory of the transition from subsonic to supersonic flow was applied to an entire body of revolution of finite length, and the lower and upper critical Mach numbers were calculated. These results were compared with supersonic values. The drag of the afterbody (behind the maximum thickness) at M = 1 is shown to be practically equal to the whole supersonic drag of this part. Even the linear supersonic theory holds for all supersonic Mach numbers. The small subsonic region on the tip at the upper critical Mach number has no appreciable influence.

RUT. 01:001

Rutgers U. [Dept. of Mathematics] New Brunswick, N. J.

LOCALIZATION ON SPHERES, by V. L. Shapiro. July 2, 1956, 15p. (AFOSR-TN-56-311) (AF 18(600)-1595) AD 94846 Unclassified

Also published in Trans. Amer. Math. Soc., v. 86: 212-219, Sept. 1957.

The main result is given by the following theorem:

Let $S \sum_{n=1}^{\infty} Y_n(x)$ be a series of surface spherical

RUT. 01:002 - RUT. 03:001

harmonics with $Y_n(x) = 0(n^\beta)$, $\beta \geq 0$, uniformly for x on Ω. Let F be the Riemann function associated with S. Then if F is of class C^{2w} on a domain D contained on Ω, S is uniformly (C, α) summable, $\alpha > p + 2w$, to $\Delta^w F$ in every closed domain contained in D. Before proving the main result, 3 lemmas dealing with trigonometric series, and 3 lemmas dealing with surface spherical harmonics are proved. The main theorem is proved by the Heine-Borel theorem, showing that if $D(x_0, h_1)$ is contained in D, then S is uniformly (C, α) summable $\Delta^w F$ for x in $D(x_0, h_1)$. The operator Δ^w is defined by $\Delta^w = \Delta(\Delta^{w-1})$, where Δ is the Laplace operator on Ω, the unit (k-1)-dimensional sphere in Euclidean k-space.

RUT. 01:002

Rutgers U. [Dept. of Mathematics] New Brunswick, N. J.

THE UNIQUENESS OF DOUBLE TRIGONOMETRIC SERIES UNDER CIRCULAR CONVERGENCE, by V. L. Shapiro. Sept. 20, 1956, 4p. (AFOSR-TN-56-453) (AF 18(600)1595) AD 96799 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 885-887, Nov. 1956.

With M = (m, n), X = (x, y), MX = mx + ny and $|X| = (x^2 + y^2)^{1/2}$, with m and n integers, the following theorem is proved: Let

$$S_R(X) = \sum_{1 \leq |M| \leq R} a_M e^{iMX},$$

where $a_M = 0(1)$ as $|M| \Rightarrow \infty$. If $S_R(X) \Rightarrow 0$ as $R \Rightarrow \infty$ for all X, then $a_M = 0$ for all M. For the proof, the set Z of discontinuity points of F(X) on the plane is shown to fill the sufficient condition if Z is the empty set.

RUT. 02:001

Rutgers U. Dept. of Physics, New Brunswick, N. J.

EFFECTS OF DIFFUSION ON FREE PRECESSION IN NUCLEAR RESONANCE EXPERIMENTS, by H. Y. Carr and E. M. Purcell. Jan. 19, 1954 [9] p. incl. illus. diagrs. (In cooperation with Harvard U. Lyman Lab. of Physics, Cambridge, Mass.) (In its Annual Research Report, no. 8, Sept. 1, 1954; AD 48577) [AFOSR-TN-54-27] (Sponsored jointly by Office of Naval Research, Atomic Energy Commission, The Radio Corp. of America, Rutgers U. Research Council, and [Air Force] Office of Scientific Research under AF 18(600)975) AD 48577(e) Unclassified

Also published in Phys. Rev., v. 94: 630-638, May 1, 1954.

Nuclear resonance techniques involving free precession are examined, and, in particular, a convenient variation of Hahn's spin-echo method is described. This variation employs a combination of pulses of different intensity or duration ("90-degree" and "180-degree" pulses). Measurements of the transverse relaxation time T_2 in fluids are often severely compromised by molecular diffusion. Hahn's analysis of the effect of diffusion is reformulated and extended, and a new scheme for measuring T_2 is described which, as predicted by the extended theory, largely circumvents the diffusion effect. On the other hand, the free precession technique, applied in a different way, permits a direct measurement of the molecular self-diffusion constant in suitable fluids. A measurement of the self-diffusion constant of water at 25°C is described which yields $D = 2.5\ (\pm 0.3) \times 10^{-5}$ cm^2/sec, in good agreement with previous determinations. An analysis of the effect of convention on free precession is also given. A null method for measuring the longitudinal relaxation time T_1, based on the unequal-pulse technique, is described. (Contractor's abstract)

RUT. 03:001

Rutgers U. [Dept. of Physics] New Brunswick, N. J.

BLOCH EQUATIONS WITH DIFFUSION TERMS, by H. C. Torrey. May 8, 1956, 7p. (AFOSR-TN-56-182) (AF 18(603)6) AD 87055 Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-12, 1956.

Abstract published in Bull. Amer. Phys. Soc., Series II, v. 1: 282, June 21, 1956.

Also published in Phys. Rev., v. 104: 563-565, Nov. 1, 1956.

The phenomenological Bloch equations in nuclear magnetic resonance are generalized by the addition of terms due to the transfer of magnetization by diffusion. The revised equations describe phenomena under conditions of inhomogeneity in magnetic field, relaxation rates or initial magnetization. As an example, the equations are solved in the case of the free precession of magnetic moment in the presence of an inhomogeneous magnetic field following the application of a 90° pulse with subsequent applications of a succession of 180° pulses. The spin-echo amplitudes agree with the results of Carr and Purcell (Phys. Rev., v. 94: 630, 1954) from a random walk theory. (Contractor's abstract)

STL. 01:001

St. Louis U. [Dept. of Physics] Mo.

REDUCTION OF RELATIVISTIC TWO-PARTICLE WAVE EQUATIONS TO APPROXIMATE FORMS. II, by Z. V. Chraplyvy. Sept. 18, 1953, 18p. incl. diagrs. (Technical rept. no. 1) (AF 18(600)789) AD 18908 Unclassified

Also published in Phys. Rev., v. 92: 1310-1315, Dec. 1, 1953.

A method of reducing 2-particle relativistic wave equations is presented which is free of the mass restriction $m_1 m_2$. In a discussion of the matrices involved, the postulate of an even-even transformed Hamiltonian is dropped, and the less stringent requirement of a uU-separating or an 1L-separating H_{Tr} leads to a whole class of usable transformation is calculated in detail. Different transformations give different expressions for H_{Tr}, but they coincide after the Dirac matrices β^{I} and β^{II} are replaced by 1 or -1. Consequently, the reduced wave equation is the same in all cases. (ASTIA abstract)

STL. 01:002

St. Louis U. [Dept. of Physics] Mo.

REDUCTION OF RELATIVISTIC TWO-PARTICLE WAVE EQUATIONS TO APPROXIMATE FORM, by Z. [V.] Chraplyvy and F. [N.] Glover. Aug. 16, 1954, 85p. incl. diagrs. refs. (Technical rept. no. 2) (AF 18(600)789) AD 57906 Unclassified

In a system of 2 particles (even without an external field), the field by which they interact with each other plays an essential role; however, it is convenient to have at least an approximate description of this interaction in terms of quantities referring to the particles rather than to the field itself. A 2-particle equation (approximately relativistic), yielding such a description, has been established by Breit (Phys. Rev., v. 34: 553, 1929; Ibid., v. 36: 383, 1930; Ibid., v. 39: 616, 1932). More recently Salpeter and Bethe gave a 2-particle equation based on the Feynman formalism of quantum electrodynamics. Any of these 2-particle equations has 16 components which may be reduced to a simplified form consisting of only 4 components. The development of reduction method, analogous to that of Foldy and Wouthuysen (F-W) is the aim of this study. investigation indicated that this would entail more than just a formal generalization of the 1-particle method of (F-W). There is found to exist a whole class of applicable transformations, which, however, when followed by an adequate cut in the equations, furnish the same final form of the reduced equation. The search for such transformations must be based on a study of the properties of 16- by 16-matrices which is given in Chapter I. In Chapter II, a summary of the F-W method is presented in order to secure suitable starting points for the extensions and generalizations developed in Chapter III, "Transformation of a 2-Particle Equation," and in Chapter IV, "Reduction of the 2-Particle Case." In the remaining chapters of this study, the method is applied to the Breit equation, to the Salpeter-Bethe equation, and to an amplified Breit equation.

STL. 01:003

St. Louis U. [Dept. of Physics] Mo.

REDUCTION OF RELATIVISTIC TWO-PARTICLE WAVE EQUATIONS TO APPROXIMATE FORMS, by Z. [V.] Chraplyvy and F. [N.] Glover. Final rept. Aug. 16, 1955, 54p. incl. diagrs. tables, refs. (Technical rept. no. 3) ([AF]OSR-TN-55-238) (AF18-(600)789) AD 71406 Unclassified

Previous studies are continued on a reduction method for 2-particle equations analogous to that of Foldy and Wouthuysen (Phys. Rev., v. 78: 29, 1950). Consideration is given to the amplified Breit equation, and a new formulation of the large component method of reduction is presented. The new formulation permits a comparison of the large component reduction method for 1- and 2-particle problems with the method of successive canonical transformations of Foldy and Wouthuysen in the 1- and 2-particle cases. (ASTIA abstract)

STL. 01:004

St. Louis U. [Dept. of Physics] Mo.

REDUCTION OF RELATIVISTIC TWO-PARTICLE WAVE EQUATIONS TO APPROXIMATE FORMS. III, by W. A. Barker and F. N. Glover. [1955] [8]p. incl. tables, refs. [AF 18(600)789] Unclassified

Published in Phys. Rev., v. 99: 317-324, July 1, 1955.

The interaction between two fermions of charge ϵ_I and ϵ_{II} and intrinsic magnetic moment μ_I and μ_{II} is described by a sixteen-component wave equation of the Breit type. The method of reduction of two-particle wave equations, as given in two previous papers by Chraplyvy, is used to convert this equation to an approximate four-component Pauli equation. A simple perturbation calculation is used to determine the contribution of the intrinsic magnetic moments to the fine and hyperfine structure of hydrogen and positronium. (Contractor's abstract)

STL. 01:005

St. Louis U. [Dept. of Physics] Mo.

REDUCTION OF RELATIVISTIC WAVE EQUATIONS AND THE "CONTACT INTERACTION," by F. N. Glover and Z. V. Chraplyvy. [1956] 12p. illus. (AF 18(600)789) Unclassified

Also published in Phys. Rev., v. 103: 821-824, Aug. 1, 1956.

A new formulation of the large-component reduction

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method for one- and two-particle relativistic wave equations is presented and compared with the reduction procedure by the method of successive canonical transformations. Sufficient conditions are given for the identity, to the order $(1/c)^2$, of the energy spectra obtained by the two methods. The "contact interaction" term resulting from the latter procedure is shown to arise in the former as well, contrary to a statement by Wu and Tauber. (Contractor's abstract)

STL. 02:001

St. Louis U. Dept. of Physics, Mo.

FOREIGN GAS PRESSURE BROADENING OF LINEAR MOLECULES, by K. L. Perkine, A. V. Bushkovitch, and L. J. Kieffer. [July 24, 1956] [3]p. incl. table. [AF 18(600)1590] Unclassified

Published in Jour. Chem. Phys., v. 26: 779-781, Apr. 1957.

Calculations have been made for the general cases of a linear polar molecule interacting with the following foreign molecules: monatomic, linear nonpolar, and linear polar. The interactions of importance are the first-order London dispersion force for the first two cases and the combined dipole-quadrupole, quadrupole-quadrupole, and first-order London dispersion forces for the third case. In the case of OCS with He, O_2, and N_2O the calculations yield 3.22, 5.41, and 7.41 A, respectively, in reasonable agreement with experiment. (Contractor's abstract)

SAN. 01:001

[Sandberg-Serrell Corp., Pasadena, Calif.]

A SUMMARY OF THE TECHNIQUES OF VARIABLE MACH NUMBER SUPERSONIC WIND TUNNEL NOZZLE DESIGN, by J. T. Kenney and L. M. Webb. Oct. 1954, 133p. incl. diagrs. refs. (NATO AGARDograph rept. no. 3) [AFOSR-TR-54-14] (AF 18(600)847) AD 56640 Unclassified

A survey is presented of the techniques of two-dimensional (supersonic) wind tunnel nozzle design. A procedure for the aerodynamic design of flexible nozzles capable of continuous Mach number variation is developed in detail. The special structural, mechanical, calibration, and cost estimation problems involved in flexible nozzle construction are discussed. (AGARD abstract)

SCL. 01:001

Santa Clara U. [Dept. of Mathematics] Calif.

ON SINGULARITIES OF SOLUTIONS OF DIFFERENTIAL EQUATIONS OF THE ELLIPTIC TYPE, by E. Netanyahu. June 1954, 11p. ([AF]OSR-TN-54-138) (AF 18(600)1036) AD 54369 Unclassified

Also published in Jour. Rational Mech. and Analysis, v. 3: 755-761, Nov. 1954.

Partial differential equations of the elliptic type

$L(u) = \frac{1}{4}\Delta u + \frac{1}{2}Au_x + \frac{1}{2}Bu_y + Cu = 0$, where A, B, C, are assumed to be entire functions of x and y (even when continued to complex values) are considered. The main theorem, proved by means of the Bergman integral operator method, is the following one: Any subsequence D_{mn}, n fixed, m 0, 1, 2, ... of the series development of the real solution

$$U(z, z^*) = \sum_{m,\ n=0}^{\infty} D_{mn} z^m z^{*n}$$

of $L(u) = 0$ determines the location and character of the singularities of $U(z, z^*)$ up to a finite number of isolated ones. (Contractor's abstract)

SCL. 01:002

Santa Clara U. Dept. of Mathematics, Calif.

INVESTIGATIONS ON COMPRESSIBLE FLUID FLOWS, by A. D. Wasel. Technical rept. Jan. 1955, 46p. incl. diagrs. tables, refs. ([AF]OSR-TN-54-360) (AF 18(600)1036) AD 52470 Unclassified

A summary is presented of some theoretical results and some applications resulting from investigations of 2-dimensional, steady, compressible fluid flows. The basic theory underlying this work is that which pertains to second-order linear partial differential equations of the form $\frac{\partial^2 v}{\partial z \partial \bar{z}} + b(z, \bar{z})\frac{\partial u}{\partial z} + c(z, \bar{z})\frac{\partial u}{\partial z} + d(z, \bar{z})u +$ $e(z, \bar{z}) = 0$, where $z = y + iy$ and $\bar{z} = x - iy$. Methods are developed for the evaluation of Bergman's formulas for the determination of compressible fluid flow patterns bounded by segments of straight lines and portions of free boundary. This requires a construction of a set of particular solutions of the equation satisfied by the stream function ψ in a certain plane and the orthonormalization of this set of solutions with respect to the boundary in that plane. Bergman's integral operator for generating solutions of equations of the above form is studied with regard to possible simplification. Comparisons are made between different forms of the operator. A form is developed which permits a theory concerning singularities of solutions to the stream function equation corresponding to singularities of the so-called associate functions. A new integral operator is introduced. It's domain of definition is determined, and forms of it are developed which could serve as a basis for theory concerning this operator analogous to that concerning the Bergman operator. Sample computing machine programs and a wiring diagram are appended.

Sarah Mellon Scaife Radiation Lab., Pittsburgh, Pa.
see Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.

Sibley School of Mechanical Engineering, Ithaca, N. Y.
see Cornell U. Sibley School of Mechanical Engineering, Ithaca, N. Y.

SOU. 01:001

Soundrive Engine Co., Los Angeles, Calif.

STUDIES OF HIGH AMPLITUDE SOUND. A. MEASUREMENTS OF THE ACOUSTIC IMPEDANCE OF A RESONATOR AT LARGE AMPLITUDES. B. MEASUREMENTS OF THE ATTENUATION OF REPEATED SHOCK WAVES. C. A LOGARITHMIC AMPLIFIER, by O. B. Wilson, Jr. and D. A. Bies. Aug. 1954 [37]p. incl. diagrs. refs. (Report no. 79) ([AF]OSR-TN-54-276) (AF 18(600)495) AD 52274 Unclassified

The experimental investigation of the acoustic impedance of a Helmholtz-type resonator at very high amplitudes of excitation is presented. Sound levels up to 180 db and particle velocity amplitudes in the neck of the resonator up to 1.5×10^4 cm/sec were used. The results at lower levels are compared with those of previous investigators whose work has been confined to levels below 140 db and particle velocity amplitudes in the resonator neck below 4×10^3 cm/sec. Experimental work on the rate of attenuation of repeated shock waves in a 5-in. tube is reported. Qualitative agreement with theory is found, but there is at present no adequate explanation of quantitative discrepancies. The design and construction of a logarithmic amplifier is discussed. (Contractor's abstract)

SOU. 01:002

Soundrive Engine Co., Los Angeles, Calif.

STUDIES OF VERY HIGH AMPLITUDE SOUND, by O. B. Wilson, Jr. and D. A. Bies. Apr. 1955, 22p. incl. diagrs. table. (Rept. no. 82) ([AF]OSR-TR-55-10) (AF 18(600)495) AD 72433; PB 137707 Unclassified

A standing wave technique was used to investigate the acoustic impedance of a Helmholtz-type resonator over a wide range of sound levels. At large sound pressure levels above 150 db, the sound waves propagating down the impedance tube became essentially repeated shock waves so that it was necessary to use a filter in the monitoring system, and to consider only the behavior of the fundamental component in the repeated shock wave. In this way, a range of sound pressure levels in the resonator from 100 to 170 db was investigated. Two different methods of mounting the resonator were considered. In one case the resonator was mounted on the side of the impedance tube next to a solid end plate terminating the tube, and in the other case the resonator was mounted on the solid end plate coaxially with the impedance tube. At the higher levels of excitation a rise in resonant frequency and in acoustic resistance was noted in both cases, but the details of the effects in each case were quite different. With the resonator mounted on the side the rise in the acoustic resistance followed Sivian's formula (Jour. Acoust. Soc. Amer., v. 7: 94, 1935) while the mass end correction decreased only at very high sound pressure levels. With the resonator mounted on the end, the rise in acoustic resistance was at first more rapid, then less rapid than Sivian's formula would predict. The decrease in mass end correction with increasing sound pressure level began at a lower level and was more pronounced than in the former case.

SCU. 01:001

South Carolina U. [Dept. of Mathematics] Columbia.

THE FIVE-POINT DIFFERENCE EQUATION WITH PERIODIC COEFFICIENTS, by T. Fort. Oct. 1956, 14p. [AF 18(603)23] Unclassified

Published in Pacific Jour. Math., v. 7: 1341-1350, Fall 1957.

The five-point equation is investigated for solutions and individual characteristics with $k_1(i, j)y(i-1, j) + k_2(i, j)y(i+1, j) + k_3(i, j)y(i, j-1) + k_4(i, j)y(i, j+1) + k_5(i, j)y(i, j) = 0$ where k_1, k_2, k_3, k_4, and k_5 are defined for integral values of i and j over the rectangle $1 \leq i \leq n\omega - 1$, $1 \leq j \leq \omega - 1$. The semi-periodicity of the solutions is established by the theorem that no characteristic value is zero. The roots of the characteristic equation are also proven to be distinct. Multiple roots are discussed.

SOC. 01:001

Southern California U., Los Angeles.

AN INVERSION FORMULA FOR LAPLACE TRANSFORMS AND SEMI-GROUPS OF LINEAR OPERATORS, by R. S. Phillips. [1954] [32]p. (AF 18(600)163) Unclassified

Published in Ann. Math., v. 59: 325-356, Mar. 1954.

A discussion is presented of the conditions that a closed linear operator be the infinitesimal generator (i.g.) of a semi-group of bounded linear operators (b.l.o.) $T(s)$, $s > 0$, Abel summable to the identity at $s = 0$. It is proved, in section 2, that $F(\cdot)$ is the Laplace transform of a measurable submultiplicative function ($0 \neq \cdot(s_1 + s_2) \leq \cdot(s_1)\cdot(s_2)$ integrable near $s = 0$, if the following conditions are satisfied: (i) there exists a real $\cdot$ such that $F(\cdot)$ is completely monotonic in $(\cdot, \infty)$, (ii) $\lim \cdot \to \cdot F(\cdot) = 0$ and (iii) $G(k+m+1, \cdot) \leq G(k, \cdot)G(m, \cdot)$ for $G(n, \cdot) = (-1)^n(n!)^{-1}F^{(n)}(\cdot)$, and for integers k, $m \geq 0$. This result is applied, in section 3, to the class of semi-groups $T(s)$ satisfying $\int_0^1 T(s)x\, ds < \infty$ for each x. For those $T(s)$ strongly Abel summable to the identity at $s = 0$, the i.g. A defined by strong $\lim_{h \downarrow 0} h^{-1}(T(h) - I)x$ is not in general closed. The Laplace transform of such $T(s)$ is shown to be equal to the resolvent of $\bar{A}$, the smallest closed extension of A. A necessary and sufficient condition that $A = \bar{A}$ is that $T(s)$ be strongly Cesàro

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summable to the identity at s = 0. In section 4, similar results are obtained under the further hypothesis $\int_0^1 ||T(s)||ds$, specializing to give results concerning semi-group theory due to Hille, the reviewer and the author. In the final section is discussed the perturbation, by a b.l.o., of the i.g. of semi-groups of the above type. The method and the results are extensions of the author's previous paper (Trans. Amer. Math. Soc., v. 74: 199-221, 1953; Math. Rev., v. 14: 882). (Math. Rev. abstract)

SOC. 02:001

Southern California U. Dept. of Chemistry, Los Angeles.

DERIVATIVES OF SULFENIC ACIDS. XXII. STUDIES OF SULFENATE ESTERS (THIOPEROXIDES). PART 2, by L. Goodman and N. Kharasch. Mar. 1955, 31p. incl. diagrs. tables, refs. (Technical note no. 1) ([AF]OSR-TN-55-62) (Also bound with its Final rept.; AFOSR-TR-57-32; AD 120492) (AF 18(600)844) AD 59561 Unclassified

Presented at meeting of Organic Division of the Amer. Chem. Soc., Cincinnati, Ohio, Apr. 2, 1955.

Also published in Jour. Amer. Chem. Soc., v. 77: 6541-6546, Dec. 20, 1955.

A kinetic study of the reaction $ArSCl + CH_3OH \rightleftharpoons ArSOCH_3 + HCl$ (1), where Ar = 2,4-dinitrophenyl, in the absence of pyridine, with pyridine present, and with the highly hindered amine, N,N-dimethylmesidine leads to the conclusion that the powerful catalytic effect of pyridine on reaction 1 involves formation of the intermediate 2,4-dinitrobenzenesulfenylpyridinium chloride, $(ArSNC_5H_5)Cl^-$. The attainment of equilibrium 1 is measurably slow, and favors the reactants ($K_{28°} \sim 10^{-3}$), in ethylene chloride solution. An infrared technique was used to follow the kinetics. Other tertiary amines, e.g., triethylamine and acridine, also catalyze reaction 1. The results obtained with the special case of reaction 1, above, appear to apply also to the general case of reaction 1, involving other sulfenyl halides and alcohols. To evaluate the utility of 2,4-dinitrobenzenesulfenyl chloride for the characterization of more complex alcohols, the reactions with ethylene glycol, pinacol, allyl alcohol, cinnamyl alcohol, benzhydrol, triphenylcarbinol, 2-methyl-3-butyn-2-ol, and propargyl alcohol were studied. Several new examples of 2,4-dinitrobenzenesulfenate esters are reported, and the complexities which can be encountered with various of the above alcohols are illustrated and interpreted. (Contractor's abstract)

SOC. 02:002

[Southern California U. Dept. of Chemistry, Los Angeles.]

THE ALCOHOLYSIS OF 2,4-DINITROBENZENESULFENYL CHLORIDE, by L. Goodman and N. Kharasch. [1955] [1]p. (AF 18(600)844) Unclassified

Presented at meeting of Organic Division of the Amer. Chem. Soc., Cincinnati, Ohio, Apr. 2, 1955.

Study was made of the strong catalytic effect of pyridine in the reaction $ArSCl + ROH \rightleftharpoons ArSOR + HCl$, with Ar = 2,4-dinitrophenyl and R = methyl (reaction 1). The rate of reaction 1 was studied in the absence of pyridine, with pyridine present and with the highly hindered amine, N,N-dimethylmesidine, in ethylene chloride as solvent. At 28°, the reaction approaches equilibrium at a measurably slow rate and the equilibrium favors the reactants ($K_{28°} \sim 10^{-3}$). With one mole, or with excess of pyridine present, however, reaction is practically instantaneous and complete. With excess N,N-dimethylmesidine (which is highly hindered, but slightly more basic than pyridine) reaction 1 also goes to completion, but again measurably slowly and at a rate dependent on the concentration of mesidine. The reaction in the latter case was found to be first order with respect to the sulfenyl chloride. The rates were followed by an infra-red technique. The above results suggest that the effect of pyridine of reaction 1 involves the intermediate formation of 2,4-dinitrobenzenesulfenylpyridinium chloride $[(NO_2)_2\text{-}C_6H_3\text{-}S\text{-}NC_5H]^+Cl^-$. Triethylamine, quinoline and acridine have similar effects. An attempt to isolate the pyridinium intermediate was, however, not successful. The synthetic utility of reaction 1 has also been extended to various examples, such as the 2,4-dinitrobenzenesulfenates of ethylene glycol, pinacol, allyl alcohol, cinnamyl alcohol and 2-methyl-3-butyn-2-ol. The complexities which can be encountered in these reactions are illustrated, as are also the difficulties which may arise in extending the reaction to benzhydrol, triphenylcarbinol and propargyl alcohol. (Contractor's abstract, modified)

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Southern California U. Dept. of Chemistry, Los Angeles.

THE UNIQUE PROPERTIES OF 2,4-DINITROBENZENESULFENYL CHLORIDE, by N. Kharasch. [1955] [7]p. incl. tables, refs. (Summary of a paper presented at Duquesne U., Pittsburgh, Pa., Dec. 1955) (Also bound with its Final rept.; AFOSR-TR-57-23; AD 120492) [AF 18(600)844] Unclassified

Published in Jour. Chem. Education, v. 33: 585-591, Nov. 1956.

A review is presented of research on the ionic reaction mechanisms of 2,4-dinitrobenzenesulfenyl chloride to show the major analytic and synthetic aspects of the chemistry of this sulfenyl halide.

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Southern California U. Dept. of Chemistry, Los Angeles.

DERIVATIVES OF SULFENIC ACIDS. XXVIII. THE REACTION OF 1,2-EPOXIDES WITH 2,4-DINITROBENZENESULFENYL CHLORIDE, by D. Peters and N. Kharasch. [Feb. 1956] 10p. incl. table, refs. (Technical note no. 2) (AFOSR-TN-56-87)

(AF 18(600)844) AD 82001 Unclassified

The reactions of 2, 4-dinitrobenzenesulfenyl chloride (I) with selected 1, 2-epoxides or chlorohydrins have been examined. These latter reactants include: ethylene oxide; 2-chloroethanol; cyclohexane oxide; trans-1, 2-chlorocyclohexanol; propylene oxide; 1-chloro-2-propanol; styrene oxide; 2-chloro-2-phenylethanol; 2-chloro-1-phenylethanol; and the nonreactive cis- and trans-stilbene oxides. The tabular data given present reactants, product, % yield, mp, % unreacted I in the absence of pyridine, and calculated and found C, H, and N. In all cases in which pyridine was used, varying amounts of the highly insoluble bis(2, 4-dinitrophenyl) disulfide were precipitated. Since the hydrolysis of the sulfenyl chloride occurs very rapidly in the presence of pyridine, and the disulfide is known to be the major product, it is believed that the disulfide results from a reaction with H_2O present in the system. As a result, the yields of products obtained are probably determined by the amounts of moisture in the reaction mixtures, rather than by the course of the main reactions with the epoxides or chlorohydrins. It is probable that the effect of pyridine in the reactions of I with epoxides involves reactions of the epoxides with the pyridine-sulfenyl complex, previously formulated as 2, 4-dinitrobenzenesulfenylpyridinium chloride. This mechanism explains the catalytic role of pyridine and is similar to the one suggested by Steward and Cordts (Jour. Amer. Chem. Soc., v. 75: 2658, 1953) for an analogous reaction with episulfides in which the addition of 1-chloro-2-propanesulfenyl chloride to propylene sulfide gave bis(1-methyl-2-chloroethyl) disulfide.

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Southern California U. Dept. of Chemistry, Los Angeles.

DERIVATIVES OF SULFENIC ACIDS. XXV. THE REACTION OF 1, 2-EPOXIDES WITH 2, 4-DINITROBENZENESULFENYL CHLORIDE, by D. Peters and N. Kharasch. [Feb. 13, 1956] [3]p. incl. table, refs. (Also bound with its Final rept.; AFOSR-TR-57-23; AD 120492) (AF 18(600)844) Unclassified

Published in Jour. Org. Chem., v. 21: 590-592, May 1956.

Verbatim published version of TN-56-87 (item no. SOC. 02:004), except for rept. numeration in title.

SOC. 02:006

Southern California U. Dept. of Chemistry, Los Angeles.

DERIVATIVES OF SULFENIC ACIDS. XXIX. BIS(2, 2'-FLUOROSULFONYL)AZOBENZENE VIA 2-NITROBENZENESULFENYL CHLORIDE AND HYDROGEN FLUORIDE, by D. L. Chamberlain, D. Peters, and N. Kharasch. [1956] 19p. incl. diagrs. refs. (AF 18-(600)844) Unclassified

The reaction of 2-nitrobenzenesulfenyl chloride (I) with liquid hydrogen fluoride was studied as a possible route to 2-nitrobenzenesulfenyl fluoride (II). Besides tars, and a small amount of an unidentified, colorless product (found when carbon tetrachloride was used as a diluent) there was formed 5-15% of the bright-red bis(2, 2'-fluorosulfonyl)azobenzene, III. The proof of structure of III is given and related preparative details are reported. (Contractor's abstract)

SOC. 03:001

Southern California U. Dept. of Chemistry, Los Angeles.

THE ADDITION OF p-THIOCRESOL TO BICYCLIC OLEFINS. QUANTITATIVE ANALYSIS FOR REARRANGEMENT PRODUCTS, by J. A. Berson and W. M. Jones. May 11, 1956, 14p. refs. [AFOSR-TN-56-254] (AF 18(600)1544) AD 88974 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 6045-6048, Dec. 5, 1956.

The free radical additions of p-thiocresol to exo-cis-3, 6-endo-methylene-Δ^4-tetrahydrophthalic anhydride and the corresponding dimethyl ester yielded the unrearranged p-tolyl thio ethers as the major products. The total absence of rearrangement in the products obtained from the reaction of p-thiocresol and the ester was determined by isotope dilution analysis. (Contractor's abstract)

SOC. 03:002

Southern California U. Dept. of Chemistry, Los Angeles.

CONVERSION OF A 1, 4-DIOL TO A LACTONE BY RANEY NICKEL, by J. A. Berson and W. M. Jones. June 1956, 4p. incl. diagr. (AFOSR-TN-56-268) (AF 18(600)1544) AD 88988 Unclassified

Also published in Jour. Org. Chem., v. 21: 1325-1326, Nov. 1956.

$LiAlH_4$ (I) (10 g) and 250 cc anhydrous Et_2O was refluxed with stirring and the condensate passed through 28.5 g endonorbornane-2, 3-dicarboxylic anhydride in a Soxhlet apparatus, the resulting mixture cooled, treated dropwise with 81 cc iso-PrOH (II) and then 66 cc saturated NaCl solution, stirred 30 min, and filtered, the filter cake washed with 2:3 II-Et_2O, and the filtrate evaporated to give 21 g gummy solid, distilled at 148-50°/1.5 mm and recrystallized from C_6H_6-C_6H_{14} (III) to give 9.5 g 2, 3-bis(hydroxymethyl)norbornane (IV), melting at 61-2°; bis(p-tolluenesulfonate), melting at 128-9°. Raney Ni (freed of H_2O by washing with EtOH and of EtOH by azeotropic distillation with C_6H_6) (10 g), 50 cc C_6H_6, and 1 g IV was refluxed 3 hrs, filtered, the filter cake washed with C_6H_6, and the filtrate evaporated. Crystallization of the residue from C_6H_{14} gave 0.83 g solid, melting at 42-4°; purification by solution in 5% NaOH, reprecipitation with acid, and recrystallization from C_6H_{14} gave the pure lactone (V), melting at 145-6° (shrinking

at 135-40°), insoluble in bicarbonate and cold NaOH, negative test with $KMnO_4$ and 2,4-$O_2NC_6H_4NH$-NH_2. V (0.570 g) in 25 cc absolute Et_2O, was added to 0.30 g I in 50 cc Et_2O with vigorous stirring, refluxed 3 hr, and worked up with 3.3 cc II and 3.3 cc saturated NaCl as above. Evaporation of solvents and recrystallization of the residue from III gave 0.450 g IV, melting at 59-61°. IV (1.0 g), 2 cc 10% NaOH, and 100 cc ice was treated with 135 cc 1% $KMnO_4$ with stirring, allowed to stand overnight, filtered, and the filtrate acidified and extracted with $CHCl_3$. The extract was dried over $MgSO_4$, filtered, evaporated, the residue leached with 3 cc hot 5% NaOH, and the insoluble gummy residue filtered off. The precipitate obtained on acidification of the filtrate was washed with 5% $NaHCO_3$ and H_2O to give 0.11 g V, melting at 139-41°, identified by infrared spectrum. (C. A., 1950: 5305f)

SOC. 04:001

Southern California U. Dept. of Chemistry, Los Angeles.

ON POINCARÉ RECURRENCES, by H. L. Frisch. [Aug. 9, 1956] 15p. refs. (Technical rept. no. 1) (AFOSR-TN-56-374) (AF 18(603)122) AD 95810 Unclassified

Also published in Phys. Rev., v. 104: 1-5, Oct. 1, 1956.

In connection with the tracing of the origin of the apparent irreversibility exhibited by a class of simple mechanical systems, namely all multiply or conditionally periodic Hamilton Jacobi systems, estimates are obtained for the Poincaré recurrence time of such a system in terms of the preassigned limits of error of the mechanical recurrence, ε. By applying the theory of diophantine approximations, the asymptotic fraction of the time a system spends in such recurrence is found exactly. These results allow further deductions concerning the fraction of time a given system obeys a strict version of the Second Law of Thermodynamics as well as the existence and order of magnitude of the average Poincaré recurrence time of the Gibbsian ensemble of such systems whose degrees of freedom are indistinguishable. The relation of the results obtained for this important class of mechanical systems and the resolution of the paradoxes of heat theory propounded by Zermelo Loschmidt, etc. due to Boltzmann and von Smoluchowski is discussed. An especially easily visualized model, the one-dimensional gas of hard spheres, is treated, in particular, in some detail (Contractor's abstract)

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Southern California U. Dept. of Chemistry, Los Angeles.

THE TIME-LAG IN DIFFUSION, by H. L. Frisch. [Aug. 9, 1956] 8p. (Technical rept. no. 2) (AF 18-(603)122) AD 95811 Unclassified

Also published in Jour. Phys. Chem., v. 61: 93-95, Jan. 1957.

Explicit expressions for the time lag in linear diffusion of a gas or vapor through a membrane with concentration dependent diffusion coefficient are obtained without explicitly solving the diffusion equations. Generalizations of the method used to obtain the time lag are indicated. The use of the derived relations is sketched by applying them to several cases of physical interest. (Contractor's abstract)

SOC. 04:003

Southern California U. Dept. of Chemistry, Los Angeles.

THE TIME LAG IN NUCLEATION, by H. L. Frisch. [1956] [21]p. incl. diagrs. refs. (Technical rept. no. 3) (AFOSR-TN-56-557) (AF 18(603)122) AD 110377 Unclassified

Also published in Jour. Chem. Phys., v. 27: 90-94, July 1957.

A theory of the time lage of nucleation L based on the Zeldovich modification of the Becker-Döring theory of nucleation of a new phase (B) from a pure old phase (A) is presented in accord with the L used in diffusion theory. The complete spectrum of embryos f(g, t) or the flux of embryos is attributed a hypothetical time lag which is validated without explicit knowledge of f(g, t) over the whole range of values of g and t. The "memory effects" of the time lag are able to account for certain nucleation processes involving condensed phases (and the reversal processes).

SOC. 05:001

Southern California U. Engineering Center, Los Angeles.

AN INVESTIGATION OF SHOCK WAVE — BOUNDARY LAYER INTERACTION, by R. L. Chuan. Aug. 1955, 46p. incl. illus. diagrs. (USCEC rept. no. 40-201) ([AF]OSR-TN-55-299) (AF 18(600)1145) AD 72049 Unclassified

Experimental results are presented for an investigation of the characteristics of separating and reattaching boundary layer flow over a compression corner on a flat plate for M 2.54 and Re (based on 1 in.) 6×10^5. Detailed measurements of the boundary layer structure showed that in transitional interaction the flow can be characterized in terms of the mean temperature and mean velocity by 2 separate curves, one for the laminar separating flow and the other for the turbulent reattaching flow; while in turbulent interaction the entire flow can be characterized by one such curve. The rate at which momentum is transported from the free stream to the viscous region was determined for the transitional and turbulent cases, and was found to be highly dependent on the Reynolds number (based on a boundary layer momentum thickness). (ASTIA abstract)

SRI. 01:001

Southwest Research Inst., San Antonio, Tex.

FLOW IN A VISCOUS VORTEX, by C. D. Pengelley. Mar. 16, 1956, 59p. incl. diagrs. tables. (Rept. no. 494C-1) (AFOSR-TN-56-126) (AF 18(600)1540) AD 86002 Unclassified

Equations have been derived for velocity, temperature and pressure distribution in a 2-dimensional viscous vortex with a steady state component of radial flow. Radial velocity has been assumed small compared with the tangential component, and heat transfer has been neglected. The equations have been based, upon the following well-established principles: (1) the Navier-Stokes equation in its most general form, (2) the first law of thermodynamics, and (3) the gas laws. A reference radius has been defined where viscous stress is zero; using this, nondimensional forms have been set up and generalized charts prepared for ready visualization and numerical applications. Due to the classical concept of viscosity as used in the Navier-Stokes equation, results are strictly applicable to laminar flow only; a discussion is presented regarding possible application to turbulent flow. (ASTIA abstract)

STR. 01:001

Stanford Research Inst., Menlo Park, Calif.

THEORETICAL CONSIDERATIONS ON PERFORMANCE CHARACTERISTICS OF SOLAR FURNACES, by E. Loh, P. Duwez and others. Jan. 16, 1956, 27p. incl. diagrs. (Technical rept. no. 1; Rept. no. 3) (AFOSR-TN-56-69) (AF 18(600)1499) AD 81521 Unclassified

This study contains a theoretical discussion of the parabolic-type solar furnace. Calculations of the heat flux and the maximum temperature obtainable at the focus are presented for furnaces of different diameter-to-focal-length ratios. The analysis is extended to the California Institute of Technology lens-type furnace. The calculations indicate that the upper practical limit of a parabolic furnace has a rim angle θ between 50° to 60° or a diameter-to-focal-length ratio of about 2.0. Above a rim angle of 60° there is very little increase in the maximum temperature obtainable at the focus. In addition, the difficulty of constructing an accurate parabolic surface increases with increasing rim angle. The results presented here indicate that a paraboloid of relatively low quality is capable of achieving temperatures over 2000°K with a low heat flux of about 20 cal/sec/sq cm. On the other hand, a research furnace capable of attaining temperatures in the range of 3600° to 4200°K, or a furnace capable of high heat flux values above 230 cal/sec/sq cm, would have to have a paraboloid of very high quality.

STR. 01:002

Stanford Research Inst., Menlo Park, Calif.

THE OPERATION AND USE OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY LENS-TYPE SOLAR FURNACE, by N. K. Hiester, E. Loh, and T. E. Tietz. Apr. 24, 1956, 24p. incl. illus. diagrs. Technical rept. no. 2; rept. no. 5) (AFOSR-TN-56-248) (AF 18(600)1499) AD 88368 Unclassified

A description is given of the lens-type solar furnace. The concentration of solar energy is accomplished by using converging lenses. The 19 large lenses, with their axes pointed toward the sun, are arranged with one in the center, 6 surrounding this, and then 12 around the central 7. The converging rays from the sun are brought to these lenses by 18 oblique mirrors. The concentration efficiency, η_c, defined as the ratio of the power received within the smallest sun image to the total power passing through the optical system, was calculated to be 45%. The concentration ratio, C, which is the ratio of heat flux per unit area at the sun image to the actual flux per unit area received at the furnace site, was calculated to be 19.7×10^3. The computed maximum-attainable temperature, Tm, for a cavity receiver under ideal conditions was 4700°K. These theoretical values of η_c, C, and Tm are for the case where the target plane is perpendicular to the rays coming from the sun.

STR. 01:003

Stanford Research Inst., Menlo Park, Calif.

ECONOMIC AND DESIGN STUDY OF SOLAR FURNACES, by R. E. De La Rue, Jr., T. E. Tietz, and N. K. Hiester. June 21, 1956, 52p. incl. diagrs. tables, refs. (Rept. no. 6; Technical rept. no. 3) (AFOSR-TN-56-382) (AF 18(600)1499) AD 95818 Unclassified

Also published in Jour. Solar Energy Science and Engineering, v. 1: 28-43, Apr.-July 1957.

Investigation was continued on the feasibility of adapting a lens-type solar furnace for research on solids at high temperatures. The theoretical and practical factors which affect the specific performance characteristics and costs of solar furnaces are reviewed. Technical and economic considerations indicated that the best design for a large solar furnace should incorporate: (1) a parabolic concentrator consisting of adjustable curved-mirror segments; (2) a stationary concentrator with its axis horizontal, with an auxiliary movable mirror to follow the sun; (3) a 50° to 70° angle between the image area and the rim of the concentrator; and (4) a reflecting surface consisting of back-silvered glass. The actual heat flux available at the target was expressed as $p = 46.1 \times 10^3 E p_o \sin^2 \theta$, where E is the over-all efficiency factor of the solar furnace, p_o is the solar constant, and θ is the rim angle. Consideration was given to the factors which affect the performance characteristics and their effect on the size requirements of a furnace. The specifications to allow operation at 2 flux levels and image diameters were evaluated with respect to cost by the use of 3 possible methods to meet the requirements. A preliminary structural design and cost estimate for a solar furnace system having a 100-ft parabolic concentrator with a

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movable auxiliary mirror to follow the sun is presented. The study results were extrapolated to give cost curves for furnace systems with 50- to 200-ft-diam concentrators. Comparison between flat-plate and parabolic concentrator segments showed that the parabolic concentrator was most economical.

STR. 01:004

Stanford Research Inst., Menlo Park, Calif.

PHASE RELATIONSHIPS IN THE ZIRCONIA-THORIA SYSTEM, by P. Duwez and E. Loh. Sept. 4, 1956, 18p. incl. diagrs. tables, refs. (Technical rept. no. 4; rept. no. 7) (AFOSR-TN-56-459) (AF 18(600)1499) AD 97076 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 40: 321-324, Sept. 1957.

The phase relationships in the zirconia-thoria system were investigated by x-ray diffraction and dilatometric methods. The specimens were melted in air at the focus of a solar furnace. The existence of a cubic CaF_2 type solid solution was established for thoria concentration above 17.5 mol %. This solid solution is stable only at high temperature; after prolonged heating at 2000°C and below, it decomposes into tetragonal zirconia (which during subsequent cooling undergoes the unavoidable tetragonal-monoclinic inversion) and a thoria-rich phase containing at least 99 mole % thoria. (Contractor's abstract)

STR. 01:005

Stanford Research Inst., Menlo Park, Calif.

HEAT FLUX MEASUREMENTS AT THE SUN IMAGE OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY LENS-TYPE SOLAR FURNACE, by E. Loh, N. K. Hiester, and T. E. Tietz. Sept. 14, 1956, 17p. incl. diagrs. tables. (Rept. no. 8; technical rept. no. 5) (AFOSR-TN-56-587) (AF 18(600)1499) AD 110383 Unclassified

Also published in Jour. Solar Energy Science and Engineering, v. 1: 23-26, Apr.-July 1957.

Flux measurements were made at the focus of the CIT lens-type solar furnace using two U. S. Naval Radiological Defense Laboratory (NRDL) water-cooled radiometers. Maximum flux values were obtained for three cases: central lens only operating, central seven lenses operating, and finally, all lenses operating. For each of these cases, flux profiles were obtained by traversing the radiometer through the sun image. A maximum flux value of 220 cal/sec/sq cm was recorded with all lenses operating. The direct solar radiation received at the furnace site at this time was about 1.04 cal/min/sq cm. Under these conditions the furnace operating efficiency was found to be 47.2%. The losses of 52.8% are ascribed to transmission losses in the lenses, reflectivity losses at the mirrors, the geometrical imperfection of the individual lenses and mirrors, and lack of perfect superposition of the nineteen images. (Contractor's abstract)

STR. 01:006

Stanford Research Inst., Menlo Park, Calif.

STUDY OF THE UTILIZATION OF A SOLAR FURNACE FOR HIGH TEMPERATURE RESEARCH ON SOLIDS, by T. E. Tietz and N. K. Hiester. Final summary rept. Sept. 28, 1956, 8p. (Rept. no. 9) (AFOSR-TR-56-56) (AF 18(600)1499) AD 115011 Unclassified

The application of solar furnaces to research on solids at elevated temperature is studied. The investigation comprised theoretical, design, and experimental study. The results of these studies previously presented in five separate reports (see item nos. STR. 01:001-STR. 01:005) are summarized.

STA. 01:001

Stanford U. Applied Mathematics and Statistics Lab., Calif.

EXTENSIONS OF A THEOREM OF LOEWNER ON INTEGRAL OPERATORS, by D. C. Benson. Apr. 16, 1954. 41p. (Technical note no. 1) ([AF]OSR-TN-54-59) (AF 18(600)680) AD 29641 Unclassified

Extensions are considered of a result of Loewner (Ann. Math., v. 49: 316-332, 1948) which gives a necessary and sufficient condition that a function k(t), L-integrable on [0, 1] have the property that, for every continuous function x(t) of period 1, the closed curve in the x-y plane, $x = x(t)$, $y = y(t) = -\int_0^1 k(\tau)x(t-\tau)d\tau$ has non-negative index with respect to every point of the x-y plane not lying on this curve. The extensions considered include: (1) the function k(t) is Lebesque integrable on the half line $[0,\infty]$. The operator $y(t) = -\int_0^\infty k(\tau)x(t-\tau)d\tau$ is applied to functions x(t), which are continuous in $(-\infty, \infty)$ and such that $\lim_{t \to \pm\infty} x(t) = 0$. Then $\lim_{t \to \pm\infty} y(t) = 0$ and $x = x(t)$, $y = y(t)$ may be considered as a representation of a closed curve. The curve $x = x(t)$, $y = y(t)$ is considered, and the question is asked as to which functions k(t) generate only curves of non-negative circulation. (2) Consideration is given to the original problem when all of the integrations are taken in the sense of the Cauchy principal value. Assume that $k(t) = \frac{\varphi(t)}{t^\alpha(1-t)^\alpha}$ where $\varphi(t)$ is L-integrable on the interval $[0, 1]$ and $0 < \alpha < 1$. The integral operator $y(t) = P\int_0^1 k(\tau)x(t-\tau)d\tau$ is applied to a class of functions x(t) which satisfy a suitable Holder condition (to insure the existence and continuity of y(t)). The symbol P denotes that the integration is taken in the sense of the Cauchy principal value. The above question is again asked. (ASTIA abstract)

STA. 01:002

Stanford U. Applied Mathematics and Statistics Lab., Calif.

ON SOME CRITICAL POINTS OF HIGHER ORDER, by C. Loewner. Nov. 30, 1954 [25]p. (Technical note no. 2) ([AF]OSR-TN-54-309) (AF 18(600)680) AD 48583 Unclassified

The report contains a study of critical points of functions or mappings defined for sufficiently differentiable functions. The simplest critical points are stationary points of a differentiable function. In general, a critical point is defined by a system of differentiable relations containing derivatives up to an order k, which is then called the order of the critical points under consideration. Several theorems are proved about existence of critical points under conditions regarding the boundary values and the qualitative behavior of the functions involved. (Contractor's abstract)

STA. 01:003

Stanford U. Applied Mathematics and Statistics Lab., Calif.

ON FREE BOUNDARY PROBLEMS AND CONFORMAL MAPPING, by R. Finn. Mar. 11, 1955, 63p. incl. diagrs. refs. (Technical note no. 3) ([AF]OSR-TN-55-44) (AF 18(600)680) AD 58419 Unclassified

A study is made of existence, uniqueness, and stability questions for the 2-dimensional steady flow of a perfect fluid with formation of a free boundary at an interface of discontinuity. The first proof is given of the existence of a flow through an asymmetric nozzle into a medium of constant pressure. Also, it is shown that for symmetric nozzles the restrictions on total curvature of the boundary which have appeared in previous literature are of no mathematical significance. The existence of multisheeted flows is demonstrated, and boundaries are characterized which do not admit nonsingular flows. Several related problems are also considered, e.g., the flow of fluid past a boundary with formation of an infinite wake. (Contractor's abstract)

STA. 01:004

Stanford U. Applied Mathematics and Statistics Lab., Calif.

ON SOME CONVEX CONES AND ASSOCIATED MONOTONE FUNCTIONS, by D. P. Squier. July 29, 1955, 57p. (Technical note no. 4) ([AF]OSR-TN-55-224) (AF 18(600)680) AD 70391 Unclassified

The concept of a monotone function is defined for any linear space S by means of a convex cone K in S. A function $f(\xi)$ which maps a subset of S into S is called monotone increasing on the subset if it preserves the order of the elements so that $\alpha \geq \beta$ implies $f(\alpha) \geq F(\beta)$ for every α and β in the domain of definition of $f(\xi)$. Attention is given to spaces of real binary forms in x and y with the requirement that the convex cones are closed and invariant under linear transformations on the variables x and y. The analysis shows that in spaces of odd degree forms the whole space is the only closed cone. In spaces of even degree, any closed cone is contained in either the set of nonnegative forms or the set of nonpositive forms, and also contains a certain closed cone or its opposite which is the smallest. For binary quartics, all closed cones are determined and characterized by means of an invariant of the positive definite forms. Elements in the smallest closed cone in the space of forms of degree 2m are characterized by means of the matrix of coefficients of a quadratic form in m + 1 variables. In special spaces with special convex cones, functions are defined on the space by means of a scalar function f(t) defined on an interval together with a generalized concept of eigenvalues. Those functions f(t) are determined which yield a monotone function on the space.

STA. 01:005

Stanford U. [Applied Mathematics and Statistics Lab.] Calif.

ON TOTALLY POSITIVE MATRICES, by C. Loewner [1955] [3]p. [AF 18(600)680] Unclassified

Published in Math. Zeitschr., v. 63: 338-340, 1955.

A semigroup S_n (containing the identity matrix I) has as elements the non-singular matrices of S_n, with n the order of totally positive square matrices. It is shown for the case considered, that a semigroup can be completely recreated from its infinitesimal semigroup, even if the semigroup is connected.

STA. 01:006

Stanford U. Applied Mathematics and Statistics Lab., Calif.

HOMOLOGY AND FLOWS ON MANIFOLDS, by T. Frankel. Mar. 28, 1956, 19p. (Technical note no. 5) (AFOSR-TN-56-141) (AF 18(600)680) AD 86018 Unclassified

Also published in Ann. Math., v. 65: 331-339, Mar. 1957.

An investigation is made of the manner in which the homology of a manifold influences the vector and tensor fields on that manifold. The vector fields give rise to 1-parameter groups of point transformations on the manifold and interest is focused on those transformations which conserve a volume element. Such divergence free vectors and their associated transformations are called flows. For flows which are also isometries of a Riemannian metric, a proof is presented that the homology class of any possible closed trajectory is essentially determined by means of De Rham's theorem; this is not true if the isometry requirement is not met. A homological form of a theorem of Cartan (Ann. Soc.

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Polon. Math., v. 8: 181-225, 1929) is proved for flows on a homogeneous space, and the theorem that the homology class of any possible closed trajectory is essentially determined by De Rham's theorem is interpreted within the framework of homogeneous spaces. An extension is given by Weyl's theorem for compact semi-simple Lie groups.

STA. 01:007

[Stanford U. Applied Mathematics and Statistics Lab., Calif.]

ON SOME TRANSFORMATION SEMIGROUPS, by C. Loewner. [1956] [14]p. (AF 18(600)680) Unclassified

Published in Jour. Rational Mech. and Analysis, v. 5: 791-804, Sept. 1956.

Semigroups projection transformations or transformations of the Moebius group are considered in this paper. D is an open convex domain of the n-dimensional projective space which can be associated with a semigroup of projective transformations. Analogously in Moebius geometry a semigroup M_D of transformations transforms the domain D into itself. The first section derives distortion theorems for the semigroup P_D for arbitrary domains D and M_D in spherical domains. In section two, finer distortion theorems for M_D are obtained but only for circles in the plane. Section three holds group-theoretical considerations giving a group-theoretical considerations giving a group-theoretical characterization of some of the semigroups P_D and M_D.

STA. 01:008

Stanford U. Applied Mathematics and Statistics Lab., Calif.

SOME THEOREMS ON DISCONTINUOUS PLANE FLUID MOTIONS, by R. Finn. [1955/1956] [46]p. incl. diagrs. refs. (AF 18(600)680) Unclassified

Published in Jour. Analyse Math., v. 4: 246-291, 1955/1956.

Proofs are given of results stated in an earlier note (Proc. Nat'l. Acad. Sciences, v. 40: 983-987, 1954; Math. Rev., v. 16: 296). The demonstrations are based on the well-known Levi-Civita representation for free boundary flows, and make use of the method of continuity. In addition to the work reported in the earlier note, the author also studies by the same method the classical problem of free-boundary flow past a polygonal obstacle. For this problem, a local uniqueness theorem is proved for concave obstacles (especially significant in that no restrictions are placed on total curvature), and an existence theorem is obtained for both symmetric and asymmetric convex obstacles, again with no restriction on curvature. Finally, the existence theorems are extended to apply to curved nozzles and obstacles. (Math. Rev. abstract)

STA. 02:001

Stanford U. Dept. of Mechanical Engineering, Calif.

THE COMPUTATION OF THE LAMINAR COMPRESSIBLE BOUNDARY LAYER, by I. Flügge-Lotz. Final rept. June 15, 1954 [65]p. incl. diagrs. tables, refs. ([AF]OSR-TN-54-144) (AF 18(600)586) AD 40185 Unclassified

A difference method was developed for computing shear stress and enthalpy $i = c_pT$ as functions of the coordinate x along the wall and the velocity u parallel to the wall. Pressure gradient and temperature distribution along the wall are given continuous finite functions of the coordinate x. Density and viscosity coefficients depend on the local temperature in the boundary layer. The method is tested in regions of pressure decrease and increase. Various examples are included to show the influence of the pressure gradient on skin friction and heat transfer.

STA. 03:001

Stanford U. Dept. of Physics, Calif.

INTERPRETATION OF ELECTRON SCATTERING EXPERIMENTS, by L. I. Schiff. June 24, 1953, 16p. diagrs. refs. (Technical rept. no. 1) (AF 18(600)545) AD 16169 Unclassified

Also published in Phys. Rev., v. 92: 988-993, Nov. 15, 1953.

The results of electron scattering experiments are interpreted with the aid of the first Born approximation. These experiments imply nuclear charge distributions that are peaked at the center and taper off smoothly. The rms radii of the charge distributions, and the nuclear Coulomb energies, are in approximate agreement with those computed from the usual uniform charge distribution. The effect of radiation loss and nuclear excitation are discussed qualitatively, and the effect of a nuclear electric quadrupole moment is considered quantitatively. The over-all conclusion is that these effects cannot account for the discrepancy between the observed scattering cross section which decreases monotonically with increasing angle and the diffraction minima and maxima expected from a uniform charge distribution with a sharp or moderately rounded edge. Theoretical improvements on the first Born approximation are being undertaken. (ASTIA abstract)

STA. 03:002

Stanford U. Dept. of Physics, Calif.

LATTICE-SPACE QUANTIZATION OF A NONLINEAR FIELD THEORY, by L. I. Schiff. Aug. 6, 1953, 30p. diagrs. refs. (Technical rept. no. 2) (AF 18(600)545) AD 15602 Unclassified

Also published in Phys. Rev., v. 92: 766-779, Nov. 1, 1953.

A method is developed for the approximate diagonalization of certain types of quantum field Hamiltonians which is not limited to weakly nonlinear systems. It consists of omitting the gradient terms in zero order and diagonalizing the resulting Hamiltonian by replacing the field defined in a continuum space by a field defined in a lattice space. This unperturbed system is equivalent to a countably infinite number of uncoupled nonlinear oscillators, which are then coupled together when the gradient terms are included as a perturbation. The method is applied to the quantization of the classical nonlinear meson theory previously introduced (L. I. Schiff, Phys. Rev., v. 84: 1, 1951) to give a qualitative explanation of the saturation of nuclear forces, according to which a positive φ^4 term is added to the field Hamiltonian. Although the quantized theory is manifestly noncovariant, a single-particle solution exists that has an approximately relativistic relation between energy, momentum, and rest mass. It is essential that the lattice constant be kept finite, as all computed physical quantities become meaningless in the continuum limit (in which the lattice constant approaches zero). These particles obey Einstein-Bose statistics, and they scatter from each other. Nucleons are introduced as classical sources for the meson field, and calculations are made on the nucleon isobaric state, interaction mesons with nucleons and heavy nuclei, and nucleon-nucleon interaction. A brief discussion is given of the possibility of extending the method to the quantization of both meson and nucleon fields when they are strongly coupled together. (ASTIA abstract)

STA. 03:003

Stanford U. Dept. of Physics, Calif.

PHOTOPRODUCTION OF π-MESON PAIRS, by R. D. Lawson. Aug. 27, 1953, 15p. diagrs. refs. (Technical rept. no. 3) (AF 18(600)545) AD 18727
Unclassified

Also published in Phys. Rev., v. 92: 1272-1279, Dec. 1, 1953.

A perturbation study of the photoproduction of π-meson pairs by γ-rays incident on portions is made for both pseudoscalar and pseudovector coupling. Expressions are derived for the possible cross sections, assuming that the nucleon is infinitely heavy. The effect of first-order nucleon recoil on the (π^+, π^-) cross section, assuming pseudoscalar coupling, is considered. Curves illustrating the results are given. The possibility of obtaining information on the type of interaction operative between mesons and nucleons from a study of the pair production cross sections is discussed. (Contractor's abstract)

STA. 03:004

Stanford U. Dept. of Physics, Calif.

PHASE SHIFT CALCULATION OF HIGH ENERGY ELECTRON SCATTERING BY NUCLEI, by D. R. Yennie, R. N. Wilson, and D. G. Ravenhall. Oct. 1953, 3p. diagrs. (Technical rept. no. 4) (AF 18(600)545) AD 18892
Unclassified

Also published in Phys. Rev., v. 92: 1325-1326, Dec. 1, 1953.

A numerical phase shift calculation was performed to examine the accuracy of the Born approximation. The results disagreed with those of Parzen (Phys. Rev., v. 80: 355, 1953). Generally, the calculation followed the methods of Acheson (Phys. Rev., v. 82: 488, 1951) and Parzen. The details of the calculation are to be published. The phase shift relative to that of the Coulomb was calculated for the first nine partial waves; the last shift was less than 0.003° in all cases. All the phase shifts were negative and tended monotonically to zero. Uniform and exponential charge distributions were used for Au and Cu. Scattering angle vs differential cross-section curves are given for the phase shift analysis of Au and Cu, as well as the Born approximation.

STA. 03:005

Stanford U. Dept. of Physics, Calif.

ON THE EXPRESSION FOR THE TOTAL CROSS SECTION, by L. I. Schiff. Jan. 8, 1954, 5p. (Technical rept. no. 5) ([AF]OSR-TN-54-7) (AF 18(600)545) AD 27412
Unclassified

Also published in Prog. Theoret. Phys., v. 11: 288-290, Mar. 1954.

A simple derivation is presented for the well-known expression for the total cross section in terms of the imaginary part of the coherent forward scattered amplitude. The derivation shows that there is a shadow remnant beyond the actual shadow, within which the forward coherent scattering intensity is diminished, of approximate radius $(r/k)^{1/2}$, where r is the distance from the scattering center and $k = 2\pi/\lambda$ is the wave number. A qualitative understanding of the shadow remnant is obtained in terms of the uncertainty principle. (ASTIA abstract)

STA. 03:006

Stanford U. Dept. of Physics, Calif.

NUCLEAR MULTIPOLE TRANSITIONS IN INELASTIC ELECTRON SCATTERING, by L. I. Schiff. July 1954, 24p. incl. table, refs. (Technical rept. no. 7) ([AF]OSR-TN-54-191) (AF 18(600)545) AD 41720
Unclassified

Also published in Phys. Rev., v. 96: 765-772, Nov. 1, 1954.

Expressions are obtained for the differential cross sections for inelastic scattering of fast electrons with excitation of various nuclear multipole transitions. The most probable transitions are those that involve collective motion of many nucleons, and in this case the term

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arising from the transition charge density dominates those that come from the current and magnetization densities. There is then a close relation between the probability for inelastic electron scattering and the probability for the corresponding radiative electric multiple transition, although an assumption must be made as to the shape of the transition charge density. This is illustrated with a detailed discussion of the collective electric quadrupole transitions, using the model of Bohr and Mottelson. When the transition is produced by one or a small number of nucleons, or when it is of magnetic multipole type, there is likely to be little relation between inelastic scattering and radiation probabilities. The electric moncpole transition ($0+ \longrightarrow 0+$) is also discussed. It is shown how the elastic scattering can be corrected for unresolved inelastic scattering, as well as elastic quadrupole scattering, before an analysis is made in terms of the spherically symmetric part of the static nuclear charge density, and also how the strength, as well as the shape of the transition charge density, can be determined experimentally when only relative measurements of inelastic scattering are available. (Contractor's abstract)

STA. 03:007

Stanford U. Dept. of Physics, Calif.

RESULTS OF A PHASE SHIFT CALCULATION OF HIGH ENERGY ELECTRON SCATTERING, by D. G. Ravenhall and D. R. Yennie. Aug. 1954, 4p. diagrs. (Technical rept. no. 8) ([AF]OSR-TN-54-209) (AF 18(600)545) AD 41801 Unclassified

Also published in Phys, Rev., v. 96: 239-240, Oct. 1, 1954.

The results of a phase shift analysis of the scattering of 84, 126, 154, and 183 mev electrons on gold are described. For "smoothed uniform" charge distributions, characterized by a central region of almost constant density and a surface region in which the density drops to zero, it is found that at these energies the surface structure is unimportant. The best fit with the experimental data is given by a distribution with rms radius $\sqrt{3/5}\ A^{1/3} \times 1.20 \times 10^{-13}$ cm, and surface thickness 1.65×10^{-13} cm. (Contractor's abstract)

STA. 03:008

Stanford U. Dept. of Physics, Calif.

PHASE SHIFT CALCULATION OF HIGH ENERGY ELECTRON SCATTERING, by D. R. Yennie, D. G. Ravenhall, and R. N. Wilson. Mar. 1954, 29p. diagrs. tables, refs. (Technical rept. no. 6) ([AF]OSR-TR-54-11) (AF 18(600)545) AD 30601 Unclassified

Also published in Phys. Rev., v. 95: 500-512, July 15, 1954.

The details of a phase shift calculation of high energy electron scattering by nuclei are given, together with some preliminary results. A new method for summing the Legendre series for the Coulomb scattering amplitude is described. The results indicate that the first Born approximation does not give cross sections accurate enough for a reliable interpretation of the experiments. From a comparison of the few theoretical cross sections already obtained with the experiments in gold at 125 mev, very tentative conclusions about the nuclear charge distribution are drawn. It is pointed out that an analysis of results at two or more energies will be a much more sensitive test of possible charge distributions. (Contractor's abstract)

STA. 03:009

Stanford U. [Dept. of Physics] Calif.

PHASE SHIFT CALCULATION OF HIGH-ENERGY ELECTRON SCATTERING BY NUCLEI, I (Abstract), by D. R. Yennie, R. N. Wilson, and D. G. Ravenhall. [1954] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., Stanford U., Calif., Dec. 28-30, 1953.

Published in Phys. Rev., v. 93: 948-949, Feb. 15, 1954.

The computational program for calculating the elastic scattering of electrons from spherically symmetrical charge distribution is described, and in the following paper the results are presented and compared with experiment. The calculation follows in general the methods given by Parzen and Acheson, with some modifications in the details. To calculate the phase shifts, the radial wave functions inside the nucleus are integrated numerically and fitted to Coulomb functions (obtained by series expansion about the origin) outside the nucleus. In order to obtain relatively accurate differential cross sections for large angles ($> 90°$), it is necessary that the phase shift errors be kept small (less than 10^{-4} radian). In this angular region it is also necessary to know the Coulomb scattering amplitude very accurately. A new method of summing the series for this amplitude will be given. (Contractor's abstract)

STA. 03:010

Stanford U. [Dept. of Physics] Calif.

PHASE SHIFT CALCULATION OF HIGH-ENERGY ELECTRON SCATTERING BY NUCLEI, II (Abstract), by D. G. Ravenhall, D. R. Yennie, and R. N. Wilson. [1954] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., Stanford U., Calif., Dec. 28-30, 1953.

Published in Phys. Rev., v. 93: 949, Feb. 15, 1954.

For gold, $Z = 79$, differential cross sections for uniform exponential and intermediate charge distributions have been calculated. Compared with the first Born approximation, the maxima and minima given by the uniform charge distributions are smoothed out, the

first minimum appearing only as a point of inflection. The slope of the cross section for the exponential distribution is greater than that given by the first Born approximation; this effect can be understood qualitatively as being due to the increase of the electron's wave number inside the attractive potential of the nucleus. For comparison, some distributions for copper ($Z = 29$) have also been obtained. The maxima and minima are more pronounced and are shifted to smaller angles relative to the Born approximation, an effect explainable qualitatively in terms of the effect wave number. Further calculations now in progress will be reported and compared with the experimental results of Hofstadter, Fechter, and McIntyre. (Contractor's abstract)

STA. 03:011

Stanford U. [Dept. of Physics] Calif.

SECOND BORN APPROXIMATION TO THE SCATTERING OF FAST ELECTRONS AND POSITRONS BY NUCLEI (Abstract), by R. N. Wilson. [1954] [1]p. [AF 18(600)-545] Unclassified

Presented at meeting of the Amer. Phys. Soc., Stanford U., Calif., Dec. 28-30, 1953.

Published in Phys. Rev., v. 93: 949, Feb. 15, 1954.

The scattering of a Dirac particle in an electrostatic potential is calculated in second Born approximation. A charge distribution of the form $\rho(r) = (Ze/8\pi a^3)\exp(-r/a)$ is chosen because the integrations can be performed exactly and because it is of interest to compare the result with an exact calculation by phase shift analysis. In the imaginary part of the second-order contribution to the scattering amplitude there appear divergent terms which are to be interpreted as phase corrections to the first-order contribution. A comparison is made of the results of this calculation with the first Born approximation and with the exact phase shift calculation. (Contractor's abstract)

STA. 03:012

Stanford U. Dept. of Physics, Calif.

THE SIGN OF THE PHASE SHIFT IN THE ELASTIC SCATTERING OF ELECTRONS, by D. R. Yennie, D. G. Ravenhall, and E. Baranger. [1954] [2]p. [AF 18-(600)545] Unclassified

Published in Phys. Rev., v. 93: 1128-1129, Mar. 1, 1954.

The total phase shift, in the phase-shift analysis of the scattering of electrons from a nuclear charge distribution, can be expressed as the sum of 2 terms: $\eta_l = \eta_l^c + \delta_l$, with η_l^c being the phase shift of the l^{th} partial wave for a pure Coulomb field and δ_l the additional phase shift due to the modification of the Coulomb field inside the nucleus. The assertion that for large l, δ_l approaches zero through positive values is found incorrect. Proof is given that for all reasonable charge distributions inside the nucleus $\delta_l < 0$.

STA. 03:013

Stanford U. Dept. of Physics, Calif.

NUCLEAR DISPERSION CONTRIBUTION TO HIGH-ENERGY ELECTRON SCATTERING, by L. I. Schiff. Jan. 1955, 16p. (Technical rept. no. 9) ([AF]OSR-TN-55-27) (AF 18(600)545) AD 55259 Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Also published in Phys. Rev., v. 98: 756-760, May 1, 1955.

An expression for the contribution of virtual intermediate states of the nucleus (nuclear dispersion) to the elastic and inelastic scattering of high-energy electrons is obtained. The closure relation for the nuclear states is used to put this in a form which depends only on the properties of the initial and final states. An estimate of this contribution in comparison with the first-order scattering shows that it is expected to be small but not negligible for the light elements and somewhat larger for the heavy elements, when the electronics have several hundred mev energy. The estimate is only valid for large scattering angles. More detailed knowledge of the 1- and 2-proton transition charge densities would be required in order to extend the range of validity. It seems likely that the bulk of the dispersion correction would be taken into account if the correct electron wave functions in the static Coulomb field were to be used in place of plane waves. (Contractor's abstract)

STA. 03:014

Stanford U. Dept. of Physics, Calif.

ELECTRIC MONOPOLE TRANSITIONS IN C^{12} AND AND O^{16}, by L. I. Schiff. Feb. 1955, 16p. refs. (Technical rept. no. 11) ([AF]OSR-TN-55-41) (AF 18(600)545) AD 55261 Unclassified

Also published in Phys. Rev., v. 98: 1281-1285, June 1, 1955.

The matrix element (ME) was calculated for electric monopole transitions ($0^+ \longrightarrow 0^+$) between the ground and 7.68-mev states in C^{12}. The calculations were based on jj-coupling independent-particle model in which 2 nucleons undergo transitions between the $p_{3/2}$ shell and the $p_{1/2}$ shell. Pair forces were included to first order, and the sum-over configurations were performed exactly by means of a Green's function. (For simplicity an infinitely deep square-well independent-particle potential was assumed.) The calculated ME was -1.58×10^{22} CR cm^2, with R measured in cm and C in mev-cm^3. By using R 3.0×10^{-13} cm and the experimental value of ME (3.8×10^{-26} cm^2) of

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Oppenheimer and Schwinger (Phys. Rev., v. 56: 1066, 1939) and Dalitz (Proc. Roy. Soc. (London), v. 206A: 521, 1951), the neutron-proton interaction value, $C = 8.0 \times 10^{-36}$ mev-cm^3 was obtained. Since this is about 6 times the volume integral of the triplet neutron-proton interaction when it is assumed to be of Gaussian form, a model is required which is more collective than the independent-particle model (with pair interactions) and less collective than the α-particle or elastic-fluid models in order to account for the experimental value of ME. (ASTIA abstract)

STA. 03:015

Stanford U. Dept. of Physics, Calif.

LATTICE SPACE QUANTIZATION OF COUPLED MESON AND NUCLEON FIELDS, by D. H. Holland. Jan. 1955, 17p. (Technical rept. no. 10) ([AF]OSR-TN-55-42) (AF 18(600)545) AD 55260 Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Also published in Phys. Rev., v. 98: 788-792, May 1, 1955.

The lattice space quantization method of Schiff (Phys. Rev., v. 92: 766, 1953) for treating nonlinear mesons is used to quantize coupled mesons and nucleon fields. Neutral pseudoscalar mesons with pseudoscalar coupling to neutral Dirac nucleons are assumed, and only the fields at the lattice points of a cubic lattice are considered. A lattice space Hamiltonian is found, and momentum terms are treated as petrurbations. To zero order, the lattice points are uncoupled so that the state function is written as a product of functions describing a single point. Finding a particular point function requires the solution of a set of coupled differential equations. Linear combinations of zero-order solutions are found which diagonalize the perturbation to the lowest order and which can be interpreted as 1-particle momentum eigenstates. Linear combinations of 2-particle momentum states are obtained which approximately diagonalize the perturbation, and, from these, scattering cross sections are calculated. The lattice constant, l, appears in the final results and must be regarded as a parameter of the theory. This constant must be much larger than the meson Compton wave-length for the perturbation approximation to be valid.

STA. 03:016

Stanford U. Dept. of Physics, Calif.

ON THE RADIATIVE CORRECTION TO HIGH-ENERGY ELECTRON SCATTERING, by H. Suura. Mar. 1955 [24]p. incl. diagrs. refs. (Technical rept. no. 12) ([AF]OSR-TN-55-93) (AF 18(600)545) AD 60034 Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Also published in Phys. Rev., v. 99: 1020-1028, Aug. 1, 1955.

Abstract published in Phys. Rev., v. 98: 278, Apr. 1, 1955.

An analysis is presented of the 1-photon radiative correction to the high-energy electron scattering by a nuclear field to all orders of Born approximation for the nuclear potential. The leading term of the fractional decrease of the elastic scattering cross section is shown to be exactly the same as that given by the first Born approximation. The effect of the long Coulomb tail on the IR divergence is analyzed in detail. In addition, the origin of the log m term which appears in the radiative correction is analyzed.

STA. 03:017

Stanford U. Dept. of Physics, Calif.

DEUTERON MODEL CALCULATION OF THE HIGH-ENERGY NUCLEAR PHOTOEFFECT, by K. G. Dedrick. May 1955 [26]p. incl. diagrs. tables, refs. (Technical rept. no. 13) ([AF]OSR-TN-55-135) (AF 18(600)545) AD 63957 Unclassified

Also published in Phys. Rev., v. 100: 58-66, Oct. 1, 1955.

The high-energy nuclear photoeffect has been calculated according to the "deuteron model" of Levinger. In this model, the photo process occurs when a neutron and a proton which are scattering one another inside the nucleus absorb the energy of the incident photon and escape from the nuclear potential well into the laboratory. The nuclear photoeffect cross section is then obtained by averaging the cross section for the above process over all possible neutron-proton pairs in the nucleus, assuming a nucleon momentum distribution. The electric dipole and quadrupole interactions of the radiation field with the neutron and proton are included, and the magnetic terms are neglected. The averaging over all neutron-proton pairs is performed by means of a random flight formulation of the problem. The analytical work involved may conveniently be done using either a zero temperature Fermi ground state nucleon momentum distribution or a Gaussian distribution. Numerical results for the energy and angle distributions of photoneutrons and photoprotons are presented in the case of the Gaussian distribution, for 4 photon energies between 50 and 125 mev. (Contractor's abstract)

STA. 03:018

Stanford U. [Dept. of Physics] Calif.

ELECTRIC QUADRUPOLE EFFECTS IN SCATTERING OF HIGH-ENERGY ELECTRONS BY HEAVY NUCLEI (Abstract), by B. W. Downs, D. G. Ravenhall, and D. R. Yennie. [1955] [2]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 277-278, Apr. 1, 1955.

Using a modified Born approximation, calculations have been derived of the contributions to the differential scattering cross section which arise from the static quadrupole moment and from the collective electric quadrupole transitions (excitation of low-lying collective rotational states of the target nucleus). For nuclei having large intrinsic quadrupole moments these contributions partially smooth the diffraction wiggles in the scattering curves calculated by the method of Yennie et al.; the theoretical curves are thus brought into better agreement with the experimental data. The quadrupole charge distribution and the extent to which its details affect the scattering cross section are discussed. Results are presented for scattering of 183 mev electrons by tantalum. (Contractor's abstract)

STA. 03:019

Stanford U. [Dept. of Physics] Calif.

ELECTRODISINTEGRATION OF THE DEUTERON (Abstract), by V. Z. Jankus. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 278, Apr. 1, 1955.

Calculations have been made on the disintegration of the deuteron in high-energy electron impact. With increase of momentum transfer the inelastic cross section increases at the expense of the elastic, while the sum of the two remains approximately equal to the Mott cross section. The energy spectrum of the scattered electron has been obtained using the Møller potential. In this calculation it was necessary to take account of the proton-neutron interaction in the final S state. The influence of this interaction on the states of higher angular momentum has been found to be much smaller. The results indicate that the cross section is sensitive to the effective range of proton-neutron forces, especially at high momentum transfers, such a produced by 300 mev electrons scattered at 60°. (Contractor's abstract)

STA. 03:020

Stanford U. [Dept. of Physics] Calif.

EXCITED STATES OF C^{12} AND O^{16} (Abstract), by L. I. Schiff. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of Amer. Phys. Soc., Chicago, Ill., Nov. 26-27, 1954.

Published in Phys. Rev., v. 98: 235, Apr. 1, 1955.

The matrix element for the electric monopole transition in O^{16} computed from the pair emission lifetime has roughly the same magnitude as the matrix element between the ground and 7.68-mev states in C^{12} estimated from inelastic electron scattering, assuming that the latter is also electric monopole. Both matrix elements are much smaller than would be expected on the basis of an alpha particle model, an elastic fluid model, or a $1S \rightarrow 2S$ transition of a single proton. It seems possible that this can be explained on the independent particle model (IPM) if two particles change their states. The transition is then forbidden if the IPM is taken literally, but becomes allowed if some interaction between particles is admitted in addition to that which is included on the average in the IPM. An estimate of the magnitude of this residual interparticle interaction that is required to explain the matrix elements are presented. (Contractor's abstract)

STA. 03:021

Stanford U. [Dept. of Physics] Calif.

HIGH-ENERGY ELECTRON SCATTERING AND THE CHARGE DISTRIBUTIONS OF SELECTED NUCLEI (Abstract), by B. Hahn, D. G. Ravenhall, and R. Hofstadter. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 278, Apr. 1, 1955.

Recent improvements in experimental technique have made it possible to measure more accurately the angular distribution of high-energy electrons (180 mev) scattered by heavy and medium nuclei. Small differences in scattering cross sections of two nuclei can be established by measuring ratios of counting rates at each scattering angle. Scattering ratios of gold with respect to hydrogen have been measured, as well as ratios with respect to Rh, Ta, W and U. Ta, W, and U definitely show less pronounced diffraction wiggling in the angular distribution than Pb^{208}, Au, and Bi. It is fairly difficult to fit the experimental results for Ta, W, and U with phase shift calculations to a spherically symmetric charge distribution. A possible explanation of these relatively smooth angular distributions may involve nuclear-quadrupole effects. (Contractor's abstract)

STA. 03:022

Stanford U. [Dept. of Physics] Calif.

A MODIFIED BORN APPROXIMATION FOR ELECTRON SCATTERING CALCULATIONS (Abstract), by D. R. Yennie, D. G. Ravenhall, and R. W. Downs. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 277, Apr. 1, 1955.

STA. 03:023 - STA. 03:026

It has been shown previously that for heavy elements the Born approximation is inadequate for calculating high-energy electron scattering. However, after the problem of scattering in a central potential has been solved exactly (by numerical methods), additional effects can be treated by perturbation theory. Since the unperturbed scattering waves are known only through their partial wave decomposition, this method leads to a tedious, though straightforward, computation. An analytic approximation to the complete unperturbed scattering wave has been found which restores the perturbation calculation to the simplicity of the Born approximation; the approximation is good in the neighborhood of the nucleus. In this region the approximate function is very nearly a plane wave with normalization and wave number altered from that of the incident wave; in addition the wave fronts are slightly curved. This modified Born approximation is used to estimate the sensitivity of electron scattering to small changes in the radial charge distribution. (Contractor's abstract)

STA. 03:023

Stanford U. [Dept. of Physics] Calif.

PHASE SHIFT ANALYSIS OF HIGH-ENERGY ELECTRON SCATTERING (Abstract), by D. G. Ravenhall and D. R. Yennie. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 277, Apr. 1, 1955.

Results of a phase shift analysis of high-energy electron scattering is reported. Previously, experimental data on gold at several energies have been compared with cross sections obtained by using a "smoothed uniform" charge distribution. The effect of altering the central charge density has now been investigated, in an attempt to improve the agreement with these experiments, and in order to examine the extent to which the experiments determine the charge distribution. Some results are also presented for other nuclei whose distortion (i.e., intrinsic quadrupole moment) is small enough that the assumption of a spherically symmetrical charge distribution is justified. (Contractor's abstract)

STA. 03:024

Stanford U. [Dept. of Physics] Calif.

W. K. B. APPROXIMATION TO PHASE SHIFTS (Abstract), by S. P. Heims, D. R. Yennie, and D. G. Ravenhall. [1955] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 278, Apr. 1, 1955.

The computing time required to evaluate exactly the phase shifts for the nuclear electron scattering at very high energies increases roughly as the square of the energy. For this reason the W. K. B. approximation for the phase shifts is being reconsidered. Using this approximation, E. Baranger has obtained cross sections at 150 mev for mercury that agree well with those obtained by the exact method, and the accuracy of the W. K. B. approximation improves as the energy increases. The phase integral is evaluated numerically rather than by the analytic approximation used by Baranger. Phase shifts and cross sections obtained by this method are compared with those obtained by the exact method. (Contractor's abstract)

STA. 03:025

Stanford U. [Dept. of Physics] Calif.

LOW-ENERGY PHYSICS FROM A HIGH-ENERGY STANDPOINT, by L. I. Schiff. [1955] [4]p. incl. refs. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28, 1955.

Published in Science, v. 121: 881, June 24, 1955.

A lucid survey in elementary terms is presented of the information gained from high-energy experiments involving nuclear charge distributions and ground and low-excited states of nuclei. Photo-disintegration, μ-meson capture and scattering and high-energy electron scattering are discussed in particular.

STA. 03:026

Stanford U. [Dept. of Physics] Calif.

THE EFFECTS OF SHORT-RANGE CORRELATIONS [IN POSITION] BETWEEN TWO PROTONS IN THE ELASTIC SCATTERING OF HIGH-ENERGY ELECTRONS BY HEAVY NUCLEI, by B. W. Downs. [Oct. 3, 1955] [21]p. incl. diagr. [AF 18(600)545] Unclassified

Also published in Phys. Rev., v. 101: 820-825, Jan. 15, 1956.

An expression is obtained for the leading term in the 2-proton contribution to the scattering cross section with a 2-proton charge density which is a Yukawa function of the separation between 2 protons. The cross section for scattering from more complicated charge distributions can be generated from this basic result by differentiation with respect to the Yukawa range parameter. The 2-proton cross section is evaluated for a charge density in which short-range correlations in position between 2 protons appear. Results are given for the scattering of 600-mev electrons by heavy nuclei. (Contractor's abstract)

STA. 03:027

Stanford U. [Dept. of Physics] Calif.

INELASTIC ELECTRON SCATTERING BY CARBON (Abstract), by D. G. Ravenhall. [1955] [2]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., Southern California U., Los Angeles, Dec. 28-30, 1955.

Published in Phys. Rev., v. 100: 1797-1798, Dec. 15, 1955.

The experimental results of Fregeau and Hofstadter on the scattering of 187-mev electrons by carbon contain differential cross sections for both elastic and inelastic processes. The former can be related to the charge distribution of the nucleus in its ground state, and the latter are associated with nuclear excitation, in this case to each of the first three levels, at 4.43, 7.68, and 9.61 mev. The spins and parities of the first two levels are known to be 2^+ and O^+ respectively, and the experimental results relating to these levels and to the ground state are in qualitative agreement with the predictions of the shell model. In this paper a discussion is given of the excitation to the 9.61-mev level, and of the information it gives concerning the spin and parity of this level. Further experiments which could assist in giving an unambiguous assignment are also discussed. (Contractor's abstract)

STA. 03:028

Stanford U. Dept. of Physics, Calif.

CALCULATION OF ELECTRON-DEUTERON SCATTERING CROSS SECTIONS, by V. Z. Jankus. Feb. 1956 [20]p. incl. diagrs. refs. (Technical rept. no. 14) (AFOSR-TN-56-48) (AF 18(600)545) AD 80560 Unclassified

Also published in Phys. Rev., v. 102: 1586-1591, June 15, 1956.

Elastic and inelastic cross sections for electron-deuteron scattering with large momentum transfers were investigated. The calculations were performed in the first Born approximation. The neutron-proton interaction was described by a phenomenological potential, and the nucleons were represented by point charges and point magnetic moments. The finite size of nucleons caused major corrections to the results. The calculations treated the deuteron nonrelativistically, while the electron was considered extremely relativistic. Thus the wave functions for incident and scattered electrons were represented by plane waves, and the deflection of the electrons generated Møller potentials to act upon the charge and current distributions in the deuteron. The calculations showed that the elastic cross section is sensitive to the presence or absence of the hard core in the interaction and that the inelastic cross section is sensitive to the presence or absence of the neutron-proton interaction in the final ^3P state. The calculations used bare nucleons to represent the proton and the neutron.

STA. 03:029

Stanford U. Dept. of Physics, Calif.

THE ZERO-ZERO TRANSITION IN CARBON 12, by B. F. Sherman and D. G. Ravenhall. Mar. 1956 [18]p. refs. (Technical rept. no. 15) (AFOSR-TN-56-152) (AF 18(600)545) AD 86311 Unclassified

Also published in Phys. Rev., v. 103: 949-955, Aug. 15, 1956.

The electric monopole transition density between the ground state and the 7.68 mev level of C^{12} is examined on the basis of the nuclear shell model. It is found to vanish for all stages of intermediate coupling if only the $(1p)^8$ configuration is involved. A nonzero value is obtained by including states of the $(1p)^7$ (2p) configuration, which are the results of a residual central internucleon interaction. For computational simplicity, both this and the spin-orbit interaction are first treated as perturbations about the L-S limit. Since the results show that the residual interaction is probably too large for this to be reliable, an attempt is made to diagonalize the Hamiltonian exactly, but the severe restriction on the number of states considered makes the result rather unsatisfactory. It is concluded that if all of the possible states of the low-lying configurations were to be included in the diagonalization, agreement with experiment might result, but that in this case some semi-collective model might better be applied. (Contractor's abstract)

STA. 03:030

Stanford U. Dept. of Physics, Calif.

AN APPROXIMATION METHOD FOR HIGH-ENERGY POTENTIAL SCATTERING, by L. I. Schiff. Apr. 1956, 24p. refs. (Technical rept. no. 16) (AFOSR-TN-56-162) (AF 18(600)545) AD 86582 Unclassified

Also published in Phys. Rev., v. 103: 443-453, July 15, 1956.

An approximation method for high-energy potential scattering is developed that expresses the scattered amplitude in terms of a quadrature, similar to the Born approximation but superior to it in accuracy. It is valid when the potential is slowly varying compared to a wavelength, $|V|/E'$ is small compared to unity, is either small or large compared to $(kR)^{-1/2}$, and $|V|R/\hbar v$ is unrestricted in magnitude, where E', , k, and v are the kinetic energy, scattering angle, wave number, and speed of the scattered particle, respectively, and V and R are rough measures of the strength and range of the scattering potential, which may be complex. For comparison, the Born approximation requires that $|V|R/\hbar v$ be small compared to unity.

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The procedure consists in summing the infinite Born series after approximating each term by the method of stationary phase. Both the Schrödinger and Dirac equations are treated, and it is expected that the method can be extended to the scattering theory of other wave equations. The relation of the present work to previous work of others is discussed, and the limitations of WKB or eikonal-type approximations are explored. The method is expected to be especially useful for calculating the scattering of fast electrons, neutrons, and protons from nonspherical nuclei. (Contractor's abstract)

STA. 03:031

Stanford U. Dept. of Physics, Calif.

APPROXIMATION METHOD FOR SHORT-WAVELENGTH OR HIGH-ENERGY SCATTERING, by L. I. Schiff. Sept. 1956 [16]p. (Technical rept. no. 17) (AFOSR-TN-56-407) (AF 18(600)545) AD 96215 Unclassified

Also published in Phys. Rev., v. 104: 1481-1485, Dec. 1, 1956.

The approximation method developed recently is extended to the scattering theory of Maxwell's equations, and of the Schrödinger equation with spin-orbit interaction. Both of these situations are more complicated than the Schrödinger and Dirac cases considered earlier. While the electromagnetic case yields the earlier type of result in which the Born formula is modified by the inclusion of an additional phase factor, the Schrödinger spin-orbit case cannot be put in such a simple form. Brief mention is also made of the tensor interaction, which is even more complicated than the spin-orbit interaction, and of the space-exchange interaction, which can only be treated by this method if the potential is symmetric with respect to inversion. (Contractor's abstract)

STA. 03:032

Stanford U. Dept. of Physics, Calif.

PION PRODUCTION IN ELECTRON-PROTON COLLISION, by R. H. Dalitz and D. R. Yennie. Nov. 1956 [59]p. incl. diagrs. tables, refs. (Technical rept. no. 18) (AFOSR-TN-56-533) (Sponsored jointly by [Air Force] Office of Scientific Research under (AF 18(600)-545), Office of Naval Research, and Atomic Energy Commission) AD 110352 Unclassified

Also published in Phys. Rev. v. 105: 1598-1615, Mar. 1, 1957.

The close relationship between photo-pion and electro-pion production from protons allows an unambiguous first estimate (the standard value) for the ratio of these cross sections, based on assumptions very close to those of the Weizsäcker (Zeitschr. Phys., v. 88: 612, 1934)-Williams (Phys. Rev., v. 45: 729, 1934; Kgl. Videnskab. Selskab, Mat-fys. Medd. Danske, v. 13: 4, 1935) method. Deviations of the ratio from this estimate arise from pion production by the longitudinal components of the field of the scattered electron and from the variation of the off-diagonal transverse excitations from their on-diagonal photoproduction values. The dependence of these deviations on the physical processes contributing to the electromagnetic excitation of pions is discussed in terms of matrix elements specified in the pion-nucleon center of mass system, both for various phenomenological contributions and for specific meson theories. The experimental values reported are interpreted as an indication of the smallness of longitudinal production, in qualitative accord with the fixed source theory. These features may also be investigated by study of the energy spectrum of inelastically scattered electrons and of the azimuthal variation of pion production relative to the scattering plane, which are also discussed here. (Contractor's abstract)

STA. 03:033

Stanford U. Dept. of Physics, Calif.

ELECTROMAGNETIC STRUCTURE OF NUCLEONS, by D. R. Yennie, M. M. Lévy, and D. G. Ravenhall. Nov. 1956, 1v. incl. diagrs. refs. (Technical rept. no. 20) (AFOSR-TN-56-559) (AF 18(600)545) AD 110379 Unclassified

Also published in Rev. Modern Phys., v. 29: 144-157, Jan. 1, 1957.

The extent to which the results of the separate experiments performed upon phenomena of the nucleon electromagnetic interaction type can be combined into a consistent picture of nucleons as charge-current distributions. Neutron scattering by atoms gives information about the volume integral of the electron-neutron interaction. An interpretation is made in terms of a simple meson model of nucleon structure in which the "physical" nucleon is made up of "bare" nucleons and pions interacting in a charge-symmetrical manner. Other speculative ways of interpreting results are commented upon.

STA. 03:034

Stanford U. Dept. of Physics, Calif.

HIGHER-ORDER RADIATIVE CORRECTIONS TO ELECTRON SCATTERING, by D. R. Yennie and H. Suura. Nov. 1956 [14]p. incl. diagrs. refs. (Technical rept. no. 19) (AFOSR-TN-56-560) (AF 18(600)-545) AD 110380 Unclassified

Also published in Phys. Rev., v. 105: 1378-1382, Feb. 15, 1957.

The question of higher order radiative corrections in the infrared region is examined, and it is shown that Schwinger's conjecture that the functional dependence of these radiative corrections on the energy resolution is asymptotically true for small ΔE ($\Delta E \ll$ E-energy available for radiation). The cause of the statistical independence of the soft quanta is examined in some

detail. A discussion of the literature and previous results is given.

STA. 03:035

Stanford U. [Dept. of Physics] Calif.

SHORT WAVELENGTH SCATTERING APPROXIMATIONS (Abstract), by L. I. Schiff. [1956] [1]p. [AF 18(600)545] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 66, Jan. 30, 1956.

The Born series for the exact scattering amplitude associated with the Schrödinger equation is simplified by applying the stationary phase approximation in the short wavelength case. The series can then be summed in two ways. One of these leads to an expression already obtained by Glauber, who used the WKB approximation for the wave function in the integral equation for the scattered amplitude. The other yields a superficially different expression first derived by the author with the help of a WKB approximation for the Green's function. The two expressions are equivalent, but Glauber's seems to be slightly more convenient for numerical computation. This point, and the extension to the Dirac equation, is discussed. (Contractor's abstract)

STA. 03:036

Stanford U. [Dept. of Physics] Calif.

SCATTERING OF CLASSICAL ELECTRONS BY NUCLEI, by S. P. Heims, D. G. Ravenhall, and D. R. Yennie. [1956] [19]p. incl. diagrs. refs. [AF 18(600)545] Unclassified

Published in Amer. Jour. Phys., v. 24: 568-573, Nov. 1956.

In connection with recent research at Stanford University on the scattering of high-energy electrons by atomic nuclei, a study is made of the scattering of extremely relativistic classical charged particles by a distribution of charge. The approximation is made that the mass of the scattered particle can be neglected; this is valid for the energies used in the experiments (between 100 and 200 mev). In the case of the point charge, orbits appear in which the particle encircles the nucleus many times before emerging. Cross sections are obtained for this case, for the spherical shell, and for the "smoothed uniform" charge distribution. From these results, it is clear that the experimentally interesting region is completely inaccessible to classical particles, and that the process observed corresponds more to the diffraction of waves. (Contractor's abstract)

STA. 04:001

Stanford U. Div. of Engineering Mechanics, Calif.

THE SOLUTION OF COMPRESSIBLE LAMINAR BOUNDARY LAYER PROBLEMS BY A FINITE DIFFERENCE METHOD. PART I. DESCRIPTION OF THE METHOD, by I. Flügge-Lotz and D. C. Baxter. Sept. 30, 1956, 81p. incl. diagrs. tables, refs. (Technical rept. no. 103) (AFOSR-TN-56-544) (AF 18(600)1488) AD 110363 Unclassified

The differential equations of the boundary layer can be conveniently treated by the described method. Such a method will allow the determination of boundary layer behavior under any combination of pressure gradient and wall temperature of heat transfer rate variation. The stability of the finite difference solution of the boundary layer equations, and of parabolic equations in general, has been investigated and found to place certain restrictions on the mesh sizes which may be used. Series expansions in powers of the velocity for the dependent variables τ^2 and $i_\mu \tau$ (pertaining to shear stress and enthalpy, respectively) can be used to allow determination of the wall conditions. The finite difference solution of the boundary layer equations has been programmed for the IBM 650 digital computer, and the computation of an extensive series of examples under various combinations of heat transfer rate and pressure gradient has been started. (Contractor's abstract)

STA. 05:001

Stanford U. Electronics Research Lab., Calif.

THE ANALYSIS AND SYNTHESIS OF GROUND-GRID AMPLIFIER TRANSFER FUNCTIONS, by W. A. Christopherson. May 12, 1952, 110p. incl. illus. refs. (Technical rept. no. 46) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U22181; ATI-154480 Unclassified

The need for wide-band (50 to 75 megacycles), band-pass amplifiers operating at center frequencies in the ultra-high frequency range (above 300 megacycles) and having voltage gains of at least one thousand cannot be satisfied through the use of present day pentode tubes. However, such amplifiers can be designed by incorporating presently available ultra-high frequency triode types in grounded-grid operation if stagger tuning is employed to preserve gain band-width product and to produce the necessary selectivity. An alternative method is to use a traveling-wave tube, though this has several practical disadvantages having to do with noise-figure, selectively, and physical size. This investigation was undertaken to develop techniques of analysis and synthesis that would make possible the systematic design of a stagger-tuned cascade of grounded-grid triode amplifiers having a prescribed gain-magnitude response. The first part of this report is concerned with the analysis of grounded-grid cascades. It is shown that the cascade is not unilateral and that the equivalent circuit is a passive ladder

STA. 05:002 - STA. 05:003

network. However, series resistors in the equivalent ladder network allow the sections corresponding to the stages of the cascade to behave as though they are nearly unilateral. Deviations from unilateral behavior are defined as interaction. The tubes act as impedance transformers having low input-impedance and high output-impedance. It is necessary to obtain gain by employing only four-terminal interstages that act as current transformers. Thus, the choice of interstages is restricted. The second part of the report is concerned with the synthesis of prescribed gain-magnitude functions of grounded-grid cascades. A simple interstage network is selected with which it is possible to obtain a band-pass response. The resultant amplifier transfer function has three clusters of poles (points of infinite gain) on the band-pass complex-frequency plane. There is a pole in each cluster for each stage of the amplifier. The problem of arranging the poles to obtain the desired gain-magnitude response is solved by transforming it to a low-pass complex-frequency plane where there is only one cluster of poles. The solution of the problem in such a low-pass plane is known for a variety of gain-magnitude responses. Hence, the problem is solved if the inverse transformation from the low-pass plane to the high-pass plane can be carried out. This problem is actually by-passed, and the alignment data (center frequency and three -db bandwidth) for each stage are obtained directly from the low-pass plane solution. This is accomplished by using a plot of the correspondence of the imaginary axes of the low-pass and band-pass planes. Since the alignment data is obtained directly in the synthesis procedure, only approximate design equations are needed for the interstage networks. These are developed in the third part of the report. The final adjustment is performed experimentally. Throughout the development of the synthesis procedure, interaction is assumed to be negligible in order to simplify the problem. Thus it is necessary to investigate methods of reducing interaction so that this assumption is justifiable. It is shown that the order of the stagger-tuned stages is a very important factor in reducing interaction. In the final part of the report, the design of a low-frequency-analog amplifier (eight megacycle center frequency, one megacycle bandwidth) is described in order to illustrate the use of the synthesis and design techniques. The experimental results obtained with this amplifier check closely with the results predicted by the theory. (Contractor's abstract)

STA. 05:002

Stanford U. Electronics Research Lab., Calif.

HELIX IMPEDANCE OF TRAVELING WAVE TUBES, by P. K. Tien. June 27, 1952, 26p. incl. diagrs. (Technical rept. no. 50) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U23274; ATI-159659 Unclassified

The impedance parameter $E^2z/2\beta^2P$ of a circular helix was investigated for a tape-helix model in which a helix of width δ and pitch p is assumed to be wound of infinitely thin conducting tape. (E_z is the maximum value of the axial electric field on the axis of a helix carrying power P and with a phase constant β.) The results indicate that the impedance has a smaller value than for the sheath-helix model and is considerably reduced at larger values of ka, the ratio of the helix circumference to the free-space wave length. Analysis of a tape helix surrounded by a dielectric medium established that the impedance of a helix of circular wire, supported by a dielectric structure, can be estimated on the basis of the phase velocity reduction. The estimates using this procedure were in agreement with measurements on various tube designs. Two ways of improving the helix design for use in traveling wave tubes were indicated: (1) to increase the dielectric loading factor and (2) to reduce the space harmonic component fields. The dielectric loading factor can be raised by using dielectric supports so that most of the dielectric material is away from the helical surface; the space harmonic component fields can be reduced either by using a larger ratio of δ/p or a smaller value of ka.

STA. 05:003

Stanford U. Electronics Research Lab., Calif.

THE MECHANISM OF RADIO REFLECTIONS FROM METEORIC IONIZATION, by V. R. Eshleman. July 15, 1952, 128p. incl. diagrs. table, refs. (Technical rept. no. 49) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U23268; ATI-163933 Unclassified

A theory of radio reflections from cylinders of ionization is presented in an attempt to explain the characteristics of radio echoes from meteor trails. The theoretical approaches to the problem were (1) solution of the electromagnetic-wave equation for dielectric columns with cylindrical symmetry and (2) a summation of the fields scattered by the individual electrons in the column. Neither method was easily applicable for finding reflections from a column of arbitrary properties; however, consideration of both led to approximate expressions for the reflections as a function of size, number of electrons, and radial variation of electron density. A meteor-trail model which is proposed to explain conflicting experimental results consists of a column with a dense core surrounded by a larger, more dilute region of ionization. This model would produce the observed increase in the number and amplitude of meteor echoes with wave length as well as the difference in polarization effects measured at different wave lengths. High electron densities in the dense core of the column appeared responsible for the small percentage of long-duration echoes; these durations were believed to be enhanced by the sharp boundaries of this inner core. The amplitude fluctuations observed in long-duration echoes were attributed to (1) upper atmosphere winds and turbulence and (2) expansion of the sharply bounded inner core of ionization. A theoretical treatment of forward scattering from meteor trails indicated that the duration of meteor echoes is expected to increase markedly with the distance between the transmitting and receiving locations.

STA. 05:004

Stanford U. Electronics Research Lab., Calif.

GRID-MODULATED TRAVELING WAVE TUBE FOR LOW-PASS AMPLIFICATION, by J. T. Mendel. July 31, 1952, 92p. incl. diagrs. tables. (Technical rept. no. 47) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U23203; ATI-166259
Unclassified

The fundamental limitations of conventional wideband low-pass amplifiers using triodes and pentodes preclude the possibility of extending the gain-bandwidth performance of these devices much beyond present day standards. The network approach to extremely large bandwidths is seriously hampered by the difficulties encountered in the physical realization of the component parts. Parasitic inductances and capacitances, and the effects of conventional networks are virtually impossible to eliminate. To circumvent the limitations of vacuum tube networks, the inherent broadband high-gain properties of the traveling-wave tube have been utilized to achieve low-pass video amplification. The video signal is used to modulate the beam current of a helix type TWT, and consequently the effective gain of the table varies according to the input signal. A microwave local oscillator supplies a carrier signal to the input of the helix and the modulated output of the TWT is fed into a grounded-grid microwave triode which serves as a plate detector. Following the detector is a low-pass filter which rejects the microwave frequency components appearing at the plate of the detector. At the output of the low-pass filter the original video signal appears at an amplified level. Thus, the basic principles of modulation, amplification, and detection are combined in a system to accomplish low-pass amplification. The analysis that a video gain of 36 db over the pass band 0-1000 mc is possible with components which are easily realized in view of modern construction techniques. A gain of 60 db with the same video bandwidth is possible if a second unmodulated TWT is employed to serve as a linear power amplifier. With respect to gain and bandwidth, the indicated performance of this system is better by an order of magnitude than other more conventional broadband amplifiers available at this time. An experimental system has been constructed and tested to verify the predicted behavior. The experimental measurements of bandwidth and video gain were in close agreement with the analytic results. It was found that with the proper level of input carrier power the output power of the TWT was a linear function of beam current over a wide range, and consequently the system could be made linear for much larger input video powers than the analysis indicated. Although the grounded-grid triode detector used in the experimental system was adequate for measurement purposes, a tube of larger power capabilities would be needed for a practical high gain amplifier. The overall video noise figure is shown to be several db larger than that of the modulated TWT when operating as a microwave amplifier. If a representative low noise TWT were used the video noise figure would be of the order of 15 db. (Contractor's abstract)

STA. 05:005

Stanford U. Electronics Research Lab., Calif.

TRAVELING WAVE AMPLIFICATION OF MILLIMETER, by H. Heffner. July 31, 1952 [118]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 51) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U24219; ATI-169726
Unclassified

An investigation of the helix and certain heavily loaded waveguides is made to determine their suitability as slow wave structures of millimeter wave amplifiers. Fundamental mode interaction in these circuits is found to be unsuitable because of the minuteness of the dimensions involved and the excessive close tolerances required in their construction. The periodically loaded guide is shown to exhibit space harmonics of the fundamental mode whose velocities may be made many times lower than that of the fundamental. Interaction with these space harmonics is investigated particularly with regard to the finned rectangular guide and is shown to lead to practical millimeter wave amplifiers if the impedance magnification around either the high or low frequency cut-off regions is utilized. The advantages of low frequency cut-off operation are pointed out. A detailed analysis of the expected gain in the vicinity of the low frequency cut-off including the effects of loss and space charge for the first space harmonic of the fin-opposite-fin and fin-opposite-slot corrugated guide is made. Interaction with backward waves is investigated and is shown to form a high gain, narrow band, regenerative-type amplifier, and, at higher beam currents, a continuously voltage tunable oscillator suitable for use in the millimeter wave region. The start-oscillation conditions including the effect of space charge are quoted. The probable occurrence of backward wave oscillations in forward wave space harmonic amplifiers is pointed out and methods for their elimination proposed. The easitron, consisting of a resonant wall surrounding an electron beam, is analyzed and shown to form a high gain narrow band amplifier. Circuits of both cylindrical and rectangular geometry are proposed for millimeter wave easitrons and curves of expected gain are drawn. The problems of circuit excitation are pointed out. The results of a representative sample of nine experimental tubes of both the space harmonic and easitron type are given and compared with the theory presented. (Contractor's abstract)

STA. 05:006

Stanford U Electronics Research Lab., Calif.

SUPERREGENERATIVE OPERATION OF A TRAVELING-WAVE AMPLIFIER, by F. M. Turner. Aug. 1, 1952 [20]p. incl. illus. tables. (Technical rept. no. 52) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U24070; ATI-166258
Unclassified

STA. 05:007 - STA. 05:009

Superregeneration is a method of operation whereby the tendency of a traveling-wave amplifier to oscillate is utilized to obtain high gain and improved sensitivity. In superregenerative operation the traveling-wave tube is allowed to oscillate periodically. The conditions of operation are such that the amplitude of oscillation is greatly increased when a signal is received. Conventional operation, in which attenuation is added to the helix structure, and superregenerative operation are compared. Gain is increased from 18 to 50 db and sensitivity is improved by at least 5 db during superregenerative operation. Superregenerative amplification is not, however, amplification in the true sense. Many frequencies other than those contained in the signal are present at the output. (Contractor's abstract)

STA. 05:007

Stanford U. Electronics Research Lab., Calif.

SCATTER-SOUNDING: A TECHNIQUE FOR STUDY OF THE IONOSPHERE AT A DISTANCE, by O. G. Villard, Jr. and A. M. Peterson. Aug. 1952, 16p. incl. illus. tables, refs. (Technical rept. no. 54) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U24482; ATI-169853 Unclassified

Presented at URSI-IRE meeting, Nat'l. Bur. Standards, Washington, D. C., Apr. 21-24, 1952.

Also published in I. R. E. Trans. of Professional Group on Antennas and Propagation, v. PGAP-3: 186-201, Aug. 1952.

Echoes arising through back-scattering when radio waves strike the ground at oblique incidence are readily detectable even with low power and provide a useful means for studying the ionosphere at a distance. Use of a rotatable directional antenna, with PPI display of the back-scattered echoes is convenient. The techniques, called scatter-sounding, permits systematic investigation of geographical variations in F-layer MUF, and makes possible for the first time study of the detailed spatial distribution of sporadic-E clouds and other anomalies. The characteristics of F-layer back-scatter echoes are reviewed from the standpoint of their usefulness in ionospheric research. As an aid in interpretation, the following relationships, calculated on the basis of a parabolic model of the F-layer, are presented in graphical form: (1) echo amplitude and pulse width, (2) echo delay time and distance to the edge of the skip zone, and (3) equivalent transmission path length and the corresponding vertical angle. Experimental verification of the pulse width-echo amplitude relationship is found to agree well with the simple theory. Examples of some practical uses of scatter-sounding are given. (Contractor's abstract)

STA. 05:008

Stanford U. Electronics Research Lab., Calif.

SYNTHESIS OF DISTRIBUTED AMPLIFIERS FOR PRESCRIBED AMPLITUDE RESPONSE, by A. D. Moore. Sept. 1, 1952, 95p. incl. diagrs. tables, refs. (Technical rept. no. 53) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) U24220; ATI-171341 Unclassified

The purpose of this investigation is the development of synthesis techniques for distributed amplifiers in order to produce amplitude characteristics which approximate specified functions of frequency, using the concepts of modern network theory. Conventional distributed amplifiers are designed by an extension of the principles of image-parameter filter synthesis; this study shows that it is possible to combine the more effective insertion loss method of filter design with an interactive process to achieve prescribed amplitude characteristics for distributed-amplifier stages in specified circuit configurations. The relationship between this problem and the more complete one of general active network synthesis is described. Amplifiers with resistively terminated ladder-like reactive structures in the plate and grid networks are analyzed. It is shown that the number of degrees of freedom available for approximation purposes in the gain function of a distributed-amplifier stage is usually less than the number apparent in the degree of the function. For this reason, it is generally impossible to match exactly an arbitrarily specified function of the same degree if the corresponding circuit is to be physically realizable. In order to satisfy the requirements of approximation and realizability simultaneously, an interative procedure is introduced; variation of the gain function to meet each of the two requirements in turn produces a converging solution. Although no formal proof of convergence is given, the examples show that the method can give useful results after very few steps. The solutions are not unique; a number of discrete choices must be made during the design, so that a finite number of different circuits can be obtained, all in the specified configuration. Some of the available degrees of freedom are not used in the method and must be determined from other considerations. Design techniques for maximally-flat and equal-ripple types of amplitude response are considered in detail. The maximally-flat specification is most easily satisfied; methods are described for numerous special cases, including some which reduce the number of choices which must be made. Modifications applicable to multi-stage amplifiers are described. Illustrative examples are presented for two- and three-tube stages in various configurations, with greatest emphasis on the maximally-flat designs. The principle difficulty in all cases is the necessary factorization of polynomials of high degree; suggestions for simplifying this problem are included. Although the principle remains the same for more elaborate designs, the numerical computation becomes excessive for the usual desk calculator. For this particular form of active network, the iterative solution to the approximation and realization problems presents a new technique in network synthesis. (Contractor's abstract)

STA. 05:009

Stanford U. Electronics Research Lab., Calif.

EXTENDED-RANGE RADIO TRANSMISSION BY

OBLIQUE REFLECTION FROM METEORIC IONIZATION, by O. G. Villard, Jr., A. M. Peterson and others. Oct. 1, 1952, 23p. incl. illus. diagrs. tables. (Technical rept. no. 55) ([Sponsored jointly by Office of Naval Research, Signal Corps, and Air Force Office of Scientific Research] under N6onr-25107) U24483; ATI-169854 Unclassified

It has been found that radio communication between relatively low-power stations operating at 14 megacycles and separated by distances of roughly 1200 km may be maintained at times when no layer transmission to any point on the earth's surface can be demonstrated to be present. The signal obtained is subject to considerable fading, but some signal is nearly always detectable. The contribution of overlapping oblique-incidence meteor reflections to the observed signal is considered in the light of some preliminary theoretical and experimental findings. It is clearly important to assess the meteoric contribution with care, since the possibility that meteoric reflections alone could account for the signal does not seem unreasonable. Suggestions for futher investigation are given. (Contractor's abstract)

STA. 05:010

Stanford U. Electronics Research Lab., Calif.

THE POTENTIAL ANALOGY AS APPLIED TO A DRIVING POINT IMMITTANCE FUNCTION, by E. M. Goldfarb. Dec. 1, 1952, 81p. incl. illus. refs. (Technical rept. no. 56) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 3548 Unclassified

The principles and techniques of synthesizing a 1-terminal pair (which is useful in interstage and feed-back networks) are developed with the object of presenting a practical approach to the synthesis of an immittance with a magnitude that is almost constant over a specified band of frequencies. The 1-terminal pair is considered to have a constant value which may be approximated in either a Tchebycheff or Butterworth manner. The potential analogy is used to relate the magnitude and phase functions to the scalar potential and stream functions about filaments of charge. The maximum number of poles and zeros (positive and negative charges) which are needed for the accuracy of the approximation are established. They are then located so that the absolute value approximates a constant value along the pass band. When the negative charge is properly quantized, a constant k is added to the exponential of the complex function which will move the negative charges to the positive charges along odd π lines of flux. For some k k_c, the charges will be located to be analogous to the magnitude squared of a positive real immittance which is approximately constant over a band of frequencies. Graphical root locus techniques are used to locate the minimum permissible value of the constant. The ultimate limiting factors to a full realization of the driving point immittance in a physical form are the wiring and physical components. (ASTIA abstract)

STA. 05:011

Stanford U. Electronics Research Lab., Calif.

RADIO COMMUNICATION BY SCATTERING FROM METEORIC IONIZATION, by V. R. Eshleman and L. A. Manning. Dec. 1, 1952 [41]p. incl. illus. tables, refs. (Technical rept. no. 57) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force of Scientific Research] under N6onr-25107) AD 3587 Unclassified

By a consideration of the amplitude and duration of echoes forward-scattered from individual meteor ionization trails, and of the probability of detecting randomly oriented trails over an oblique radio propagation path, an estimate of the contribution of meteoric ionization to extended range HF and VHF radio transmission has been obtained. It has been concluded that meteoric ionization alone would give a virtually continuous signal for a transmission path of about 1000 km at frequencies near 15 megacycles. For the very-high frequencies, scattering from meteor trails has been found to be at least an important contributing factor to the propagation of a signal over an oblique path. A precise evaluation of the role of this process must await a better determination of the number of trails as a function of their ionization density. (Contractor's abstract)

STA. 05:012

Stanford U. Electronics Research Lab., Calif.

THE EFFECT OF RADAR WAVELENGTH ON METEOR ECHO RATE, by V. R. Eshleman. Feb. 1, 1953, 16p. incl. refs. (Technical rept. no. 59) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 3549 Unclassified

A new theory is given for the way in which the number of echoes received from sporadic meteor ionization trails varies with radar wavelength and other system parameters. Previously published explanations of the echo rate dependence on wavelength are critically examined. The present explanation of echo rate variations is based on a more complete analysis of the radio reflection process than is afforded by the Lovell-Clegg theory. A number of apparent conflicts in earlier investigations are reconciled by the new theory. (Contractor's abstract)

STA. 05:013

Stanford U. Electronics Research Lab., Calif.

THE DESIGN, PHYSICAL REALIZATION, AND TRANSIENT BEHAVIOR OF DOUBLE-TUNED AMPLIFIERS OF ARBITRARY BANDWIDTH, by M. M. McWhorter. Feb. 9, 1953, 106p. incl. illus. diagrs. tables, refs. (Technical rept. no. 58) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 4318 Unclassified

STA. 05:014 - STA. 05:017

An experimental study of new synthesis techniques resulted in a stagger-tuned, double-tuned amplifier which has a center frequency of 30 mc, an 18.2-mc bandwidth, a maximally flat gain characteristic, and a midband gain of 43.2 db. An exact low-pass to band-pass transformation was employed which permits utilization of both double-tuned interstages and staggering techniques. The design, tuning, and limitations of the physical networks to produce such an amplifier are discussed together with the measured characteristics of the experimental amplifier. The staggering technique permits cascading stages without narrowing the overall bandwidth. An amplifier was designed without staggering to obtain a comparison of staggered and nonstaggered double-tuned amplifiers. Methods of obtaining the transient response are reviewed, and the need for a simple method of obtaining the transient response is demonstrated. An analog circuit containing only single-tuned RLC and RC circuits is described. The analog has the advantages of precision and ease of tuning. The results obtained from the analog are oscillograms which show the envelope of the transient response of 2, very-wide-band, stagger-tuned, double-tuned amplifiers. The analog can also be used to measure the rejection of transient signals with carrier frequencies outside of the pass band of the analog. Results of measurements of the transient selectivity are included. (ASTIA abstract)

STA. 05:014

Stanford U. Electronics Research Lab., Calif.

IONOSPHERIC WIND ANALYSIS BY METEORIC ECHO TECHNIQUES, by L. A. Manning, A. M. Peterson, and O. G. Villard, Jr. Feb. 15, 1953 [37]p. incl. illus. table. (Technical rept. no. 60) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 3386 Unclassified

The meteoric method for finding the velocities of winds in the lower E-region is extended. The previously given procedure for finding vector-average wind is shown to be unaffected by the presence of turbulent wind components. A new procedure is worked out for finding root-mean-square values of the horizontal and vertical wind components. By looking at the statistics of reduction procedures, estimates of the accuracies of the method are found; the sources of error are discussed. Relationships between sample size and accuracy are given. Typical results of the method are presented. (Contractor's abstract)

STA. 05:015

Stanford U. Electronics Research Lab., Calif.

METEOR SCATTER: A NEWLY-DISCOVERED MEANS FOR EXTENDED RANGE COMMUNICATION IN THE 15- AND 20-METER BANDS, by O. G. Villard, Jr. and A. M. Peterson. Apr. 7, 1953 [6]p. incl. illus. (Technical rept. no. 62) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 12429 Unclassified

Also published in QST, v. 37: 11-15, 124, 126, Apr. 1953.

This article describes a newly discovered type of propagation that is always present, for which the optimum communication distance is of the order of 800 miles. It has gone undetected for many years because it is usually masked by other forms of propagation and requires first-rate for its exploitation-equipment which, however, is not at all unusual. (Contractor's abstract)

STA. 05:016

Stanford U. Electronics Research Lab., Calif.

ON THE APPROXIMATION OF ARBITRARY PHASE-FREQUENCY CHARACTERISTICS, by V. H. Grinich. May 1, 1953, 102p. incl. illus. diagrs. refs. (Technical rept. no. 61) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 12808 Unclassified

Design methods were achieved for obtaining an approximation to any given phase-vs-frequency function. The Taylor series approximation in the low-interval case is discussed for its value as a final solution to the approximation problem and as an aid in obtaining Chebyshev approximations. Darlington's approximation method (Bell System Tech. Jour., v. 31: 613-655, 1952) employing a Chebyshev polynomial series is discussed, particularly with respect to conformal transformations and the linear low-interval phase. Taylor approximations were made for an arbitrary band-interval phase and the simultaneous band-interval and phase problem. Elliptic transformations were used to apply Taylor approximation techniques to the nearly equal-ripple (Chebyshev) approximations. Examples of band-interval Chebyshev approximations are presented for the linear phase, the wide-band phase discriminator, standard and direct-approach constant-phase-difference networks, phase equalization for a coaxial cable, and the simultaneous constant attenuation-and-linear phase problem. A discussion is included of (1) the symmetric functions which occur in the Taylor approximations and (2) the expansion of an arbitrary function in a series of elliptic dn functions.

STA. 05:017

Stanford U. Electronics Research Lab., Calif.

A TRAVELING-WAVE ELECTRON DEFLECTION SYSTEM, by R. C. Honey. May 1, 1953, 58p. incl. illus. refs. (Technical rept. no. 63) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 12598 Unclassified

A detailed study is made of a slow-wave structure whose transverse electric fields may be utilized for

deflecting an electron stream. It is a special case of parallel zig-zag lines since it does not propagate a mode whose transverse electric fields are zero along the plane of symmetry. The phase velocity of such lines as a function of frequency is determined both theoretically and experimentally for a wide range of geometries. A theoretical analysis of the interaction of electrons with purely transverse fields is included which takes into account the deflection occurring within the deflection space as well as within the drift space. The results are applied to traveling-wave structures, and the electron velocities are determined which produce the maximum deflection as a function of frequency, phase velocity, and geometry of structure and drift space. A tube utilizing a zig-zag line deflection structure 9 in. long was built and its phase velocity measured from 100 to 2700 mc. The tube exhibited a maximum sensitivity of over 1 mm total deflection for an input power 20 db below 1 mw. The deflection sensitivity is discussed from several theoretical viewpoints. A matching section tapering from coaxial line to line-over-plane transmission line is described in detail. It is concluded that such zig-zag line structures, in either the form of a line over a plane or of parallel lines, show promise for use in traveling-wave deflection devices. (ASTIA abstract)

STA. 05:018

Stanford U. Electronics Research Lab., Calif.

QUASI-DISTORTIONLESS FILTER FUNCTIONS, by J. L. Stewart. May 25, 1953, 35p. incl. illus. (Technical rept. no. 64) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 12807
Unclassified

Fourier and Laplace methods are reviewed for obtaining low-pass filter functions. The first method describes the input signal as a Fourier series in which frequency components are known, and the second describes the signal as the Laplace transform of the time variable. The signal described by a time-function power series is designated as the quasi-distortionless method. Low-pass filter functions are obtained by this method which exhibit either delay or prediction. Quasi-distortionless functions of increasing complexity are listed, and a discussion is given of their network realizations. Second-, third-, and fourth-order amplitude functions are plotted for comparison with a maximally flat function. Specific networks discussed include the shunt-peaked, linear-phase, and series-peaked circuits. The general quasi-distortionless network is derived in an appendix on the basis of the central moments of pulse-like input and output functions.

STA. 05:019

Stanford U. Electronics Research Lab., Calif.

SOME PROPERTIES OF A SHEATH HELIX WITH A CENTER CONDUCTOR OR ELECTRICAL SHIELD, by G. W. C. Mathers and G. S. Kino. June 17, 1953, 34p. incl. illus. (Technical rept. no. 65) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 14909
Unclassified

This report outlines the theoretical analysis of a cylindrical helix with either an external shield or a center conductor. The current sheath model of the helix is used in the analysis. The results are presented in the form of equations and graphs which give the ratio of the square of the electric field to the power flow, (modified by appropriate normalizing factors) as a function of frequency for various ratios of the helix-to-conductor radii. The electric fields used in these graphs are the longitudinal electric field at the center of the helix and at the helix, and the radial electric field at the conductor and at the helix. In addition, the input impedance (defined on a power-current basis) for such helical transmission systems has been evaluated and plotted as a function of frequency. These results show that it is possible to obtain a wideband match from a coaxial line to a helical transmission system with a closely spaced shield or center conductor. Several simple matching techniques are briefly explained. (Contractor's summary)

STA. 05:020

Stanford U. Electronics Research Lab., Calif.

METEORIC RADIO ECHOES, by L. A. Manning. July 15, 1953, 29p. illus. diagrs. refs. (Technical rept. no. 66) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 16402
Unclassified

Also published in I. R. E. Trans. of Professional Group on Antennas and Propagation, v. AP-2: 82-90, Apr. 1954.

A summary of progress in radio meteoric detection is presented which classifies the accomplishments under the headings of astronomical properties, tools for determining properties of the atmosphere, and contributions to radio propagation. Methods of radiant determination are discussed as well as velocity measurements. Velocity measurements made by the Doppler meteor-whistle technique for thousands of meteors indicate that the meteors are members of the solar system. The need for a satisfactory technique to measure the rate of occurrence and distribution in size of meteoric particles is indicated as well as a reliable theory relating meteoric mass and ionization production to augment present information concerning the distributions of the smaller meteoric masses. Various theories are described which attempt to explain the processes in the ionization trail. An important problem remains in relation to the recombination coefficient applicable to meteoric ionization. Meteor studies of wind motion utilize body-Doppler and double-Doppler techniques. The former technique yields information concerning the radial velocity component of the wind, the speed and

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direction of the average translation of the air mass, and the rms wind speed. The results of both theory and experiment indicate that meteors should be considered as possible transmission mechanisms at frequencies above the normal layer criticals.

STA. 05:021

Stanford U. Electronics Research Lab., Calif.

THE STRENGTH OF METEORIC ECHOES FROM DENSE COLUMNS, by L. A. Manning. Aug. 1, 1953 [12]p. incl. illus. (Technical rept. no. 67) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 16401 Unclassified

Echo strengths from dense meteoric ionization columns were calculated under the assumption of a cylindrically symmetrical distribution of refractive index about the trail axis. Sufficiently large columns were assumed so that geometrical optics and ray-tracing methods are applicable. The results indicate that when refractive effects are considered, the maximum received power from a diffusion formed trail is 70% of that computed by using the critical radius method.

STA. 05:022

Stanford U. Electronics Research Lab., Calif.

COUPLED-HELIX ATTENUATORS FOR TRAVELING-WAVE TUBES, by O. G. Owens. Aug. 26, 1953, 44p. incl. illus. tables. (Technical rept. no. 68) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 18468 Unclassified

An investigation was made of the problem of constructing a coupled-helix device which would operate over a wide range of frequencies. The attenuator is intended for use with a high-power hollow-beam traveling-wave tube operating over the 70- to 300-mc range. A theoretical analysis of the problem is presented. Tests of experimental helices indicated that attenuation by such devices is possible, and that a terminated low-loss coupled helix can be made to have a broad range of attenuation. By taking into account the dielectric loading of the tube envelope, an outer helix with synchronous velocity can be designed on the basis of an equivalent unloaded inner helix. The positions of attenuation maxima and the shape of the attenuation curve can be predicted in this way with fair accuracy.

STA. 05:023

Stanford U. Electronics Research Lab., Calif.

EXPERIMENTS ON RADIATION BY FAST ELECTRON BEAMS, by H. Motz, W. [H.] Thon, and R. N. Whitehurst. [1953] [8]p. incl. illus. (Technical rept. no. 71) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 19030 Unclassified

Also published in Jour. Appl. Phys., v. 24: 826-833, July 1953.

The results of some experiments on millimeter wave and light generation by means of an undulator are described. After a brief survey of the theoretical background the design of a magnet system is discussed. An experiment is described in which a 100-mev electron beam from the Stanford linear accelerator passed through the undulator. Light radiated by the beam was observed and the plane of polarization determined. A small linear accelerator with good bunching action was used for an experiment on millimeter wave generation. At a beam energy of 3 mev, radiation in a wavelength band below 1.9 mm was observed. A peak power output of the order of one watt was obtained. Millimeter waves generated in the accelerator tube were also observed.

STA. 05:024

Stanford U. Electronics Research Lab., Calif.

THE DISTRIBUTED PAIR, by D. O. Pederson. Oct. 5, 1953, 21p. incl. diagrs. tables. (Technical rept. no. 70) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 19061 Unclassified

An analysis is presented for the distributed amplifier (distributed pair) in which the grid and plate networks are simple ladders without any node bridging. The shunt elements of the networks are restricted to a complexity no greater than parallel combinations of resistance and capacitance, and the series elements are restricted to series combinations of resistance and inductance. Design procedures include either rigorous mathematical synthesis and approximation techniques or intuitive cut-and-try methods based on an understanding of the pair. Two amplifiers were built by means of the latter method. On a gain-magnitude basis these simple amplifiers compare favorably with cascades of conventional interstages for bandwidth requirements of about 10 mc. However, the distributed pairs become more advantageous as the bandwidth requirement is increased. The pair also provides a greater available output voltage and will have a more linear input-output voltage characteristic. The frequency or transient characteristic of the pair can be modified (by simple changes in the values of the network elements) to obtain a desired characteristic with little or no change in the gain level. (ASTIA abstract)

STA. 05:025

Stanford U. Electronics Research Lab., Calif.

RESONANCE PHENOMENA IN TIME-VARYING CIRCUITS, by M. C. Herrero. Oct. 15, 1953, 97p. incl. illus. diagrs. tables, refs. (Technical rept. no. 69) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 20154 Unclassified

Also published in I. R. E. Trans. of Professional Group on Circuit Theory, v. CT-2: 35-41, Mar. 1955.

A study was made of the sweeping-filter and its applications to panoramic receivers. The latter were defined as receivers which display their responses as functions of the receiver frequency setting. The envelope of the steady-state solution of the sweeping filter was obtained directly. The method of solution utilized a system transfer function defined as the ratio of amplifier output to input as both vary exponentially with time. The case of a variable inductance in a parallel RLC filter was studied in detail. A combination of parameters small compared to unity was indicated for a quasi-steady-state solution. A comparison was made between the sweeping-filter and the gliding-tone problems in panoramic receivers of the sweeping-local-oscillator type. In the gliding-tone problem the peak of the solution for the system output decreased with increasing sweeping frequency, and instability could not occur. In the sweeping filter the peak magnitude was almost constant, and instability occurred under some conditions. Experimental results are included for a backward-wave amplifier used as a sweeping filter at 2000 mc. Analogies and differences of this case with previous cases are tabulated. Various types of parametric excitation are compared, and the resulting solutions are interpreted physically.

STA. 05:026

Stanford U. Electronics Research Lab., Calif.

THEORY OF RADIO REFLECTIONS FROM ELECTRON-ION CLOUDS, by V. R. Eshleman. Dec. 1, 1953, 37p. incl. diagrs. tables, refs. (Technical rept. no. 72) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 24168 Unclassified

Also published in I. R. E. Trans. of Professional Group on Antenna Propagation, v. AP-3: 32-39, Jan. 1955.

Approximations to the reflection coefficients of electron-ion clouds of various sizes, shapes, and densities are determined. A simplified approach to the problem is employed, wherein the total reflection from the low-density clouds is computed by summing the scattered wavelets from the individual electrons, while the high-density clouds are treated as total reflectors at the critical density radius. Some of the limitations of this method are discussed. While more elaborate determinations should be used in certain regions of cloud size and density, the method used here provides an over-all, first-order approximation of the effects of size, shape and density on the reflecting properties of electron-ion clouds. Several possible applications of the theoretical results are outlined. (Contractor's summary)

STA. 05:027

Stanford U. Electronics Research Lab., Calif.

LARGE SIGNAL THEORY OF THE TRAVELING-WAVE TUBE (INCLUDING THE EFFECTS OF LOSS, SPACE CHARGE AND FINITE "C"), by H. C. Poulter. Jan. 28, 1954, 87p. incl. diagrs. tables. (Technical rept. no. 73) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 47136 Unclassified

An extension is made of the large signal theory of Nordsieck (Proc. Inst. Radio Engineers, v. 41: 630-637, 1953) of the traveling-wave tube to include the effects of circuit loss, finite C (Pierce's gain parameter), and space charge. The effect of loss is included by considering the equivalent transmission line to be lossy. The effect of finite C is included by retaining all the terms involving C which were neglected in the small C theory, and under conditions of finite C there is an additional term which did not appear in the earlier theory. Space-charge effects are included by considering the field acting upon the electrons to consist of a circuit field and a space-charge field. The latter is evaluated by expanding the charge distribution of the beam in a Fourier series in the time domain. The electric field associated with each of the Fourier components of charge is approximated, and a weighting function is derived which relates the space-charge field at a particular electron to the distribution of charge about that electron. Equations are developed which allow for the computation of cases where the electric field is not constant across the beam, but calculations based on these equations are impractical at present. The numerical calculation procedure for thin beams is described, and results are presented in the form of graphs for thin beams for C = 0.2, d = 0.0, b = 1.5 and 2.2; d is Pierce's loss parameter, and b is defined by $v_0 = \frac{u_0}{1 + bc}$, where v_0 is the wave velocity on the helix in the absence of a beam, and u_0 is the beam velocity.

STA. 05:028

Stanford U. Electronics Research Lab., Calif.

THE INFLUENCE OF POSITIVE IONS OF ELECTRON-BEAM PROFILES, by B. H. Wadia. Jan. 28, 1954, 66p. incl. illus. diagrs. (Technical rept. no. 74) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 27028 Unclassified

The presence of residual gas within the envelope of an electron tube leads to the formation of positive ions by collision with electrons. Because of the nature of the fields in the drift space, the ions formed are in continuous motion toward the cathode and a variation of ion density in the drift space results. This distribution of positive ions determines the net negative charge effective at each point in the drift space, and hence controls the shape of the beam. This work concerns the possibility of controlling the positive-ion distribution in such a manner as to obtain a nondiverging electron beam. The loss of positive ions to the cathode may be counteracted in two ways. First, by increasing the pressure, one may obtain such a high rate of production of ions that complete neutralization is possible despite

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the losses. Alternatively, the flow of ions toward the cathode may be eliminated by interposing a positive hump of potential in their path. Both these methods of control have been known for some time, but their simple theory has not found any consistent experimental support. Consequently it is necessary to enlarge upon the simple principles and to modify them in order to obtain a full understanding of the phenomenon and to correlate theory with experiment. The results of the investigation indicate that both methods of control involve more complicated phenomena than are accounted for in the prevailing simple theory. The first method cannot be widely applied because of practical considerations, but the second, which avoids these disadvantages, should find some application. The investigation also shows that the design of the second method, called ion trapping, is only possible by a process of trial and error. Qualitative suggestions are made which can be of help in designing an acceptable trapping system. (Contractor's summary)

STA. 05:029

Stanford U. Electronics Research Lab., Calif.

STUDY OF MICROWAVE NOISE IN BEAM-TYPE DEVICES, by G. Wade. Apr. 21, 1954, 164p. incl. illus. diagrs. refs. (Technical rept. no. 75) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 32043 Unclassified

The microwave noise properties of electron beams and of certain devices which employ beams were investigated. An approach to the problem of analyzing the noise characteristics of beams is presented which accounts for the multivelocity nature of beams. The approach embodies a set of simultaneous equations whose solutions give the variations of the magnitude of the ac current and the velocity for an arbitrary number of modulated beams which are mixed at an input plane and then allowed to travel together. The multivelocity approach gave results which were in close agreement with those of the Rack approach (Bell System Tech. Jour., v. 17: 592-619, 1938). An analysis of the rectification characteristics and the noise behavior is presented for a traveling-wave tube modified for use as a video detector. The analysis indicated that such a detector would have a smaller minimum detectable signal than do crystal detectors. The noise and amplification properties were examined for a traveling-wave amplifier which employs a coupled helix structure as a slow-wave circuit. An analysis of the interaction between lightly coupled helices and an axial beam includes a derivation of the equations for the propagation constants. (ASTIA abstract)

STA. 05:030

Stanford U. Electronics Research Lab., Calif.

NEW METHODS OF DRIVING-POINT AND TRANSFER-FUNCTION SYNTHESIS, by R. H. Pantell. July 19, 1954, 101p. incl. diagrs. refs. (Technical rept. no. 76) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 35057 Unclassified

New methods are presented for accomplishing driving-point and transfer-function synthesis by means of passive, linear, bilateral elements without including coupled coils. Two new approaches to driving-point synthesis are discussed: decomposition of the even part of the impedance function and nonladder realizations. In the former, the even part of the specified function is expressed as the sum of even functions that individually satisfy the conditions for being the even part of a positive-real function. The impedance corresponding to each even function was determined and synthesized by Brune procedure (Jour. Math. and Phys., v. 10: 191-236, 1931). By decomposition of the even functions the impedances can be made to have zeros on the $j\omega$-axis and reduced to expressions that are simpler to realize than the Brune procedure. The nonladder realizations require one less reactive element per reduction cycle than the Bott-Duffin (Jour. Appl. Phys., v. 20: 816, 1949), realization requires. A new method for RLC transfer-function synthesis presents a means for realizing a minimum-phase function H(p) to within a constant multiplier provided that H(p) has no poles on the $j\omega$-axis including infinity. Synthesis is illustrated for resistance termination at input and output and for an RC termination at both ends. The synthesis problem, regardless of the complexity of H(p), can always be reduced to the problem of synthesizing driving-point functions that are no more complicated than the ratio of quadratic polynomials in p. (ASTIA abstract)

STA. 05:031

Stanford U. Electronics Research Lab., Calif.

NOISE AT THE POTENTIAL MINIUM IN THE HIGH-FREQUENCY DIODE, by D. A. Watkins. July 29, 1954 [3]p. incl. diagrs. refs. (Technical rept. no. 89) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD C8068 Unclassified

Also published in Jour. Appl. Phys., v. 26: 622-624, May 1955.

Noise quantities at the potential minimum in the high-frequency diode are analyzed by means of a relatively simple model which assumes that the transit angle from the cathode to the potential minimum is small and that the transit angle from the potential minimum to the anode is large. The mean-square convection current is found to be about half full shot noise for a typical case and the mean-square velocity is found to be the same as in the temperature-limited case. Application of this result to an analysis of the minimum obtainable noise figure of klystrons and traveling-wave tubes using velocity-jump noise reduction shows that their noise figure can be reduced without theoretical limit by increasing the current density at the cathode.

STA. 05:032

Stanford U. Electronics Research Lab., Calif.

AN INVESTIGATION OF THE ITERATIVE SYNTHESIS OF DISTRIBUTED AMPLIFIERS, by H. B. Demuth. Aug. 5, 1954, 64p. incl. diagrs. tables, refs. (Technical rept. no. 77) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 43449 Unclassified

The iterative synthesis method of Moore (Synthesis of Distributed Amplifiers for Prescribed Amplitude Response. Electronics Research Lab., Technical rept. no. 53; item no. STA. 05:008) is applied to distributed-amplifier design through the use of electronic computing equipment. The results support the feasibility of further application of the method to different types of problems, particularly those concerning networks.

STA. 05:033

Stanford U. Electronics Research Lab., Calif.

HELIX MILLIMETER-WAVE TUBE, by W. V. Christensen and D. A. Watkins. Aug. 23, 1954, (rev. Nov. 1, 1954) [4]p. incl. illus. (Technical rept. no. 82) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 61074 Unclassified

Also published in Proc. Inst. of Radio Engineers, v. 43: 93-96, Jan. 1955.

The experimental results of a program to extend helix backward-wave oscillator techniques to the 4.5- to 6.0-millimeter range are described. The design of a tube capable of cw output over this range is presented together with operating characteristics. The tube employs a tungsten helix wound with 0.002-in. by 0.005-in. tape with a 0.025-in. inner diameter. The helix voltage is tuned from 2,400 to 850 volts to cover the range, and the cathode current is 4.0 ma. The tube with its all-glass envelope is believed to be a relatively inexpensive millimeter-wave signal source. Power output is estimated to be greater than 1 milliwatt.

STA. 05:034

Stanford U. Electronics Research Lab., Calif.

JUNCTION-TRANSISTOR CIRCUITS FOR SQUARE-WAVE GENERATION, by C. Martin, Aug. 24, 1954, 47p. incl. illus. diagrs. refs. (Technical rept. no. 78) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 54848 Unclassified

This work comprises a review of junction transistor multivibrators with the aim of finding a practical frequency-controllable square-wave generator. Two circuits appear to offer the best possibilities as far as a good waveform and a good percentage of utilization of the supply voltage are concerned. Of these two circuits, the emitter-coupled multivibrator gives broader possibilities of frequency control. This circuit has been built and tested, and it operates over a range of 50 cps to 20 kc/s, the frequency being adjustable by a single control knob. An output amplitude of 15 v is obtained using a 19 v dc supply. Analysis of the different multivibrators is developed in a manner similar to that used for vacuum-tube multivibrators. The transistor is replaced by equivalent passive T networks, the element values of which are taken from the characteristic curves or from measurements at the proper operating points. (Contractor's summary)

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Stanford U. Electronics Research Lab., Calif.

BACKWARD-WAVE OSCILLATOR EFFICIENCY, by R. W. Grow. Nov. 2, 1954, 129p. incl. illus. diagrs. refs. (Technical rept. no. 80) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 48897 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 848-856, July 1955.

Backward-wave oscillators are new and interesting devices which have characteristics different from those of other microwave tubes. This report contains the results of a study conducted for the purpose of obtaining information concerning the factors which determine the oscillation level in a backward-wave oscillator and which will permit the design of an oscillator to produce a given amount of r-f power. All of the theoretical results contained in this report are based on linear theory restricted by an arbitrary specification of the degree of saturation of the device. A large-C theory of backward-wave oscillators is derived as a basis for beginning the efficiency study. It is shown that values of large C obtained to date cannot produce any additional significant differences in the operating characteristics than would be expected from small-C theory. The efficiency of backward-wave oscillators is influenced by space charge, circuit loss, beam thickness, and velocity spread and the effect of each of these factors is presented in the report in such a manner as to provide results which can be easily applied to the understanding of backward-wave oscillators and to their design. Poor terminations at the ends of the circuit of backward-wave oscillators are shown to produce sinusoidal variations in the starting current and power-output vs frequency curves. The magnitude of the variations is determined in analytic form as a function of the reflections at the ends of the tube and the circuit loss. An additional forward-wave mode existing simultaneously with the backward-wave mode of an oscillator is shown to produce no effect with perfect matches even when both modes have identical spacial variations. It is possible that the combination of two modes and imperfect matches will affect the operating characteristics. (Contractor's summary)

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Stanford U. Electronics Research Lab., Calif.

ON THE THEORY OF JUNCTION TRANSISTORS, by R. D. Middlebrook. Dec. 16, 1954, 132p. incl. diagrs. tables, refs. (Technical rept. no. 79) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 50323 Unclassified

The theory is prefaced by a qualitative discussion of solid-state physics and crystal structure. A general qualitative development is given of the p-n-p junction transistor by way of the p-n junction rectifier and a brief discussion of crystal structure. A more detailed treatment of crystal structure is followed by the idea of energy bands which leads to the distinction between insulators, conductors, and semiconductors. Definitions are given of the Fermi level and of an intrinsic semiconductor. Equations are obtained for carrier densities in intrinsic and in impurity semiconductors, and the modification of the Fermi levels because of injected carriers is discussed. A qualitative discussion of the energy diagram is followed by a discussion of the p-n junction under applied forward dc potential. A solution is given of the continuity equation for minority carriers which leads to the rectifier characteristic of the p-n junction. The equations for carrier currents are obtained for a p-n junction under applied reverse potential. The continuity equation is solved for minority carriers in the base region, and this leads to an explanation of the power gain of a transistor. Emitter and collector minority currents are discussed, and an LF equivalent circuit is set up. The qualitative effects of feedback and capacitance in the transistor are summarized.

STA. 05:037

Stanford U. Electronics Research Lab., Calif.

A FLIP-FLOP CIRCUIT BASED ON FREQUENCY MEMORY, by H. C. Lee. Jan. 30, 1955, 42p. incl. diagrs. (Technical rept. no. 81) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 56611 Unclassified

The present report is intended to introduce the idea of counting in multi-mode oscillatory systems by use of a beat-frequency technique. To demonstrate this idea, a binary counting system which employs a balanced frequency mixer to switch from one frequency to the other is studied. The analysis is based on a bistable oscillator with two degrees of freedom, forced with an external signal. The corresponding behavior is described by a simultaneous pair of second-order nonlinear differential equations for which no general solution is known. Graphical solutions for different values of the external voltage have been obtained with the aid of the IBM computer. Conditions for switching are analyzed and discussed. It is found that for satisfactory switching it is necessary that the external voltage must exceed a certain critical value. An experimental system which has the property of a binary counter is described. The experimental results confirm the prediction of the analysis. To extend this idea, a ten-frequency decimal counter based on beat-frequency techniques is discussed. Finally, a new technique for frequency switching based on a single variable impedance is introduced and studied in terms of the behavior of the roots in the complex frequency plane. (Contractor's summary)

STA. 05:038

Stanford U. Electronics Research Lab., Calif.

NORMAL MODE THEORY IN PERTURBED TRANSMISSION SYSTEMS, by G. S. Kino. May 2, 1955, 229p. incl. diagrs. refs. (Technical rept. no. 84) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 63628 Unclassified

The reciprocity theorem is used to derive the orthogonality properties of the modes of transmission systems that are either uniform or periodic in the Z direction. Certain of the conditions are valid for modes that are not pure TE or TM, even when there is loss present, and there are several conductors passing through the cross section. It is also shown that, in a lossless system, the propagation constants of the modes (or fundamental space harmonics) are pure real or pure imaginary and the corresponding power flows are pure imaginary or pure real. The perturbation of the modes of a uniform or periodic system by change in permittivity, permeability or the current at some point, is considered by making use of normal mode expansions derived from the orthogonality conditions. It is shown that the expansion derived by Pierce for pure TM modes is valid for the non-θ-varying modes of a general circular system. A combination of Birdsall's impedance matching method and the normal mode expansion is used to derive $E^2/_{\beta}{}^2P$ at any point of a uniform transmission system. The change in the propagation constant caused by the insertion of a dielectric rod or uniform conductor into a transmission system is also calculated, and it is shown how $E^2/_{\beta}{}^2P$ may be determined from measurement of this effect. Pierce's factors C and Q for a hollow electron beam inside a sheath helix are derived from the normal mode or expansion and by a method known to be accurate; good agreement is obtained between the results. Fletcher's derivation of these parameters is discussed, and it is shown that some of the assumptions made are not valid, so that values of Q obtained are too low. The normal mode method is used to estimate QC^3 for a sheath helix or tape surrounded by dielectric. It is demonstrated that the correct value of $E^2/_{\beta}{}^2P$ has been applied in the past to periodic systems but the value of QC^3 in the presence of dielectric is somewhat lower than for the system with no dielectric. The completeness and convergence of the expansions for a sheath helix are checked by comparing with direct derivations of identical expansions from the field theory of Mittag-Leffler's method. In all important cases the expansions are convergent but are complete for the shielded helix, only when certain fast and cut-off modes that do not appear in the unshielded helix system are taken into account. These

modes form a continuum in Γ in the so-called forbidden region of the unshielded sheath helix and may be included in the normal mode expansion in the form of an integral Such an integral is shown be valid for a simple parallel plate transmission system when one plate is removed to infinity. (Contractor's summary)

STA. 05:039

Stanford U. Electronics Research Lab., Calif.

A JUNCTION-TRANSISTOR HIGH-FREQUENCY EQUIVALENT CIRCUIT, by R. D. Middlebrook. May 2, 1955, 231p. incl. illus. diagrs. tables. (Technical rept. no. 83) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 65767 Unclassified

A new junction transistor equivalent circuit, derived from theoretical principles and valid up to and beyond the alpha cut-off frequency, is presented. Two main results are achieved: first, it is shown how the behavior of a practical transistor depends on the geometry and physical properties of the transistor materials (of use to transistor designers); second, it is shown how the element values in the practical equivalent circuit may be determined numerically from six measurements made on a completed transistor (of use to circuit designers). The final equivalent circuit takes into account collector space-charge capacitance, collector space-charge-layer widening, and base resistance, and is in the form of four short-circuit admittances. Each admittance can be represented by a network of lumped elements each of which is constant with frequency. The results are obtained for the ground-base connection, but are easily modified for grounded-emitter or grounded-collector configurations. Experimental verification of the practical equivalent circuit is presented for fifteen commercial transistors of various makes and types, and it is concluded that the theoretical results obtained are substantiated both qualitatively and quantitatively. (Contractor's summary)

STA. 05:040

Stanford U. Electronics Research Lab., Calif.

ITERATIVE METHODS IN AMPLIFIER INTERSTAGE SYNTHESIS, by G. A. Caryotakis. May 2, 1955, 95p. incl. diagrs. refs. (Technical rept. no. 86) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 65768 Unclassified

A discussion is given of the design of low-pass video amplifiers for specified amplitude or phase response. This is accomplished by stagger tuning similar to that used for narrow-band amplifiers except that the problem is complicated by the presence of finite zeros in the amplifier gain function. The method used is an iterative process by means of which the elements in the predetermined amplifier configuration can be adjusted so that the gain function may approximate the desired response. The designs obtained by this method exhibit a marked increase in gain-bandwidth product over the all-pole designs. The iterative method can be applied to synthesis for prescribed phase as well as amplitude response.

STA. 05:041

Stanford U. [Electronics Research Lab.] Calif.

SOME PROPERTIES OF OBLIQUE RADIO REFLECTIONS FROM METEOR IONIZATION TRAILS, by O. G. Villard, Jr., A. M. Peterson and others. May 31, 1955, 33p. incl. diagrs. tables. (Technical rept. no. 85) (In cooperation with Stanford U. Radio Propagation Lab.) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 68059 Unclassified

Also published in Jour. Geophysical Res., v. 61: 233-247, June 1956.

Certain characteristics of radio signals propagated by reflection from meteor ionization trails from a low-power continuous-wave transmitter 960-km distant are studied at radio frequencies of 23.2, 46.4, and 92.8 megacycles. In particular, the percent of the total time that meteor reflections were detectable at each frequency is presented, and shown to be in qualitative agreement with theoretical expectations. Simultaneous recordings were also made of signals from a second remote transmitter operated at 23.1, 46.2 and 92.4 megacycles, and located at variable distances up to 180 km from the first. Based on the percent time signals received from the second transmitter were coincident with those from the first, it is concluded that reradiation from the numerous, low density trails is highly directional, and that the fading, long-enduring echoes from the relatively-infrequent, high-density trails are considerably less directional. When the transmitters were spaced in a direction perpendicular to the propagation path, the signal coincidence decreased much more rapidly with transmitter spacing than when the transmitters were spaced along the propagation path. (Contractor's summary)

STA. 05:042

Stanford U. Electronics Research Lab., Calif.

ON THE STATISTICAL DESIGN OF DEMODULATION SYSTEMS FOR SIGNALS IN ADDITIVE NOISE, by J. B. Thomas. Aug. 1, 1955, 140p. incl. diagrs. refs. (Technical rept. no. 88) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 68067 Unclassified

Demodulation system to recover message signals corrupted by additive noise are discussed with the assumption that the amplitudes of the message and the noise have Gaussian probability distributions. The maximized posterior probability density function of the

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message is given by 2 integral equations which contain as known functions the autocorrelation functions of the message and of the noise and the functional form of the modulated wave. Solutions of these equations result in receivers which are optimum on a maximum likehood basis. For the assumed Gaussian statistics, this is equivalent to being optimum on a minimum mean-square-error basis. The analysis shown that for the case of simple filtering, the optimum filter is Wiener's minimum mean-square-error filter. In the AM case the optimum receiver is a cross-correlation detector followed by a form of the Wiener filter. A more appropriate criterion than that of the mean-square error for high noise level reception is the loss of correlation between the message part of the input and the output of various AM receivers. Specification of the optimum AM receiver requires a knowledge of message and noise power spectra and of carrier amplitude and phase. The error introduced when the carrier phase and magnitude are unknown is given, and the optimum receiver is shown to be relatively insensitive to such errors. Within the limits of certain approximations, the optimum PM receiver is a lock-oscillator type of detector. (ASTIA abstract)

STA. 05:043

Stanford U. [Electronics Research Lab.] Calif.

RADIO COMMUNICATION AND SCATTER PROPAGATION, by J. D. Mitchell, Jr. Aug. 15, 1955, 49p. incl. illus. diagrs. (Technical rept. no. 87) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 68060 Unclassified

This report discusses the communication capabilities of ground-scattered propagation. It is shown that radio communication may be practical using frequencies several megacycles higher than the conventional great-circle-path maximum usable frequency (MUF). To make use of ground-scattering it will be necessary that transmitting and receiving antennas be directed towards distant scattering areas on the earth's surface which can be commonly illuminated rather than along the great-circle-path between stations. A number of experiments which demonstrate the characteristics of ground scattered propagation are discussed. The scatter-path MUF is calculated and compared with the conventional great-circle-path MUF for a number of different transmission path lengths and orientations. Possible limitations of ground scatter communications are outlined and recommendations are made for further study of this propagation mode. (Contractor's summary)

STA. 05:044

Stanford U. Electronics Research Lab., Calif.

PRINCIPLES AND CONCEPTS OF RELIABILITY FOR ELECTRONIC EQUIPMENT AND SYSTEMS. PART I. INTRODUCTION TO ELECTRONIC RELIABILITY, by W. F. Luebbert. Aug. 18, 1955, 62p. incl. diagrs. tables, refs. (Technical rept. no. 90) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 73482 Unclassified

General concepts, principles, and mathematical techniques are to be presented for the analysis of reliability in electronic equipment. Electronic reliability is pointed out as one of a number of important aspects of the broad general problem of achieving most efficient and effective performance from electronic equipment. A rationale for the development of reliable systems is developed and presented in the form of a system development check-list. A discussion is given on the term reliability and some of the meaning that might be given to it. A few of the figures-of-merit are discussed which can be used to measure the basic property akin to dependability, trustworthiness, and failure resistance. A brief, simplified introduction is given to life curves of reliability vs time description. The initial discussion is qualitative; various simple patterns of failure are introduced and described with emphasis being given to the degree of randomness in time of occurrence, to variation with time of the instantaneous hazard of failure to an individual, and to presentation, when applicable, of a simple mechanism of failure which might lead to such a pattern of failure. An analogy between equipment life patterns and human mortality is demonstrated and explained. This analogy leads to an approach which indicates that differential (or integral) equations of probability such as are used in queueing (waiting line) theory, renewal theory, and even in Gompertz-Makenham actuarial mathematics may be useful in reliability problems.

STA. 05:045

Stanford U. Electronics Research Lab., Calif.

PRINCIPLES AND CONCEPTS OF RELIABILITY FOR ELECTRONIC EQUIPMENT AND SYSTEMS. PART II. SIMPLE MODELS FOR FAILURE OF COMPLEX EQUIPMENT, by W. F. Luebbert. Aug. 18, 1955, 62p. incl. illus. diagrs. tables, refs. (Technical rept. no. 91) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 73483 Unclassified

Further analysis was conducted on simple models for the failure of complex systems. Basically, 2 types of systems are considered: (1) cascade systems, in which the failure of any essential element of the system causes failure of the system; and (2) parallel redundant systems, in which there is duplication of essential elements, so that the system remains successful as long as any of the elements remain successful. Most practical equipment systems can be broken down into combinations of these basic types. The models considered assume either complete success or complete failure of function, and hence are drastic simplifications of reality; yet, when applied realistically, with due attention to their limitations and capabilities, they are considered quite useful. (See also item no. STA. 05:044)

STA. 05:046

Stanford U. Electronics Research Lab., Calif.

THE VARIABILITY OF SOME CHARACTERISTICS OF A GROUP OF FUSED-JUNCTION TRANSISTORS, by G. H. Scithers. Sept. 16, 1955, 30p. incl. diagrs. tables. (Technical rept. no. 92) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 72662 Unclassified

An investigation of certain of the physical characteristics of transistors, derived from measurements of a group of 100 fused-junction transistors, is made for the purpose of determining the empirical relations that exist among them. Significant departure from the theoretical relations derived for the one-dimensional transistor is discovered. An approximate relation based on the measurements of the group of transistors is presented, together with some discussion of the possible reason for the discrepancy between the theoretical and empirical relations. In addition, it is shown that for this group of transistors, the low-frequency circuit parameters may be expressed as functions of but two basic physical quantities. (Contractor's summary)

STA. 05:047

Stanford U. [Electronics Research Lab.] Calif.

REGULARLY OBSERVABLE ASPECT-SENSITIVE RADIO REFLECTIONS FROM IONIZATION ALIGNED WITH THE EARTH'S MAGNETIC FIELD AND LOCATED WITHIN THE IONOSPHERIC LAYERS AT MIDDLE LATITUDE, by A. M. Peterson, O. G. Villard, Jr. and others. Sept. 30, 1955, 25p. incl. illus. diagrs. table, refs. (Technical rept. no. 93) (In cooperation with Stanford U., Radio Propagation Lab. under Office of Ordnance Research, DA 04-200-ORD-181) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 74945 Unclassified

Aspect-sensitive radio reflections in the frequency range from 6 to 30 mc have been regularly obtained from scattering sources located within the ionosphere at locations quite far south of the auroral zone. Observations have been made at two locations on the West Coast of the United States (Stanford, Calif., geomagnetic latitude 43.75°, and Spokane, Wash., geomagnetic latitude 55°). With few exceptions, the echoes occur when the line of sight from the transmitter intersects a magnetic field line at perpendicular incidence at heights corresponding to those of the E- and F-layers. Thus the E-layer echoes are obtained from areas in the immediate vicinity of the observing stations. The echoes may be detected with relatively low-power radars during the majority of the hours of darkness on almost every night. The reflection geometry and the characteristics of the echoes themselves — occurrence frequency, fading rate, etc., — all suggest that the observed low-latitude phenomenon is caused by the same general type of particle bombardment which is believed to cause the aurora. (Contractor's summary)

STA. 05:048

Stanford U. Electronics Research Lab., Calif.

SYNTHESIS OF MULTITERMINAL TWO-ELEMENT-KIND NETWORKS, by F. S. Boxall. Nov. 1, 1955, 122p. incl. diagrs. (Technical rept. no. 95) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 76262 Unclassified

A method is given by which all the realizations of a given immittance matrix may be obtained by a sequence of elementary transformations on an initial realization which is usually nonphysical. The labor involved in passing from one realization to another is small, and the designer is guided at each step of the transformation by the form of the current realization. A useful by-product of the method is the generation of equivalent networks. Since any terminal-pair voltage can be expressed as the difference of 2 terminal-to-ground voltages and since any terminal pair current can be expressed as 2 equal and opposite terminal-to-ground currents, the synthesis procedure can be applied to terminal-pair networks. The theoretical development and examples are phrased in terms of RC networks, but the results are valid for RL and LC networks after a simple change of variable. (ASTIA abstract)

STA. 05:049

Stanford U. [Electronics Research Lab.] Calif.

THEORY AND APPLICATION OF UNIFORM ELECTROSTATIC FOCUSING OF HOLLOW ELECTRON BEAMS, by C. B. Crumly. Nov. 1, 1955, 78p. incl. illus. diagrs. refs. (Technical rept. no. 457-1) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107 and DA 36-039-sc-63189) AD 79834 Unclassified

A method of focusing hollow electron beams is investigated which eliminates the need for a magnetic field. The method uses a radial electric field to counterbalance the space-charge divergence forces in axially symmetric, spinning hollow beam. The analysis shows that the nonuniform-charge-density distribution requirement is not critical for beams that are not thick. An experimental traveling-wave amplifier tube, operating in the UHF region, was designed and built, and the results confirmed the practicality of this focusing method.

STA. 05:050

Stanford U. Electronics Research Lab., Calif.

THE DESIGN OF STAGGER-TUNED DOUBLE-TUNED AMPLIFIERS FOR ARBITRARILY LARGE BANDWIDTH, by M. M. McWhorter and J. M. Pettit. Nov. 30, 1955 [9]p. incl. diagrs. (Technical rept. no. 96) (Sponsored jointly by Office of Naval Research, Signal

STA. 05:051 - STA. 05:053

Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 79928 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 923-931, Aug. 1955.

Double-tuned amplifier stages have a greater gain-bandwidth factor than single-tuned stages, and by stagger tuning the double-tuned stages the gain-bandwidth factor is better preserved as stages are cascaded than if identical stages were used. This paper presents the results of a study which has yielded accurate design curves for the wide-band case permitting straightforward synthesis of maximally-flat staggered pairs and triples. The theory leading to the design curves is described in the Appendix. (Contractor's summary)

STA. 05:051

Stanford U. Electronics Research Lab., Calif.

THE SINGLE-LAYER SOLENOID AS AN RF TRANSFORMER, by W. A. Edson. Nov. 30, 1955 [5]p. incl. diagrs. (Technical rept. no. 97) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 79929 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 932-936, Aug. 1955

A set of curves is presented which makes it relatively easy to design air-core transformers satisfying a majority of engineering needs. Inductances in the range 0.1 μh to mh, coupling coefficients in the range 0.001 to 1.0, and inductance ratios up to 100:1 are covered directly. Certain arbitrary restrictions are placed upon the proportions in order to obtain a single set of charts, but the available electrical characteristics are not limited thereby. The proportions of the resulting coils are compatible with large values of Q, but this is seldom important because heavy damping must usually be provided by associated resistors. The derivation and use of the curves is explained. (Contractor's summary)

STA. 05:052

Stanford U. [Electronics Research Lab.] Calif.

RADIO ECHOES FROM AURORAL IONIZATION DETECTED AT RELATIVELY LOW GEOMAGNETIC LATITUDES, by R. L. Leadabrand. Dec. 9, 1955, 191p. incl. illus. diagrs. refs. (Technical rept. no. 98) (In cooperation with Stanford U., Radio Propagation Lab. under Office of Ordnance Research, DA 04-200-ORD-181) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 82494 Unclassified

Radio echoes were discovered which are the result of reflection from ionization aligned with the earth's magnetic field lines. The echoes between 1400 and 4700 km correspond to reflection from ionization in the zone of maximum auroral occurrence north of Stanford. Ionization formation is attributed to the bombardment of the upper atmosphere by high-speed charged particles emitted from the sun. The echoes have great amplitudes with duration times between 1 sec and 1 hr. Their appearance and disappearance is similar to the behavior of visual aurorae; the occurrence of the echoes is related to geomagnetic disturbances. The heights of deflection are between 300 and 1200 km above the earth's surface. The paths which the auroral signals travel are greatly influenced by the presence of the normal ionospheric layers. The echoes were observed at ranges and bearings which indicate reflection from ionization at points along the auroral zone from eastern Canada to Alaska. The echoes at ranges between 220 and 1800 km correspond to reflection at points where a straight-line path from Stanford intersects the earth's magnetic field lines at perpendicular incidence. The low-latitude auroral effect appears regularly and can be detected at Stanford almost nightly. Frequently, the echoes last throughout the night. The occurrence of the low-latitude auroral echoes has little correlation with geomagnetic disturbances. The heights of reflection are restricted within the E and F layers of the ionosphere. The E-region echoes are associated with the formation of sporadic E ionization. The F-region echoes are related to spread F and F-layer irregularity appearing on the vertical-incidence sounding records.

STA. 05:053

Stanford U. Electronics Research Lab., Calif.

COMMON-BASE TRANSISTOR EQUIVALENT CIRCUITS FOR WIDEBAND AMPLIFICATIONS, by J. M. Mathias. Dec. 12, 1955, 45p. incl. diagrs. (Technical rept. no. 94) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 79930 Unclassified

The problem of choosing a transistor equivalent circuit of practical usefulness for wideband, low-pass (video) amplifiers is studied experimentally. Measurements of amplitude and phase response up to and beyond a cutoff are made on a single transistor in the grounded-base, resistance-loaded configuration. The calculated responses of several equivalent circuits of varying complexities are compared with the actual measured response. A simple T circuit, having collector capacitance and a single pole expression for α as frequency dependent elements, is found to fit the measurements as well as some of the more complicated forms. Approximate formulas are then found, which enable the cutoff frequency of such an amplifier to be calculated for all values of source and load resistance. An instrument was developed to measure accurately the phase response of the transistor amplifier. This resulted in a device, with high input impedance, that could measure the relative phase shift between a reference signal and the low-[illegible] collector signal at frequencies from the audio r[illegible]p to 10 mc. (Contractor's summary)

STA. 05:054

Stanford U. Electronics Research Lab., Calif.

COUPLED HELICES FOR USE IN TRAVELING-WAVE TUBES, by G. Wade and N. Rynn. Dec. 20, 1955 [10]p. incl. diagrs. refs. (Technical rept. no. 99) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 81064 Unclassified

Also published in I. R. E. Trans. of Professional Group on Electron Devices, v. ED-2: 15-24, July 1955.

Previous theoretical treatments concerning coupled helices in the absence of a beam, while useful for predicting approximate behavior, are not satisfactory for many tube applications because the presence of a beam can substantially modify the behavior. This paper presents a theory of propagation for coupled concentric helices in the presence of a coaxial beam and computes therefrom properties pertaining to coupler and attenuator applications. Included are curves of the propagation constants as functions of coupling coefficient and beam velocity, curves of the inner and outer helix voltages as functions of the physical dimensions, and curves which permit the frequency response for various designs of input and output couplers to be calculated. Sample calculations show that the proper length for input and output couplers is greater than the length for complete energy transfer between helices in the absence of the beam (a criterion commonly used in design work). Calculations also illustrate the related fact that the frequency for maximum transmission through a coupler is lower when the beam is turned on than when off. Only preliminary work has been done to date in computing the properties of a coupled-helix attenuator. (Contractor's summary)

STA. 05:055

Stanford U. [Electronics Research Lab.] Calif.

THE ROLE OF METEORS IN EXTENDED-RANGE VHF PROPAGATION, by O. G. Villar, Jr., V. R. Eshleman and others. Dec. 20, 1955 [9]p. incl. diagrs. refs. (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] as Technical rept. no. 100 under N6onr-25107, and Air Force Cambridge Research Center as Scientific rept. no. 3 - AFCRC-TN-55-399, AD 88666 under AF 19(604)1031) AD 81457 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 43: 1473-1481, Oct. 1955.

The main factors influencing the propagation of continuous radio signals by reflection from meteoric ionization trails are reviewed and summarized. A procedure is given for calculating the system parameters required to maintain the signal received over a given path above the cosmic background noise level for 95% of the time. It is pointed out that the variation of signal level with frequency and path length measured for certain "ionospheric forward scatter" circuits, agrees well with calculations based on the assumption that the propagation is entirely by scattering from meteor ion trails. It is suggested that ionospheric scatter is predominantly meteoric at night in the lower latitudes. To the extent that this is true, the minimum performance level of existing circuits could be improved by use of antennas designed to maximize the meteoric component of the signal. Present designs actually tend to discriminate against meteors. (Contractor's summary)

STA. 05:056

Stanford U. Electronics Research Lab., Calif.

A MEAN-SQUARE ERROR ANALYSIS OF SEVERAL DEMODULATION SYSTEMS, by B. F. Ludovici. Jan. 31, 1956, 50p. incl. diagrs. (Technical rept. no. 101) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 85618 Unclassified

Four different methods of extracting the intelligence from amplitude-modulated carrier in the presence of noise are analyzed on a mean-square error basis. Assumed is band-limited white Gaussian noise and a noise-like modulating intelligence of uniform power spectrum ranging from d-c to an upper limiting frequency equal to two-thirds of the carrier frequency. Included in the analysis are the square-law, autocorrelation, two-amplifier and crosscorrelation demodulators. As an important result, this investigation shows that the autocorrelation demodulator offers no significant improvement over the simple square-law demodulator. Improvements of approximately 3 db and 6 db can be expected from the two-amplifier and crosscorrelation demodulators, respectively. The results agree essentially with those of the other authors who carried out similar analyses on a signal-to-noise ratio basis. (Contractor's summary)

STA. 05:057

Stanford U. Electronics Research Lab., Calif.

INVESTIGATION OF A TRAVELING-WAVE TUBE WITH INTERCHANGEABLE EXTERNAL SLOW-WAVE STRUCTURES, by A. R. Matthews. Feb. 7, 1956, 158p. incl. illus. diagrs. refs. (Technical rept. no. 102) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 85155 Unclassified

An investigation was conducted on a TWT using an external slow-wave structure consisting of lumped circuit elements connected as conventional filters. The tube for maximum beam coupling is discussed along with the practical considerations for the use of lumped-circuit elements as the slow-wave structure. Electron beam focusing by means of a uniform magnetic field and by periodic electrostatic focusing voltages is briefly examined theoretically and verified experimentally. Cold tests were conducted on the m-derived low-pass

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filter. Determinations were made of the characteristic impedance, phase shift, attenuation, cutoff frequency, phase and group velocity, and the effective magnitude of circuit elements. An extension was made on the circuit characteristics of the filter for TWT space-harmonic operation. Derivations are presented for the Brillouin diagram, space-harmonic phase and group velocities, space-harmonic voltage-tuning curves, impedance parameter K, and gain parameter C. Results indicated that the external filter slow-wave structure can be developed for a practical tube having the desirable features of small size and voltage tuning in the VHF and UHF range. Periodic electrostatic focusing is demonstrated for backward-wave oscillator operation; it offers further advantages, particularly if large beam currents can be electrostatically focused. The tube is a convenient device for instructional purposes and for further theoretical investigation of such factors as the effects of a large gain parameter. The versatility of changing slow-wave structures while using the identical electron beam is unique to this tube.

STA. 05:058

Stanford U. [Electronics Research Lab.] Calif.

SOME NEW HIGH-FREQUENCY EQUIVALENT CIRCUITS FOR JUNCTION TRANSISTORS, by R. M. Scarlett. Mar. 20, 1956, 188p. incl. illus. tables. (Technical rept. no. 103) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 91300 Unclassified

A description is given of the physical processes in an idealized 1-dimensional junction transistor, leading to the fundamental equation for minority carrier motion and its appropriate boundary conditions. The small-signal solution to this equation was stated in the form of 4 short-circuit admittance (or y-) parameters. Rational function approximations are developed for the theoretical short-circuit admittance parameters. An actual transistor is assumed to be composed of the intrinsic transistor in combination with the collector space charge layer capacitance and base spreading resistance. On this basis, a derivation was undertaken, on a reasonably simple and approximate basis of small-signal equivalent circuits and 4-pole parameters representing junction transistor common-emitter and common-collector configurations. Results are presented on the development of methods for the measurement of the small-signal HF properties of junction transistors. A number of fundamental properties involving maximum single-frequency gain and potential instability were obtained for the 3 transistor configurations. Design theory for band-pass and low-pass amplifiers were presented. Discussions are appended on the electric circuit analogy for minority carrier flow in the base region, the effects of surface recombination, and the comparison of y-parameters with those given in a previous report, item no. STA. 05:039. (ASTIA abstract)

STA. 05:059

Stanford U. [Electronics Research Lab.] Calif.

ANALYSIS OF COUPLED-STRUCTURE TRAVELING-WAVE TUBES, by N. Rynn. May 7, 1956, 167p. incl. illus. diagrs. refs. (Technical rept. no. 104) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 94037 Unclassified

An analytical procedure was developed for predicting the effect of the electron beam on the coupling between the distributed circuit of a traveling-wave tube and a second transmission system placed adjacent to it and outside the vacuum envelope. Emphasis is placed on the design of couplers and attenuators for traveling-wave tubes. A theory is reviewed which includes the effect of the beam. The theory is applied to predicting the active characteristics of the couplers and one type of attenuator. The theory is extended to include loss in the coupled structure and space-charge in the beam. The coupled-mode theory is summarized and extended to the coupled-structure traveling-wave tube. A root equation is derived, the 4 complex roots of which are plotted as functions of the beam velocity parameter for many combinations of coupling, loss, space-charge, and velocity parameters. The operation of a commercial traveling-wave tube with a coupled-helix attenuator under beam-saturation conditions is determined experimentally. A comparison is made of the saturation properties of 2 different coupled-helix attenuations and a lossy-wall attenuator. Curves are presented which show that a small diameter, tightly coupled helix attenuator has more effect on the electron beam than the equivalent lossy-wall attenuator. An outline is given of the procedure to calculate the passive properties of coupled structures.

STA. 05:060

Stanford U. [Electronics Research Lab.] Calif.

AMPLIFIERS EMPLOYING POTENTIALLY UNSTABLE ELEMENTS, by G. S. Bahra. May 7, 1956, 100p. incl. diagrs. tables, refs. (Technical rept. no. 105) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 95920 Unclassified

The tendency toward oscillation which is caused by internal feedback in practical amplifying devices was studied along with the conditions under which this internal feedback may cause the device to oscillate. Studies were also made to establish the maximum gain that may be obtained from a device with circuit conditions that provide freedom from oscillation. Several types of amplifier situations employing various representative types of tubes and transistors are considered. By means of the Nyquist diagram, F(p), the characteristic function, for each of these stages is explored. The extent to which any set of termination provides freedom oscillation is indicated by a stability margin. The use of external feedback or neutralization circuits was not considered. Solutions for a wide range of representative

situations were obtained by means of an electronic computer. Design charts were prepared from the resulting data. Based on the admittances measured for 3 representative junction transistors, several amplifier stage designs were completed. These designs indicate that the gain obtained when stability is insured through control of the terminating admittances is comparable with the gain delivered by the same units in neutralized circuits. The measured gain for an actual amplifier was within 0.8 db of the design value. When the original transistor was replaced by various unselected units of the same type, the amplifier remained stable and exhibited gain variations of not greater than 2 db.

STA. 05:061

Stanford U. [Electronics Research Lab.] Calif.

THE DESIGN OF ALIGNABLE TRANSISTOR AMPLIFIERS, by J. F. Gibbons. May 7, 1956, 83p. incl. diagrs. (Technical rept. no. 106) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107) AD 94554 Unclassified

A method is presented for designing easily alignable multistage transistor amplifiers when the individual stages are not unilateral. The method consists in first describing the transistor through measurement of its Y parameters at a set of discrete frequencies in the desired amplifier passband. This definition of the device is then used to determine its maximum available gain vs frequency properties, thus providing a criterion of amplifier performance. The sensitivity of the transistor's input admittance variations is mathematically defined and given the symbol δ. This definition is used as a criterion of alignability and as a measure of the feasibility of partially or wholly neutralizing the transistor in any given application. Power gain formulas are developed in terms of δ and the measured transistor parameters. Specification of the desired power gain and sensitivity at each frequency then serves to determine the frequency behavior appropriate for the amplifier load and coupling networks. Synthesis of these networks completes the amplifier design. Several video amplifier designs are given in the text to illustrate the design procedures. Measurement of the characteristics of these amplifiers provides experimental verification of the theory. (Contractor's summary)

STA. 05:062

Stanford U. [Electronics Research Lab.] Calif.

ANALYSIS OF A NEW TYPE OF RADIO SCATTERING FROM THE IONOSPHERIC E-REGION, by P. G. Gallagher. May 7, 1956, 145p. incl. illus. diagrs. tables, refs. (Technical rept. no. 107) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107; continued by Nonr-22524) AD 95546 Unclassified

A discussion is presented on direct scattering originating in the ionospheric E-region. An attempt was made to deduce the nature of the scattering region and its relation to known properties of the ionosphere from the characteristics of the scatter echo. Special importance is attached to the fading characteristics and the typical geometrical shape of the radar echo in developing a physical model of the scatter region. Various proposals are made to account for the scattering effect, and each is analyzed theoretically. The recurrent behavior of the new scatter echo suggests that field-aligned ionization in the ionospheric E-region should be considered a part of normal ionospheric behavior. The origin of the field-aligned scatter forms can be attributed to a hydrodynamic rearrangement of ionization existing in the affected (E-layer) region, rather than to ionization by high-energy charges originating external to the affected region. A close association exists with sporadic-E but not with geomagnetic, meteoric, auroral or various solar events. The data lead to the hypothesis that in most cases sporadic-E and the new radio scattering are different manifestations of a common phenomenon; both manifestations can be observed simultaneously under a specified (but not unusual) set of conditions. The ultimate source of ionization for the new scattering cannot be determined as yet.

STA. 06:001

Stanford U. Stanford Electronics Labs., Calif.

ANALYSIS OF EXTERNAL CIRCUIT TRAVELING-WAVE TUBES, by C.-T. Sah. June 1, 1956, 141p. incl. diagrs. refs. (Technical rept. no. 1) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524; continuation of N6onr-25107) AD 100249 Unclassified

A theoretical investigation is presented of traveling-wave tubes using external slow-wave circuits of either the lumped elements or a combination of the lumped and the distribution elements. A review is given of several known methods for solving the traveling-wave-tube problem. An exact field analysis by using Maxwell's equation can give useful information only for the simplest geometries and only after making some approximations to the solutions. The best method of solution is that of the normal-mode expansion which provides accurate results in normalized forms for any slightly perturbed transmission system. An approximate method for a planar model which uses the concept of an equivalent current generator is discussed which takes into consideration all the space harmonics and gives relatively simple expressions for the solution of the problem; results cannot be reduced to a simple normalized form for application to a general transmission system with large perturbations. For small perturbations, the results give the same normalized results as those given by the normal-mode expansion method. Electronic equations are obtained for the gridless gaps by Fourier analysis of the space harmonic field. The cases are considered for interaction in the longitudinal and the transverse interaction structures. The electronic equations are obtained for uniformly

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periodic transverse and longitudinal interaction gaps with grids. The circuit relations of a filter circuit are revised. The electronic and circuit equations are combined for the 2 types of interaction gaps. The characteristics of the slow-wave circuits are compared to illustrate the best circuits for certain types of operation such as forward-wave amplification or backward-wave oscillation.

STA. 06:002

Stanford U. Stanford Electronics Labs., Calif.

COCCI INSERTION LOSS DESIGN OF ELECTRIC FILTERS, by D. J. H. Maclean. June 7, 1956, 25lp. incl. diagrs. refs. (Technical rept. no. 2) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 103219 Unclassified

The Cocci design method for LC filters meets prescribed insertion amplitude-frequency characteristics. The method is one of cascading elementary networks by the use of the appropriate mathematical tool of the chain (or general circuit parameter) matrix. The method and practical design procedures were developed by Prof. Giovanni Cocci (1907-1942) of Italy. Free translations are given of his 3 articles: Filters with the Minimum Number of Elements (Alta Frequenza, v. 11: 11-12, Nov.-Dec. 1942); Transmission Functions of Purely Reactive Quadrupoles Inserted Between Two Resistors (Alta Frequenza, v. 7: 12, Dec. 1938); and Design of Quadrupoles of Pure Reactance with Given Transmission Functions (Alta Frequenza, v. 10: 8-9, Aug.-Sept. 1941).

STA. 06:003

Stanford U. Stanford Electronics Labs., Calif.

ITERATIVE SYNTHESIS OF A LINEAR-PHASE NETWORK, by C. Y. Chang. June 25, 1956, 44p. incl. diagrs. refs. (Technical rept. no. 3) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 100245 Unclassified

The procedure is described for using the iterative method of Moore (Synthesis of Distributed Amplifiers for Prescribed Amplitude Response; item no. STA. 05:008) to synthesize a linear-phase transfer function with an equal-ripple approximation to a constant phase slope. It is economical to adopt a linear-phase network and the rate of fall of the phase slope of this transfer point will be steeper. A cascade should be arranged which consists on n/2 different second-order all pass networks if n (the number of polar or zeros) is even, or n-1 different second-order all-pass networks and 1 first-order all-pass network is n is odd so that the overall transfer will have n equal maximum phase slope points in the desired frequency band (-1 ... 1). The computation in the iterative method is aggravated as n increases.

STA. 06:004

Stanford U. Stanford Electronics Labs., Calif.

AN APPROXIMATION TO ALPHA OF A JUNCTION TRANSISTOR, by R. D. Middlebrook and R. M. Scarlett. July 12, 1956 [5]p. incl. diagrs. (Technical rept. no. 5) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524 and N6onr-25107) AD 102922 Unclassified

Also published in I.R.E. Trans. of Professional Group on Electron Devices, v. ED-3: 25-29, Jan. 1956.

A new approximation for the frequency dependence of the short-circuit current gain of a theoretical junction triode is derived, which is a rational function of frequency and convenient to use. It is shown that the approximation is in excellent agreement with the frequency response of the theoretical expression for alpha in both magnitude and phase to above the alpha cutoff frequency. The approximation is also considered in the time domain, where it is in good agreement except for small values of time corresponding to frequencies well above alpha cutoff. (Contractor's summary)

STA. 06:005

Stanford U. Stanford Electronics Labs., Calif.

SOME PROPERTIES OF LUMPED-FILTER CIRCUITS FOR TRAVELING-WAVE TUBES, by C.-T. Sah and G. A. Loew. July 20, 1956, 159p. incl. diagrs. (Technical rept. no. 4) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 104566 Unclassified

A family of curves is presented of the properties of lumped-filter circuits which are useful as slow-wave circuits for external-circuit traveling-wave tubes or as approximate equivalent circuits for traveling-wave tubes with distributed or lumped and distributed circuits. The characteristics presented include phase-frequency, the phase velocity, the group velocity, the circuit impedances and the interaction impedance characteristics as a function of frequency. These characteristics are obtained for the uniformly periodic geometry, i.e., equal lengths for all the cylinders and equal lengths for all the gaps; the gap reduction factor is not taken into consideration in the interaction impedance calculations. The circuits are assumed to be lossless. The circuits considered in this report represent only a small number of the various possible types of lumped-filter circuits that can be used as slow-wave circuits for external-circuit traveling-wave tubes. However, they do represent the simplest types of circuits. Other more complicated circuits may have more desirable properties for traveling-wave tube operation. (Contractor's summary)

STA. 06:006

Stanford U. Stanford Electronics Labs., Calif.

TRANSIENT PHENOMENA IN TRAVELING-WAVE TUBES, by A. V. Brown. July 30, 1956, 113p. incl. illus. diagrs. refs. (Technical rept. no. 6) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 104569 Unclassified

When the r-f input signal to a traveling-wave tube is pulsed on, and the electric beam in the tube is in a steady-state conditions, the rise time of the tube's output signal can be calculated with a knowledge of the tube's steady-state response versus frequency characteristics. This calculation is performed for both the forward-wave and the backward-wave amplifier. For the case with the r-f signal applied continuously to the circuit of a helix-type forward-wave amplifier and the electron beam pulsed on, transient effects of a time duration of 0.2 μ sec have been observed experimentally. It is shown that the pulse beam impresses a video signal on the helix, which causes the helix to ring. Due to the ringing phenomenon, the beam is placed out of synchronism with the circuit wave, thereby distorting the r-f output signal. Under suitable operating conditions a minimum rise time of less than 20 mμ sec was obtained. No theoretical investigation of this phenomenon was undertaken. Calculations of the beam-front distortion due to its transit down the length of the circuit were carried out. They predicted, for most conventional tubes, a collector-current rise time of less than a fifth of a beam transit time. Experimental results agreed with the theory to within a fraction of two. An investigation of the build-up process in backward-wave oscillators was performed. The theoretical results, based on a small-C linear theory, show reasonable agreement with the experimental results. The experimental results indicated build-up times of 2.5 to 0.1 μ sec for an S-band oscillator, as the tube's beam current was varied from 1.1 to 2.4 times its start-oscillation value. Fourier and Laplace transformation methods were used in the theoretical investigations. The difficulties, usually encountered when applying transformation calculus methods to distributed circuits, were considerably reduced by approximately the tube's response function before evaluating the inversion integral. (Contractor's summary)

STA. 06:007

Stanford U. Stanford Electronics Labs., Calif.

NEW SYSTEM OF PHYSICAL UNITS AND STANDARDS, by B. F. Ludovici. Aug. 25, 1956 [8]p. (Technical rept. no. 9) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25107 and Nonr-22524) AD 104884 Unclassified

Also published in Amer. Jour. Phys., v. 24: 400-407, May 1956.

The present system of physical units and standards is critically examined with a view of the possible destruction of the present primary standards through a natural catastrophe. A new system is proposed.

STA. 06:008

Stanford U. Stanford Electronics Labs., Calif.

A REPRESENTATION OF D-C CHARACTERISTICS AND TRANSIENT RESPONSE OF COMMERCIAL SEMICONDUCTOR DIODES, by F. S. Barnes. Aug. 30, 1956, 43p. incl. diagrs. refs. (Technical rept. no. 8) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 106051 Unclassified

An attempt is made to present in one place a reasonably complete analysis of the characteristics of commercial semiconductor diodes. The first portion of the paper analyzes the ideal p-n junction and the resulting distribution of carriers in the bulk of the diode. The analysis is based on a relatively simple model of the crystal structure of germanium and silicon from which the mechanisms by which currents are carried is developed and related to the case of a p-n junction. The second portion of the paper analyzes the deviations of the d-c characteristics of commercial diodes from the ideal p-n junction. The discussion of these deviations includes the effect of ohmic voltage drop through the bulk of the diode, the effect of high currents, and of the leakage currents. The final portion of the paper analyzes the transient response of these diodes in both the forward and reverse direction. The results of measurements on commercial diodes of both the forward and inverse transient response are presented and compared with the theory. (Contractor's summary)

STA. 06:009

Stanford U. Stanford Electronics Labs., Calif.

SOME RESULTS IN THE ESTIMATION OF SIGNAL PARAMETERS, by R. D. Bennion. Sept. 10, 1956, 19p. incl. diagrs. (Technical rept. no. 10) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 109752 Unclassified

This memorandum summarizes some results obtained in the study of certain aspects of signal reception in the presence of noise. Two types of difficulties are considered. First, the problem of obtaining best estimates of pulse-heights occurring with certain non-Gaussian distributions is treated. The solution in each case implies some nonlinear filtering operation. Second, pulse trains with Gaussian statistics but interdependence between adjacent pulses are considered. The "best" estimate of any pulse height is found to be a certain linear combination of the present and previous signal samples. Some suggestions for extending this result to the case of interdependence between an arbitrary number of pulses are included. (Contractor's summary)

STA. 06:010 - STA. 06:012

STA. 06:010

Stanford U. Stanford Electronics Labs., Calif.

THE TRANSVERSE-CURRENT TRAVELING-WAVE TUBE. [PART I] THEORY OF THE TRANSVERSE-CURRENT TRAVELING-WAVE TUBE. [PART II] AN EXPERIMENTAL TRANSVERSE-CURRENT TRAVELING-WAVE TUBE, by D. A. Dunn, W. A. Harman and others. Sept. 25, 1956 [18]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 12) (In cooperation with General Electric Microwave Lab.) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 109757 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 879-887, 888-89C, July 1956.

Part I. An analysis is presented of a traveling-wave tube in which unmodulated dc current is continuously introduced along the length of the tube and is removed after traveling a fixed distance in the presence of the circuit field. This change in the dc current distribution as compared with that of a conventional traveling-wave tube results in three forward growing waves instead of one; one growing exponentially as in the conventional tube, one growing linearly, and one growing as the square of distance. Expressions for the over-all gain of a forward-wave amplifier of this type are derived as a function of the usual parameters plus an additional parameter related to the distance traveled by electrons in the interaction space. The power output of this device is found to depend on saturation of individual current elements rather than of the beam as a whole, with the result that, after saturation is once reached, the power output is independent of input power. An estimate of the value of the saturation power level is obtained from the linear analysis. Part II. A transverse current traveling-wave tube employing a flat helix and a skew beam has been built and tested both as a forward wave amplifier and as a backward wave oscillator. The tube operates as an amplifier over the frequency range from 1 to 2 kmc with a power output of the order of 30 milliwatts. Tests on the tube indicated a gain vs voltage characteristic markedly different from that obtained with a conventional traveling-wave tube, particularly with respect to the wide range of current and voltage over which a large amount of attenuation in excess of the cold insertion loss of the circuit was observed. The general shapes of the curves of gain vs current and the gain and saturation power level vs frequency are as predicted from theory and display significant differences from calculated curves for an equivalent conventional tube. The nonlinear behavior of the tube, as a function of input signal level, follows the general pattern predicted from qualitative arguments. The output power is constant to within 0.05 db over an input power range of 20 to 30 db. With two signals of different frequencies supplied to the input of the tube, a region of operation was observed in which, with the input amplitude of one signal fixed, the output amplitudes of both signals were independent of the amplitude of the other (variable) input signal. (Contractor's summaries)

STA. 06:011

Stanford U. Stanford Electronics Labs., Calif.

NEGATIVE-IMPEDANCE CONVERTER DESIGN, by A. I. Larky. Oct. 30, 1956, 50p. incl. diagrs. tables. (Technical rept. no. 11) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 109753 Unclassified

An active device with the property that the driving-point immittance at one terminal-pair is the exact negative of the load immittance connected to the other terminal-pair is called a negative-impedance converter. This work describes the external or circuit properties of the ideal negative-impedance converter and relates them to certain ideal amplifier combinations. The necessary and sufficient conditions that a given device be an ideal negative-impedance converter are derived. The properties of the non-ideal negative-impedance converter are discussed and a method shown by which the non-ideal device may be made ideal by the addition of passive elements. Practical circuits are never ideal and are also subject to changes in performance due to drifts in their elements. Sensitivity criteria are developed which indicate which of the external parameters of the device most affect the negative-impedance conversion process. These are the parameters which must be most stable and this fact leads to the statement of the characteristics of a good negative-impedance converter circuit. Two transistor negative-impedance converter circuits are analyzed and compared. One of these has been published previously and the other is new. The new circuit is shown to be superior in frequency response and to have less distortion at a given signal level. The predicted behavior of these circuits is checked experimentally. (Contractor's summary)

STA. 06:012

Stanford U. Stanford Electronics Labs., Calif.

LITERATURE GUIDE ON FAILURE CONTROL AND RELIABILITY, by W. F. Luebbert. Dec. 31, 1956, 1v. incl. refs. (Technical rept. no. 13) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22524) AD 122983 Unclassified

A literature guide is presented on failure control and reliability of electronic components and equipment to show what information is available and where it can be found. References are arranged alphabetically by author by using a special IBM card format. This format may be used as a conventional annotated bibliography or as the foundation of a rapid-access, edge-punch card file. Two subject classification schemes are used. The conventional subject guide is of the type which is designed for isolation of desired articles from the list of references. The following subject headings are used in the guide, but they differ from those used for edge punching of the cards: (1) general material; (2) definition and quantification of reliability; (3) administrative aspects of reliability; (4) reliability and design;

(5) reliability and manufacture; (6) reliability versus utilization, maintenance, and repair; (7) reliability testing; (8) mathematical theory of reliability; (9) mathematical-statistical tools useful in study of reliability; (10) electron tube reliability; (11) semiconductor device reliability; (12) component reliability; (13) guided missile and airborne electronic reliability; and (14) computer reliability. The unconventional type of subject guide is a key to the edge-punching code for use with the card format. The subject classification scheme which was prepared for use with the punched cards, contains classification by author, topic, type of equipment, type of circuit, type of component, type of construction, critical environmental factor, and type of service. (ASTIA abstract)

STA. 07:001

Stanford U. High-Energy Physics Lab., Calif.

HIGH ENERGY ELECTRON SCATTERING AND NUCLEAR STRUCTURE DETERMINATIONS [1], by R. Hofstadter, H. R. Fechter, and J. A. McIntyre. Aug. 1953, 23p. diagrs. refs. (Rept. no. HEPL-205) (Sponsored jointly by Office of Naval Research under N6onr-25116, [Air Force] Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission)
AD 16168 Unclassified

Presented in part at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-May 1, 1953.

Also published in Phys. Rev., v. 92: 978-987, Nov. 15, 1953.

An investigation was made of the elastic scattering of fast electrons with energies of 125 and 150 mev by several elements. The relative angular distributions were measured for Be, Ta, Au, and Pb. The data indicated that these nuclei have charge distributions tapering off gradually from near the center to the outside. The best fit of first Born approximation form factors (Born and L. M. Yang, Nature, v. 166: 399, 1950) suggests an exponential charge distribution with rms radii 12 to 22% larger than conventional radii. The radii show considerable dependence on the function assumed for the charge-density taper. Among the tapers (Gaussian, half-uniform and half-Gaussian, uniform, and uniform with exponential) which were tried, all were definitely poorer than the exponential in representing the experimental data.

STA. 07:002

Stanford U. High-Energy Physics Lab., Calif.

INTENSITY FLUCTUATIONS IN SCINTILLATION COUNTERS, by J. A. McIntyre. [1954] [33]p. incl. table, refs. (Sponsored jointly by Office of Naval Research under N6onr-25116, [Air Force] Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) Unclassified

The statistical effects inherent in a scintillation-counter system are examined theoretically and the sources of statistical spread noted. Comparison is then made between the theory developed and the rather meager experimental data available, and the necessity for more experiments is made evident. It is also pointed out that a yet unexploited method for determining scintillator efficiencies is possible and that an improvement in the precision of gamma-ray energy measurements seems feasible. (Contractor's abstract)

STA. 07:003

Stanford U. High-Energy Physics Lab., Calif.

INELASTIC SCATTERING OF 190-MEV ELECTRONS IN BERYLLIUM, by J. A. McIntyre, B. Hahn, and R. Hofstadter. [1954] [2]p. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under [AF 18(600)646], and Atomic Energy Commission) Unclassified

Published in Phys. Rev., v. 95: 512-515, July 15, 1954.

An elastic peak A and two inelastic peaks B and C are found in the scattering of 190-mev electrons by Be. A-B = 2.54 mev; A-C = 6.96 mev.

STA. 07:004

Stanford U. [High-Energy Physics Lab.] Calif.

HIGH-ENERGY ELECTRON SCATTERING AND NUCLEAR STRUCTURE DETERMINATIONS, II, by R. Hofstadter, B. Hahn and others. [Mar. 15, 1954] [21]p. incl. diagrs. table, refs. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under AF 18(600)646, Atomic Energy Commission, and Research Corp., New York) Unclassified

Presented in part at meeting of the Amer. Phys. Soc., New York, Jan. 28-30, 1954.

Published in Phys. Ref., v. 95: 512-515, July 15, 1954 1954.

Elastic scattering measurements have been carried out with electrons in Au^{197} at energies of 84, 126, 154, and 183 mev and in Pb^{208} at 84, 153, and 186 mev. Diffraction effects are observed which appear to vary with momentum and angular position as if a fundamental parameter $p \sin \frac{\theta}{2}$ were equal to a constant for a given diffraction feature. Such a behavior would be predicted by the Born approximation. A comparison of the scattering in Au^{197} and Pb^{208} suggests that inelastic scattering does not materially influence the scattering curves presented. The appearance of diffraction effects indicates a model more nearly uniform in charge density than early tentative conclusions based on Born approximation calculations. (Contractor's abstract)

STA. 07:005 - STA. 07:008

STA. 07:005

Stanford U. [High-Energy Physics Lab.] Calif.

ELECTRON SCATTERING FROM HYDROGEN, DEUTERIUM, AND CARBON AT 190 MEV (Abstract), by J. A. McIntyre and R. Hofstadter. [1954] [1]p. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under [AF 18-(600)646], and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., Seattle, Wash., July 7-10, 1954.

Published in Phys. Rev., v. 96: 854, Nov. 1, 1954.

The recoil of the proton or deuteron permits solid targets of light and heavy polyethyiene to be used in studying the elastic scattering of high energy electrons from the nuclei of hydrogen and deuterium, as distinguished from the elastic scattering from carbon nuclei. Inelastic electron scattering peaks have been observed in carbon at 4.5 mev and 9.7 mev and add a background below the carbon elastic peak which must be substracted from the hydrogen and deuterium peaks. Angular distributions of the elastic electron scattering have been observed in hydrogen between 35° and 100° at 190 mev in the laboratory frame. The proton appears to be a point charge since the experimental points fit the Mott formula. The deuteron definitely appears as not a point charge. Its finite size is exhibited by a fivefold reduction from the Mott formula at 105° in the center-of-mass system. The rms radius of the observed charged distribution is $1.5 \pm 0.2 \times 10^{-13}$ cm. This "radius" is a measure of the rms distance between the center of mass of the deuteron structure and the position of the proton. (Contractor's abstract)

STA. 07:006

Stanford U. [High-Energy Physics Lab.] Calif.

ELECTRON SCATTERING IN HYDROGEN AND HELIUM (Abstract), by R. Hofstadter, R. [W.] McAllister, and E. Wiener. [1954] [1]p. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under [AF 18(600)646], and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., Seattle, Wash., July 7-10, 1954.

Published in Phys. Rev., v. 96: 845, Nov. 1, 1954.

To investigate the elastic scattering of high-energy electrons from hydrogen, helium, and other gases we have constructed a stainless steel scattering chamber containing gas at high pressure. The target is a right cylinder of length 2-t/2 in., diameter 3/4 in. with walls 15 mils thick and end windows of thickness 5 to 10 mils. Operation at 1000 psi has proved quite convenient. The end effects are easily subtracted out by emptying the gaseous contents and are not important except at small angles (~35°). Studies of the angular distribution in hydrogen and helium have been carried out at 190 mev in the laboratory frame of coordinates and show agreement with the Mott point-charge formula for hydrogen but distinct deviations from the Mott formula for helium. These studies thus demonstrate the finite size of the helium nucleus (the alpha particle). A preliminary estimate of the size of the alpha particle gives $1.40 \pm 0.2 \times 10^{-13}$ cm for the rms radius of the alpha particle. The rm radius is taken with respect to charge. (Contractor's abstract)

STA. 07:007

Stanford U. High-Energy Physics Lab., Calif.

HIGH-ENERGY ELECTRON SCATTERING IN Rh, Ta, W, and U (Abstract), by B. Hahn and R. Hofstadter. [1954] [1]p. (Sponsored jointly by Office of Naval Research under N6onr-25116, [Air Force] Office of Scientific Research under AF 18(600)646, Atomic Energy Commission, and Research Corp., New York) Unclassified

Presented at meeting of the Amer. Phys. Soc., Berkeley, Calif., Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 278, Apr. 1, 1955.

Recent improvements in experimental technique have made it possible to measure more accurately the angular distribution of high-energy electrons (180 mev) scattered by heavy and medium heavy nuclei. Small differences in scattering cross sections of two nuclei can be established by measuring ratios of counting rates at each scattering angle. Scattering ratios of gold with respect to hydrogen have been measured, as well as ratios with respect to Rh, Ta, W, and U. Ta, W, and U definitely show less pronounced diffraction wiggling in the angular distribution than Pb^{208}, Au, and Bi. It is fairly difficult to fit the experimental results for Ta, W, and U with phase shift calculations to a spherically-symmetric charge distribution. A possible explanation of these relatively smooth angular distributions may involve nuclear-quadrupole effects. (Contractor's abstract)

STA. 07:008

Stanford U. High-Energy Physics Lab., Calif.

SCATTERING OF 192-MEV ELECTRONS FROM DEUTERIUM, by J. A. McIntyre and R. Hofstadter. Jan. 1955, 10p. diagrs. (Rept. no. HEPL-37) [AFOSR-TN-55-20] (Sponsored jointly by Office of Naval Research under N6onr-25116, [Air Force] Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) AD 52928 Unclassified

Also published in Phys. Rev., v. 98: 158-161, Apr. 1, 1955.

Elastic scattering of 192-mev electrons from deuterium has been studied using both solid (CD_2) and high-pressure gas targets. The results obtained by these 2

methods are in agreement and yield the following conclusions: (1) the range of the neutron-proton potential is between 1 and 4 x 10^{-13} cm if a square potential well is assumed, and if the deuteron wave functions predicted by the binding energy of the deuteron are used; and (2) it is, however, impossible with the present data to eliminate the possibility of other charge distributions for deuterium such as uniform or Gaussian. Inelastic electron scattering from deuterium was also investigated, and promises to give independent information on the deuteron structure. (Contractor's abstract)

STA. 07:009

Stanford U. High-Energy Physics Lab., Calif.

HIGH-ENERGY ELECTRON SCATTERING ON NUCLEAR STRUCTURE DETERMINATIONS. III. THE CARBON 12 NUCLEUS, by J. H. Fregeau and R. Hofstadter. May 1955 [30]p. incl. diagrs. tables, refs. (Rept. no. HEPL-49) ([AF]OSR-TN-55-134) (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under AF 18(600)-646, and Atomic Energy Commission) AD 63843 Unclassified

Also published in Phys. Rev., v. 99: 1503-1509, Sept. 1, 1955.

The elastic scattering peak in C^{12} is accompanied by a number of additional peaks corresponding to inelastic scattering of electrons from the various excited levels of the C nucleus. Three levels have been investigated by this method and correspond to the 3 known states at 4.43 mev, 7.68 mev, and 9.61 mev. Angular distributions of the inelastically-scattered electrons have been obtained, as well as the angular distribution of the elastically-scattered electrons. The angular distributions of the inelastic peaks fall off less steeply with angle than the elastic peak. By comparing the scattering from C with scattering from the proton, and using the theoretical value of the cross section of electrons scattered from the proton, it is possible to obtain "absolute" values for the elastic and inelastic scattering cross sections. From the elastic scattering curve, information about the size and charge distribution in the C^{12} nucleus may be derived. The charge distribution lies approximately half way between a Gaussian and a uniform model. The rms (root mean square) radius of the resultant charge distribution is 2.40 ± 0.25 x 10^{-13} cm. (Contractor's abstract)

STA. 07:010

Stanford U. [High-Energy Physics Lab.] Calif.

HIGH-ENERGY ELECTRON SCATTERING AND THE CHARGE DISTRIBUTIONS OF SELECTED NUCLEI, by B. Hahn, D. G. Ravenhall, and R. Hofstadter. Oct. 1955 [35]p. incl. diagrs. tables, refs. (Rept. no. HEPL-68) ([AF]OSR-TN-55-320) (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under AF 18(600)-646, and Atomic Energy Commission) AD 75937 Unclassified

Also published in Phys. Rev., v. 101: 1131-1142, Feb. 1, 1956.

Experimental results are presented of electron scattering by Ca, V, Co, In, Sb, Hf, Ta, W, Au, Bi, Th, and U, at 183 mev and (for some of the elements) at 153 mev. For those nuclei for which asphericity and inelastic scattering are absent or unimportant, i.e., Ca, V, Co, In, Sb, Au, and Bi, a partial wave analysis of the Dirac equation has been performed in which the nuclei are represented by static, spherically symmetric charge distributions. Smoothed uniform charge distributions have been assumed; these are characterized by a constant charge density in the central region of the nucleus, with a smoothed-out surface. Essentially 2 parameters can be determined, related to the radius and to the surface thickness. An examination of the Au experiments shows that the functional forms of the surface are not important, and that the charge density in the central regions is probably fairly flat, although it cannot be determined very accurately. An analysis of the experiments on the nuclei Ca, V, Co, In, Sb, Au, and Bi, assuming for convenience the Fermi smoothed uniform shape, then leads to the following results: The radial parameter c (the distance to the midpoint of the surface) scales as $A^{1/3}$ for the nuclei examined and is (1.07 ± .02) $A^{1/3}$ x 10^{-13} cm; the surface thickness t (0.9 ρ_0 to 0.1 ρ_0 distance) is constant for all of these nuclei, to within the estimated error, and is (2.4 ± 0.3) x 10^{-13} cm. (Contractor's abstract)

STA. 07:011

Stanford U. High-Energy Physics Lab., Calif.

ELECTRON SCATTERING FROM THE PROTON, by R. Hofstadter and R. W. McAllister. [Jan. 24, 1955] [5]p. incl. diagr. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) Unclassified

Also published in Phys. Rev., v. 98: 217-218, Apr. 1, 1955.

The elastic scattering of 100, 188, and 236-mev electrons from protons initially at rest was examined. The data do not fit the Mott or the Rosenbluth (C. A., v. 44: 9811b, 1955) curves. If it is assumed that the proton charge cloud and its magnetic moment are both spread out in the same proportions, it is possible to reproduce experimental results. (C. A., 1955: 10755f)

STA. 07:012

Stanford U. [High-Energy Physics Lab.] Calif.

ELASTIC SCATTERING OF ELECTRONS BY Li^6 AND Li^7 (Abstract), by J. F. Strieb. [1955] [1]p.

STA. 07:013 - STA. 07:015

(Sponsored jointly by Office of Naval Research under [N6onr-25116], Air Force Office of Scientific Research under [AF 18(600)646], and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., Southern Calif. U., Los Angeles, Dec. 28-30, 1955.

Published in Phys. Rev., v. 100: 1797, Dec. 15, 1955.

Using techniques developed in this laboratory, the elastic scattering of electrons by Li^6 and Li^7 has been studied, with emphasis on the comparison of their cross sections. With high resolution, the inelastic scattering by the 0.477-mev state of Li^7 appears as a broadening of the main scattering peak, and its small contribution (~10%) is determined by comparison with the Li^6 peak. At 187 mev, $\sigma_7/\sigma_6 = \rho$ varies smoothly from 1.00 (35°) to 1.17 (80°). The magnetic contribution to ρ is estimated from the values ρ (187 mev, 65°) = 1.07 and ρ (117 mev, 118°) = 1.12; the two conditions involve equal momentum transfers; a crude interpretation of Rosenbluth's formula indicates that the effect adds 2% at 80° and less at smaller angles. For both isotopes the angular distribution at 187 mev indicates a charge distribution between the uniform and the Gaussian, with a rms radius $(2.38 \pm 0.05) \times 10^{-13}$ cm, the ratio of rms radii being $r_7/r_6 = 0.99 \pm 0.01$. (Contractor's abstract)

STA. 07:013

Stanford U. High-Energy Physics Lab., Calif.

INELASTIC AND ELASTIC SCATTERING OF 187-MEV ELECTRONS FROM SELECTED EVEN-EVEN NUCLEI, by R. H. Helm. Feb. 1956, 73p. incl. diagrs. tables, refs. (Rept. no. HEPL-40) (AFOSR-TN-56-11) (Sponsored jointly by Office of Naval Research under N6onr-25116 and Air Force Office of Scientific Research under AF 18(600)646) AD 85909 Unclassified

Also published in Phys. Rev., v. 104: 1466-1475, Dec. 1, 1956.

A survey has been made of the differential scattering cross sections for 187-mev electrons on the even-even nuclei $_{12}Mg^{24}$, $_{14}Si^{28}$, $_{16}S^{32}$, $_{18}A^{40}$, and $_{38}Sr^{88}$. It has been possible to separate the elastic scattering from the inelastic in all cases, and to resolve the inelastic groups from specific nuclear levels for at least one level in all cases. A simple Born-approximation analysis of the elastic data yields values of the effective radii and surface thicknesses of the nuclear charge densities which (if suitably corrected for failure of the Born-approximation) are in substantial agreement with the results of Hahn, Ravenhall and Hofstadter, i.e., a radius parameter (for the heavier elements) of $c = 1.08A^{1/3} \times 10^{-13}$ cm (radius of half-maximum of the charge distribution) and a surface thickness of $t = 2.5 \times 10^{-13}$ cm (thickness from 10 to 90% of the maximum of the charge distribution). Phenomenological analysis of the inelastic scattering along the lines laid down by Schiff yields some tentative multipolarity assignments, and application of some results of Ravenhall yields estimates of (radiative) partial level widths; for the E2 transitions these correspond to lifetimes of $\sim 19 \times 10^{-13}$ sec [Mg (1.37 mev)] to $\sim 1.4 \times 10^{-13}$ sec [Sr (1.85 mev)]. The observed strengths of the transitions are compared to those predicted by Weisskopf theory. (Contractor's abstract)

STA. 07:014

Stanford U. High-Energy Physics Lab., Calif.

ELASTIC SCATTERING FROM THE PROTON AND THE ALPHA PARTICLE, by R. W. McAllister and R. Hofstadter. Feb. 1956 [23]p. incl. diagrs. (Rept. no. HEPL-73) ([AF]OSR-TN-56-73) (AF 18-(600)646) AD 81525 Unclassified

Also published in Phys. Rev., v. 102: 851-856, May 1, 1956.

The elastic scattering of 188-mev electrons from gaseous targets of H and He has been studied. Elastic profiles have been obtained at laboratory angles between 35° and 138°. The areas under such curves, within energy limits of ± 1.5 mev of the peak, have been measured and the results plotted against angle. In the case of H, a comparison has been made with the theoretical predictions of the Mott formula for elastic scattering, and also with a modified Mott formula (due to Rosenbluth) taking into account both the anomalous magnetic moment of the proton and a finite-size effect. The comparison shows that a finite size of the proton will account for the results, and the present experiment fixes this size. The rms radii of charge and magnetic moment are each 0.74×10^{-13} cm $\pm$ 0.24×10^{-13} cm. In obtaining these results, it is assumed that the usual laws of electromagnetic interaction and the Coulomb law are valid at distances less than 10^{-13} cm and that the charge and moment radii are equal. In He large effects of the finite size of the α particle are observed and the rms radius of the α particle is found to be 1.6×10^{-13} cm $\pm$ 0.1×10^{-13} cm. (Contractor's abstract)

STA. 07:015

Stanford U. High-Energy Physics Lab., Calif.

THE STRUCTURE OF THE PROTON, by E. E. Chambers and R. Hofstadter. Apr. 1956 [45]p. incl. diagrs. tables, refs. (Rept. no. HEPL-78) ([AFOSR]-TN-56-151) (Sponsored jointly by Office of Naval Research under [N6onr-25116], Air Force Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) AD 86310 Unclassified

The structure and size of the proton have been studied by means of the methods of high-energy electron scattering. The elastic scattering of electrons from protons in polyethylene has been investigated at the following energies in the laboratory system: 200, 300, 400, 500, and 550 mev. The range of laboratory angles examined has been 30° to 135°. At the largest angles and the highest energy, the cross section for scattering

shows a deviation below that expected from a point proton by a factor of about nine. The magnitude and variation with angle of the deviations determine a structure factor for the proton, and thereby determine the size and shape of the charge and magnetic-moment distributions within the proton. An interpretation, which is consistent at all energies and angles and agrees with previous results obtained, fixes the rms radius at 0.77 ± 0.10 x 10^{-13} cm for each of the charge and moment distributions. The shape of the density function is not far from that of a Gaussian with rms radius 0.70 x 10^{-13} cm or an exponential with rms radius 0.80 x 10^{-13} cm. An equivalent interpretation of the experiments would ascribe the apparent size to a breakdown of the Coulomb law and the conventional theory of electromagnetism. (Contractor's abstract, modified)

STA. 07:016

Stanford U. [High-Energy Physics Lab.] Calif.

ELASTIC AND INELASTIC SCATTERING OF 187-MEV ELECTRONS FROM CARBON-12, by J. H. Fregeau. [1956] [12]p. incl. diagrs. tables, refs. (Rept. no. HEPL-87) (AFOSR-TN-56-266) (Sponsored jointly by Office of Naval Research under N6onr-25116, Air Force Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) AD 88986
Unclassified

Also published in Phys. Rev., v. 104: 225-236, Oct. 1, 1956.

The scattering of 187-mev electrons from C^{12}, reported previously, has been extended to 138°. It has been possible to separate the elastic scattering from the inelastic scattering and to resolve the inelastic groups from the 4.43-, 7.65-, and 9.61-mev nuclear levels. "Absolute" values were obtained by comparing the scattering from carbon with the scattering from hydrogen and computing the proton cross section. The angular distribution of the elastically-scattered electrons falls off more steeply than the angular distribution of the inelastically-scattered electrons. Analysis of the data, using the Born approximation, shows that the root-mean-square radius of C^{12} (corrected for breakdown of the Born approximation) is (2.37 ± 0.05) x 10^{-13} cm with a surface thickness of (2.0 ± 0.4) x 10^{-13} cm. The corresponding value of r_0 the "classical" radius parameter, is (1.33 ± 0.02) x 10^{-13} cm which is larger than that found from electron-scattering measurements for the heavy nuclei and is in agreement with the trend for light nuclei. The scattering from the 4.43-mev and 7.65-mev levels is larger than that predicted by some shell-model calculations. The transition from the ground state to the 9.61-mev level appears to be either quadrupole or electric monopole, which gives a spin and parity assignment of either 2^+ or 0^+. (Contractor's abstract)

STA. 07:017

Stanford U. [High-Energy Physics Lab.] Calif.

AN ABSOLUTE CROSS SECTION FOR ELECTRON SCATTERING FROM PROTONS, by R. W. McAllister. Oct. 1956 [1]p. (Rept. no. HEPL-109) (AFOSR-TN-56-518) (Sponsored jointly by Office of Naval Research under N6onr-25116, Air Force Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) AD 110333
Unclassified

Also published in Phys. Rev., v. 104: 1494, Dec. 1, 1956.

Scattering is reported of 189.6-mev electrons through 60° in the laboratory frame from polyethylene and carbon targets, using apparatus previously described in part (Phys. Rev., v. 92: 978, 1953; v. 95: 512, 1954; v. 99: 1503, 1955). A preliminary analysis of the experimental data yields a differential cross section of (1.20 ± 0.07) x 10^{-30} cm^2. Application of the radiative correction which is calculated as 0.836 to the Rosenbluth formula for a diffuse proton, assuming a magnetic moment rms radius of 0.77 x 10^{-13} cm yields an rms radius of 0.75 x 10^{-13} cm for the charge. This radius is consistent with existing values.

STA. 07:018

Stanford U. High-Energy Physics Lab., Calif.

ELECTRON SCATTERING FROM NEIGHBORING NUCLEI, by B. Hahn, R. Hofstadter, and D. G. Ravenhall. Nov. 1956 [9]p. incl. diagrs. (Rept. no. HEPL-113) (AFOSR-TN-56-536) (Sponsored jointly by Office of Naval Research under N6onr-25116, Air Force Office of Scientific Research under AF 18-(600)646, and Atomic Energy Commission) AD 110355
Unclassified

Also published in Phys. Rev., v. 105: 1353-1355, Feb. 15, 1957.

A new method of measuring small variations of the charge distributions of neighboring nuclei, such as isotopes and isotones, has been developed. The method is based on a determination of the ratio of electron scattering cross sections near the diffraction dips. Experimental results are given for the combinations Ni^{58}, Ni^{60} and Fe^{56}, Ni^{58}. Sample theoretical interpretations are presented. (Contractor's abstract)

STA. 07:019

Stanford U. High-Energy Physics Lab., Calif.

ELECTRON SCATTERING FROM THE DEUTERON, by J. A. McIntyre. Apr. 1956 [32]p. incl. diagrs. refs. [Rept. no. HEPL-61] (Sponsored jointly by Office of Naval Research under [N6onr-25116], Air Force Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission)
Unclassified

STA. 07:020 - STA. 07:022

Published in Phys. Rev., v. 103: 1464-1471, Sept. 1, 1956.

The charge distribution of the deuteron has been studied by electron-scattering experiments using 188-mev and 400-mev electrons. Both deuterated-polyethylene foils and deuterium gas targets were used. Two different scattering apparatuses were also used. The charge of the deuteron was found to be extended over a larger volume than that inferred from low-energy neutron-proton scattering. Specifically, the effective range of the neutron-proton potential was found to be at least $(2.18 \pm 0.15) \times 10^{-13}$ cm as compared with the n-p scattering result of $(1.70 \pm 0.03) \times 10^{-13}$ cm. It is possible also to fit the data using a 1.70×10^{-13} cm effective range, and a deuteron consisting of a point neutron and a proton with a rms radius of $(0.82 \pm 0.17) \times 10^{-13}$ cm. This procedure, however, violates the assumption of the charge independence of the internal structure of nucleons. Finally, the 1.70×10^{-13} cm effective range could be preserved by suitably modifying the Coulomb law at small distances. (Contractor's abstract)

STA. 07:020

Stanford U. High-Energy Physics Lab., Calif.

HIGH-ENERGY ELECTRON SCATTERING AND THE ELECTRODISINTEGRATION OF THE ALPHA-PARTICLE (Abstract), by R. Blankenbecler and R. Hofstadter. [1956] [1]p. (Sponsored jointly by Office of Naval Research under N6onr-25116, Air Force Office of Scientific Research under AF 18(600)646, Atomic Energy Commission, and Research Corp., New York) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 10, Jan. 30, 1956.

Electron scattering has been observed from helium gas a high pressure with the new semi-circular double-focusing magnetic spectrometer. At an energy of 400 mev in the incident beam the elastic scattering has been studied at angles between 45° and 70° in the laboratory frame. Besides the sharp elastic peaks, prominent inelastic continua have been observed at several angles. At a given scattering angle the inelastic continuum shows a strong peak at an energy approximately 20 mev below the position corresponding to scattering from the free proton. The inelastic continua also exhibit thresholds about 20 mev below the elastic scattering peaks of the alpha particle, corresponding to the ejection of a single particle from the alpha particle. Theoretical treatment of the elastic data furnishes new information on the size and shape of the alpha particle. Preliminary analysis using the Born approximation gives a rms charge radius of 1.55×10^{-13} cm if the shape is Gaussian and 1.4×10^{-13} if a uniform shape is assumed. The best fit lies between these models. The new data are thus in excellent agreement with an earlier determination. (Contractor's abstract)

STA. 07:021

Stanford U. [High-Energy Physics Lab.] Calif.

NEW DATA ON THE STRUCTURE OF THE PROTON (Abstract), by R. Hofstadter and E. E. Chambers. [1956] 1p. (Sponsored jointly by Office of Naval Research under [N6onr-25116], [Air Force] Office of Scientific Research under [AF 18(600)646], and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 10, Jan. 30, 1956.

A new semi-circular double- focusing magnetic spectrometer with 36" radius of curvature has recently been placed in operation at electron energies up to 400 mev. Detection of the scattered electrons after magnetic deflection is accomplished with a Čerenkov counter enclosed within a ten-ton shield located on the magnet and moving with it. Sharp elastic peaks corresponding to electrons scattered from protons in polyethylene are observed at energies and angles consistent with relativistic kinematics. The areas under such peaks are measured as a function of scattering angle. As observed previously at lower energies the cross section falls below the scattering expected from a point proton and (subject to the validity of the Coulomb law) indicates that the proton has a diffuse structure. By fitting the observed cross section with a phenomenological form factor corresponding to exponential charge and magnetic moment distributions a proton size can be determined. Preliminary values are $r_e = r_m = 8 \times 10^{-14}$ cm where r_e and r_m are respectively rms radii of charge and magnetic moment distributions. These results are in excellent agreement with the earlier determinations. (Contractor's abstract)

STA. 07:022

Stanford U. [High-Energy Physics Lab.] Calif.

SCATTERING OF 187-MEV ELECTRONS FROM CARBON (Abstract), by J. H. Fregeau. [1956] [1]p. (Sponsored jointly by Office of Naval Research under N6onr-25116, Air Force Office of Scientific Research under AF 18(600)646, and Atomic Energy Commission) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 9, Jan. 30, 1956.

The scattering of 187-mev electrons from carbon, reported previously, has been extended to larger angles. Measurements of the elastic scattering cross section and the cross section for inelastic scattering corresponding to the 4.43-mev excited state have been extended to 138° (the present limit of the equipment).

The absolute values have been obtained by comparison with previous results. The angular distribution of the 4.43-mev scattering falls off less rapidly with increasing angle than the elastic scattering. At angles greater than ~90°, the inelastic scattering of the 4.43-mev level is larger than the elastic; for example, at 130° the elastic scattering is 4.3×10^{-34} cm^2/sterad while the 4.43-mev scattering is 6.7×10^{-33} cm^2/sterad. Some measurements have also been made of the inelastic scattering corresponding to the 7.65-mev and 9.61-mev excited states. (Contractor's abstract)

STA. 07:023

Stanford U. [High-Energy Physics Lab.] Calif.

RESUMÉ OF TALK GIVEN AT AMSTERDAM CONFERENCE ON NUCLEAR REACTIONS (Abstract), by R. Hofstadter. [1956] 5p. incl. tables. [Rept. no. HEPL-IP-12] [AF 18(600)646] Unclassified

Presented at Conference on Nuclear Reactions, Amsterdam (Holland), June 1956.

A report is presented of studies on the charge distribution of nuclei of various elements between calcium and bismuth, investigated at Stanford U., by electron scattering methods employing energies near 180 mev. The experiments showed mainly that spherical nuclei could be represented by a model in which the skin thickness t of all such nuclei approximately equaled 2.4×10^{-13} cm, and in which the distance to the half-central-density point varied as $A^{1/3}$, i.e. $c = 1.08 \times A^{1/3} \times 10^{1/3}$ cm. The distance t is measured between points such that their values are 90 and 10 of the central density. Data are tabulated for r_o, r_1, $cA^{-1/3}$, and t determinations of the lighter nuclei of C^{12}, Mg^{24}, Si^{28}, S^{32}, and Sr^{88}; skin thickness and half-density distance relations were found to apply to a good approximation. Redefinition of r_o is given and values of an equivalent $r_o = RA^{-1/3}$, t, c, and r_1 for C^{12}, Mg^{24}, Si^{28}, S^{32}, Ca^{40}, V^{51}, Co^{59}, In^{115}, Sb^{122}, Ta^{181}, Au^{197}, Pb^{208}, Bi^{209}. Thus r_o is not a constant but equals 1.19 for heavy elements and 1.34 for lighter elements, with a gradual variation probably occurring in between. Other studies of the momentum distribution of nucleons within nuclei are briefly noted.

STA. 07:024

Stanford U. High-Energy Physics Lab., Calif.

ČERENKOV COUNTERS (Abstract), by R. Hofstadter. [1956] [1]p. [Rept. no. HEPL-IP-10] [AF 18(600)646; continued by N6onr-25116] Unclassified

Presented at CERN Symposium on High Energy Accelerators and Pion Physics, Geneva (Switzerland), June 11-23, 1956.

Published in Proc. CERN Symposium on High Energy Accelerators and Pion Physics, v. 2: 75, 1956.

In attempting to study the inelastic scattering of electrons from deuterium at high energy (500 mev) and large angles (90°-135°), it was found that scattered electrons must be carefully distinguished from mesons having the same momentum and coming from the target in the same direction as the electrons. Usually, the counting was carried on with a lucite Čerenkov counter after the scattered particles were momentum-analyzed magnetically. At electron energies (or momenta) well below the value corresponding to scattering from a free proton, a very large peak was observed. This peak has a sharp threshold on the low-energy side and fell off gradually at higher energies. As the scattering angle was varied, the threshold remained constant but the intensity changed. This fact suggested that the particles were not electrons. The threshold coincided with the energy π mesons should have if they were just to give pulses in a lucite (n = 1.50) Čerenkov counter. The counting material was, therefore, changed to the liquid $C_8F_{16}O$, which has an index of refraction of 1.276 and a density of 1.76 g/cc. The large peak disappeared and with it the threshold too. Twenty channel-discriminator runs taken with both lucite and the fluoroliquid indicate that this interpretation is correct. The present counting technique is carried on with the liquid which appears to be quite suitable for electron counting in a very high neutron and gamma-ray background. (This work was carried out by R. Blankenbecler, R. Hofstadter, and M. R. Yearian.) A total absorption TlCl crystal with a 5½-in. length and a 5½-in. diameter was used in conjunction with a Schaetti-10½-in. -diameter photomultiplier to study the properties of this counter for energetic electrons and gamma rays. Experiments were carried out with electrons of energies 200, 250 and 300 mev and definite total-absorption peaks were observed. The total widths of the pulse-height distributions at half-maximum were approximately 26% at all the energies. The positions of the maxima of the pulse-height distributions varied linearly with the energy. It appears, therefore, that TlCl will make a very successful total absorption spectrometer. (This work was carried out by A. Knudsen and R. Hofstadter.) (Contractor's abstract)

STA. 08:001

Stanford U. [High-Energy Physics Lab.] Calif.

PION PRODUCTION IN ELECTRON-PROTON COLLISIONS, by R. H. Dalitz and D. R. Yennie. [Nov. 5, 1956] [17]p. incl. diagrs. tables, refs. (Rept. no. HEPL-118) (Sponsored jointly by Office of Naval Research, Air Force Office of Scientific Research, and Atomic Energy Commission under N6onr-25116; continuation of AF 18(600)646) Unclassified

Published in Phys. Rev., v. 105: 1598-1615, Mar. 1, 1957.

The close relationship between photopion and electropion production from protons allows an unambiguous first estimate (the standard value) for the ratio of these cross sections, based on assumptions very close to those of the Weizäcker-Williams method. Deviations of the ratio from this estimate arise from pion

STA. 09:001 - STA. 10:002

production by the longitudinal components of the field of the scattered electron and from the variation of the off-diagonal transverse excitations from their diagonal photoproduction values. The dependence of these deviations on the physical processes contributing to the electromagnetic excitation of pions is discussed in terms of matrix elements specified in the pion-nucleon center-of-mass system, both for various phenomenological contributions and for specific meson theories. The experimental values reported are interpreted as an indication of the smallness of longitudinal production, in qualitative accord with the fixed source theory. These features may also be investigated by study of the energy spectrum of inelastically scattered electrons and of the azimuthal variation of pion production relative to the scattering plane, which are also discussed here. (Contractor's abstract)

STA. 09:001

Stanford U. Microwave Lab., Calif.

PARAMAGNETIC RESONANCE METHODS IN BIOLOGICAL RESEARCH, by S. Blois. Feb. 1956 [3]p. incl. diagrs. (ML rept. no. 290) (AFOSR-TN-56-14) (AF 18(600)1511) AD 94138 Unclassified

Also published in I. R. E. Trans. of Professional Group on Medical Electronics, v. ME-4: 35-37, Feb. 1956.

After a brief review involving the procedures and problems associated with performing magnetic measurements on living biological systems, the application of a paramagnetic resonance spectrometer to the study of the kinetics of biological quinones undergoing reversible oxidation-reduction is discussed. Further applications to biological research are listed.

STA. 10:001

Stanford U. Microwave Lab., Calif.

ANALYSIS OF A RESONANT-CAVITY MEASUREMENT OF THE VELOCITY OF LIGHT, by D. H. Janney. Technical rept. Oct. 1956, 123p. incl. illus. diagrs. tables, refs. (Rept. no. 343) (AFOSR-TN-56-325) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1593 and Office of Naval Research under N6onr-25123) AD 95201 Unclassified

Methods of overcoming the major sources of uncertainty in the Hansen-Bol and Essen measurements of the velocity of light by microwave resonant cavities were analyzed by theory or experiment and the potential accuracy of this type of measurement was evaluated. The procedure given by Heimer to eliminate the effects of dimensional imperfections in the cavity was extended. This experiment uses a cavity consisting of a circular cylinder of variable length. The velocity of propagation can be deduced from measurements of a single change in cavity length and the resonant frequencies of several modes. The effect of a nonvanishing cavity surface impedance was analyzed theoretically. The Q-correction which is usually used to relate the measured frequencies to the frequencies of a lossless resonator of the same dimensions is not valid for the general case in which the real and imaginary parts of the surface impedance are unequal. Specifically, the surface reactance must be known. No independent experiment is presently available for measuring the surface reactance with the desired accuracy. A combination of theory and experiment showed that if the resonant frequencies are in the range of 2000 mc to 4000 mc, the cavity length changes can be measured interferometrically with an uncertainty of about 3 parts in 10^7. At the specified frequencies the low-order TE_{Omn} modes will have Q's in the range of 50,000 to 100,000, hence the resonant frequencies probably can be detected with an uncertainty of about 1 to 2 parts in 10^7. Thus, length and frequency measurements do not preclude an uncertainty in the velocity of propagation of 1 part in 10^6. The measurement of the surface reactance limits the accuracy of the experiment. Unless this difficulty can be overcome, either by direct measurement or by use of several modes, no resonant cavity measurement of the velocity of light can have an uncertainty of less than 2 or 3 parts in 10^6. Several experiments which eliminate the effects of a nonvanishing surface impedance were analyzed theoretically and were found to have an excessively large final uncertainty. Two subsidiary problems were considered. One problem was a theoretical analysis of the effects of modes close to the one on which measurements are made, and the other was a brief experimental investigation of methods of electroforming high Q cavities. (Contractor's abstract)

STA. 10:002

Stanford U. Microwave Lab., Calif.

ACCURACY OF A MICROWAVE RESONANT-CAVITY MEASUREMENT OF THE VELOCITY OF LIGHT, by D. H. Janney. Nov. 13, 1956, 3p. incl. illus. [AFOSR-TN-56-550] [AF 18(600)1593] AD 110369 Unclassified

Also published in Phys. Rev., v. 105: 1138-1140, Feb. 15, 1957.

Most of the problems involved in a measurement of the velocity of light by a microwave resonant cavity are discussed briefly on the basis of work reported elsewhere. A more nearly complete theoretical analysis of the effects of the cavity-surface impedance is given. In general, the surface reactance and resistance must both be known to relate the measured resonant frequency to the normal-mode frequency. This problem limits the accuracy of the experiment to an uncertainty of no less than about 2 parts in 10^6. The formal requirements for reducing this uncertainty are states, but no experiment is suggested. (Contractor's abstract)

STA. 11:001

Stanford U. Microwave Lab., Calif.

DESIGN AND PERFORMANCE OF A HIGH-POWER PULSED KLYSTRON, by M. Chodorow, E. L. Ginzton and others. Sept. 1953 [18]p. incl. illus. refs. (ML rept. no. 212) (Sponsored jointly by Office of Naval Research, Signal Corps, [Air Force Office of Scientific Research], and Atomic Energy Commission under N6onr-25123) AD 27752 Unclassified

Published in Proc. Inst. Radio Engineers, v. 41: 1584-1602, Nov. 1953.

The design, theory, construction, and operation of multi-megawatt pulsed klystrons are described. The characteristics of such a klystron operating at the 20-megawatt output level is summarized as follows: operating frequency 2,857 mc, tuning range 100 mc, heater power 800 w, beam voltage 325 kv, beam current 185 amp, power gain 35 db, efficiency 33%. These results are taken to infer that the design and operation of high power klystron amplifiers in the megawatt power range is practical and straightforward. (Contractor's abstract)

STA. 11:002

Stanford U. Microwave Lab., Calif.

MEASUREMENT OF CIRCUIT IMPEDANCE OF PERIODICALLY LOADED STRUCTURES BY FREQUENCY PERTURBATION, by E. J. Nalos. Mar. 30, 1954 (rev. June 1, 1954) [4]p. incl. illus. table. (ML rept. no. 229) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123) AD 60424 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 42: 1508-1511, Oct. 1954.

A method is described for determining the circuit impedance of a slow-wave structure from experimental measurements of the perturbation in the resonant frequencies caused by passing beads through the interaction region. From these measurements the gain parameter C of such a structure, when used as a traveling-wave tube, can be determined. The results agree with measured experimental gains as well as with theoretical calculations. The method is limited to periodic structures which can be short-circuited and hence made resonant. The principles involved are not new, but their adaptation to traveling-wave tubes is not generally known.

STA. 11:003

Stanford U. Microwave Lab., Calif.

A METHOD OF IMPROVING THE EFFICIENCY OF KLYSTRONS, by R. H. Winkler. May 1, 1954, 46p. incl. illus. (ML rept. no. 235) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123) AD 35052 Unclassified

A collector device was designed which was capable of recapturing energy from the electron beam following the output gap of a klystron and feeding this energy into the pulse transformer such that the over-all efficiency of the klystron was increased. For a 2-electrode collector, the highest efficiency was 24%, a gain of 1% over a single-electrode type. Theory indicated a collector efficiency of 49% for a 3-electrode collector, but measurement failed to detect any change. Beam spreading of low-velocity electrons and collector length were cited as possible causes of low efficiency. Testing indicated that a beam-power recovery of 30% could be realized by a single-electrode collector. The optimum collector voltage (about 75% of beam voltage) is tapped from the pulse transformer with pulse tubes.

STA. 11:004

Stanford U. Microwave Lab., Calif.

CROSS-WOUND TWIN HELICES FOR TRAVELING-WAVE TUBES, by M. Chodorow and E. L. Chu. Oct. 1954, 64p. incl. illus. table. (ML rept. no. 349) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123) AD 51403 Unclassified

Also published in Jour. Appl. Phys., v. 26: 33-43, Jan. 1955.

This report describes a structure, namely a cross-wound twin helix which overcomes the disadvantages of a conventional helix for high-voltage traveling-wave tubes. The disadvantages of a single helix suitable for high voltages are: (1) the impedance for electron interaction is reduced because of the energy content of the noninteracting space harmonics; and (2) the high impedance of some of the space harmonics can result in backward-wave oscillation. In a structure consisting of helices wound in opposite directions, the symmetry of the fields results in most of the electric energy being stored in the fundamental component and most of the magnetic energy in the space harmonics. This results in a higher impedance for the fundamental component and a reduced impedance for the space harmonics. Typical numbers for dimensions suitable for 10 kv operation are an increase of a factor of 2 in the fundamental impedance and a reduction of a factor of about 20 in the -1 space harmonic for the twin helix as compared to the single helix. (Contractor's summary)

STA. 11:005

Stanford U. Microwave Lab., Calif.

ELECTROFORMING OF COPPER FOR HIGH-VACUUM APPLICATIONS, by L. H. LaForge, Jr. Feb. 1955, 19p. incl. illus. (ML rept. no. 255) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under Nonr-22506 and N6onr-25123) AD 60423 Unclassified

STA. 11:006 - STA. 11:008

Electroforming, an old process in typemaking and phonograph record reproduction, is being successfully used in a new and different field, namely, fabrication of vacuum-tube envelopes. Special requirements of this latter application are vacuum tightness and high electrical conductivity. Standard industrial processes are not suitable for this work, though well-known electrochemical procedures are used. Work yet to be done is concerned mainly with control of the operations. Waveguides and similar microwave components are formed to a thickness of 0.150 in. on stainless steel mandrels in an acid copper bath at room temperature with current density of 10 amp/ft^2, after suitable cleaning of the mandrel. Linear-accelerator sections are formed on a base of alternated copper disks and aluminum spacers by cleaning the stack of disks and spacers, silver striking and thin-silver-plating the stack, electroforming approximately 3/8 in. of copper from an acid bath at room temperature at 10 amp/ft^2 (about 5 wk plating time) and etching out the aluminum spacers with hot NaOH. Massive properties of the electroformed material are very similar to those of commercial OFHC copper, but there are microscopic differences, principally in grain structure. Voids and inclusions in the electroformed material are of the same order of magnitude as in the OFHC material. The compositions and operation of the various solutions are given in detail, and many of the significant variables are mentioned. Further work is required along these lines, but fairly consistent results can now be expected. (Contractor's summary)

STA. 11:006

Stanford U. Microwave Lab., Calif.

APPLICATION OF CERAMIC SECTIONS IN HIGH-POWER PULSED KLYSTRONS, by L. H. LaForge [Jr.]. [Apr. 1955] [7]p. incl. illus. [ML rept. no. 263] (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research under [N6onr-25121], DA 36-039-sc-63189, Norr-22512, and Nonr-22505) AD 115468 Unclassified

Published in Bull. Amer. Ceramic Soc., v. 35: 117-122, 127, Mar. 15, 1956.

Early work with klystron tubes for the Stanford linear accelerators showed the need for rf windows of material having better electrical and mechanical properties than those of glasses. Several ceramic bodies in a variety of shapes and sizes were tried on these klystrons which handle peak powers up to 30 megawatts at microwave frequencies. High-alumina compositions proved superior to other formulations for these applications. Currently several metallizing techniques are in use, with one basic modification of the molybdenum-manganese method being of broad usability. This modified molybdenum-manganese system is especially efficacious on materials of high refractoriness, working well even on sapphire. Suitable brazing materials permit direct soldering of the metallized surfaces without the intervening step of nickel plating or its equivalent. (Contractor's abstract)

STA. 11:007

Stanford U. Microwave Lab., Calif.

DESIGN AND OPERATION OF MAGNETIC UNDULATORS, by W. H. Thon. May 1955, 114p. incl. illus. tables, refs. (ML rept. no. 262) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123 and N6onr-25107) AD 66505 Unclassified

Two magnetic undulators were constructed and connected to suitable sources of bunched electron beams. The first undulator received 100-mev electrons and confirmed the theoretical prediction of radiation in the visible spectrum. A photomultiplier tube served as a radiation detector. The second undulator was designed for electrons in the range of a few mev. Radiation was detected by crystal detectors and thermistors; frequency measurements indicated about 1-mm wavelengths. A theoretical study is presented of cascade prebunching at low energy levels by 2 microwave resonators, followed by RF acceleration of the bunches in high-power microwave devices like resonators and linear accelerators. The system indicates the possibility of much tighter bunching than that employed in the millimeter-wave experiment.

STA. 11:008

Stanford U. Microwave Lab., Calif.

THE DESIGN OF HIGH-POWER TRAVELING-WAVE TUBES, by M. Chodorow and E. J. Nalos. Aug. 1955 [11]p. incl. illus. tables. (ML rept. no. 278) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123 and N6onr-25132) AD 104682 Unclassified

Also published in Proc. Inst. Radio Engineers, v. 44: 649-659, May 1956.

This paper discusses the problems involved in designing traveling-wave tubes in the range of pulsed powers of the order of a megawatt. Suitable circuits are described, together with their advantages and limitations. In general, the all-metal structures described are capable of dissipating high average powers, have good impedances at the required voltages (100-kv range), but at a sacrifice in bandwidth. Nevertheless, this class of traveling-wave tube is useful where bandwidths of 10 to 20 per cent, not obtainable from klystrons of equivalent power outputs, are of interest. The problems of tube construction and tube design are discussed. Results of tests on an experimental model tube are described, showing good agreement with available theory. A gain uniformity of 3 db over a 9 per cent bandwidth, with power outputs of 300 kw pulsed have been obtained using attenuators of nonoptimum design. Better performance should be obtainable with further improvements in beam focusing and coupler design. Higher power levels with same efficiency should be possible by designing the tube to operate at higher potentials.

STA. 11:009

Stanford U. Microwave Lab., Calif.

MASER OSCILLATORS, by J. C. Heimer. Aug. 20, 1956 [4]p. incl. illus. [ML rept. no. 322] (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under N6onr-25123 and DA 36-039-sc-7178) AD 133561
Unclassified

Also published in Jour. Appl. Phys., v. 28: 212-215, Feb. 1957.

Two maser oscillators have been constructed and operated. The behavior of one maser has been observed under various operating conditions by comparing it with the second maser which is used as a reference standard. The experimental setup is shown and experimental results are given. The frequency-pulling effects of the beam and the oscillation amplitude as a function of cavity-tuning are compared with the theoretically expected behavior. It is shown that the simple behavior predicted by the theory exists only for oscillation frequencies which are well removed from line center. The theoretical curves are obtained from a new analysis which included the velocity distribution in the beam. A comparision is made between the velocity-distributed and uni-velocity theories. It is shown that the introduction of the velocity distribution drops the maximum beam efficiency from 1 to 0.76 and cause a region of stability to appear in the beam frequency-pulling function. (Contractor's abstract)

STA. 11:010

Stanford U. Microwave Lab., Calif.

ČERENKOV AND UNDULATOR RADIATION, by H. Motz. [1956] [11]p. incl. illus. tables, refs. [ML rept. no. 362] (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force Office of Scientific Research] under [N6onr-25123]) AD 139623
Unclassified

Published in Electromagnetic Wave Theory Symposium, [1956] p. 374-384.

During the past few years several authors have suggested applications of the radiation properties of electron beams to the problems of mm wave generation and some experiments have been carried out. Some investigators have succeeded in generating coherent waves in a range below one mm wave length. It is suggested to call these waves "Interwaves" or "Zwischenwelien" as they lie between the infra-red and microwaves. A separate name might be appropriate as to the techniques for generation and detection are likely to be very different from microwave techniques. The use of Čerenkov radiation has been suggested by Abele, Danos, and Linhart, and tried, and the radiation from fast electron beams has been investigated theoretically (Ginsburg, Coleman, Motz, Combe and Felx, and Landecker) and experimentally. In this paper the theory underlying these devices will be examined from a unified point of view and the relationship between different approaches will emerge. It is hoped that the understanding of this rapidly increasing field will thereby be advanced. A related field, coherent light generation, will also be touched upon.

SYR. 01:001

Syracuse U. [Dept. of Mathematics] N. Y.

CONTRIBUTIONS TO THE THEORY OF MARKOV CHAINS [PART I], by K. L. Chung. [1953] [6]p. [Research paper no. 2411] [AF 18(600)760]
Unclassified

Published in Jour. Res. Nat'l. Bur. Standards, v. 50: 203-208, Apr. 1953.

The random variables X_n, $n = 0, 1, \ldots$, form a discrete Markov chain with states, i, j, ... and stationary transition probabilities $P_{ij}^{(m)} = P(X_{m+n} = j \mid X_m = i)$, Let

$$F_{ij}^{(n)} = P(X_n = j,\ X_r \neq j,\ 1 \leq r < n \mid X_0 = i).$$

The subscript k prefixed to a symbol means that the state k is not visited during the passage, exclusive of both terminals. Q^* means $\sum_{n=1}^{\infty} Q^{(n)}$. The author proves a large number of relations of which only some can be given here. (1) $\lim_{N\to\infty} \sum_{n=0}^{N} P_{ii}^{(n)} / \sum_{n=0}^{N} P_{jj}^{(n)}$ equals any of the three expressions $(1+{}_jP^*_{ij})/(1+{}_iP^*_{jj})$, $F^*_{ij}/{}_iP_{ij}{}^*$, $(F^*_{ij})({}_jF^*_{ji})/(F^*_{ji})({}_iF^*_{ij})$, the first always, the second if $i \neq j$, the third if $F^*_{ij}F^*_{ji} > 0$. Doeblin proved that the existence of the limit (Bull. Soc. Math. France, v. 66: 210-220, 1938); the expressions for it are new. (2) Suppose the states form a single positive recurrent class. If $j \neq k$, then

$m(i, j \cup k) = m_{ij} - {}_jF^*_{ik}m_{kj}$, $m(i, j \cap k) = m_{ij} + {}_kF^*_{ij}m_{jk}$, where m_{ij}, $m(i, j \cup k)$, and $m(i, j \cap k)$ are the mean first-passage times from i to j, i to j or k, and i to both j and k; then $m_{ik} + m_{kj} - m_{ij} = {}_kF^*_{ij}(m_{jk} + m_{kj})$. As an application certain quantities involved in the central limit theorem for Markov chains are evaluated. (3) Formulas analogous to Poincaré's formula (Feller, Introduction to probability theory ..., Wiley, New York, 1950, p. 61; Math. Rev., v. 12: 424) are given for mean first-passage times to unions or intersections of an arbitrary number of states. (4) If i, j, and k (not necessarily distinct) belong to the same positive class, $\sum_{n=1}^{\infty} (P_{ik}^{(n)} - P_{jk}^{(n)}) = (m_{jk} - m_{ik}) / m_{kk}$. There are some connections with work of the reviewer (Trans. Amer. Math. Soc., v. 73: 471-486, 1952; Math. Rev., v. 14: 567). (Math. Rev. abstract)

SYR. 01:002 - SYR. 01:006

SYR. 01:002

Syracuse U. [Dept. of Mathematics] N. Y.

CONTINUOUS PARAMETER MARKOV CHAINS, by K. L. Chung. Sept. 1954, 41p. incl. refs. ([AF]OSR-TN-54-250) (AF 18(600)760) AD 45116 Unclassified

A systematic discussion is presented of continuous parameter Markov chains for the case where all of the states are stable. Proofs are presented of the following theorems which completely describe the sample functions in such a chain: (1) there is a set $\Omega_0 \in B$ with $P(\Omega_0) = 1$ such that if $w \in \Omega_0$, then the sample function $x(\cdot, w)$ defined in the half-line $(0, \infty)$ has the following properties; the set of its discontinuities D(w) is closed and of Lebesgue measure zero; in each of the open intervals whose union is the open complement D' of D with respect to $(0, \infty)$, $x(\cdot, w)$ is a constant; in 2 adjacent intervals separated by a point of D the 2 constant values of $x(\cdot, w)$ are different; and (2) there is a set $\Omega_1 \in B$ with $P(\Omega_1) = 1$ such that if $w \in \Omega_1$, then for every finite $T > 0$, and every i, the sample function $x(\cdot, w)$ contains only a finite number of i-intervals in (0, T). The notation is as follows: Ω is a probability space with the generic point w, B is a Borel field of w-sets which includes Ω itself, and P is a complete probability measure defined on B. Recurrence and ergodicity properties are discussed which extend known results in the discrete parameter case.

SYR. 01:003

Syracuse U. [Dept. of Mathematics] N. Y.

ON A THEOREM OF DOOB AND DIFFERENTIABILITY PROPERTIES OF MARKOV TRANSITION PROBABILITY FUNCTIONS, by D. G. Austin. Sept. 1954, 17p. incl. ref. ([AF]OSR-TN-54-251) (AF 18(600)760) AD 45117 Unclassified

The following generalization to spaces of infinite measure of a fundamental lemma of J. L. Doob (Stochastic Processes, p. 56, New York, 1953) is proved: let E be a collection of sets in F containing at least one set of finite measure, then there is a countable collection of sets $E_i \in F$ such that for any $E \in F$, $\mu\{E' \cap [\cap_i E_i]\} = 0$. The notation is that of an abstract space Ω which contains a Borel field of sets F with a measure function μ defined on the sets F. Various theorems on the differentiability and related properties of the transition probability functions $p_{ij}(\cdot)$ in a Markov chain are presented including a generalization of a theorem of Auerbach (Fundamenta Mathematica, v. 11: 196-197, 1928). (ASTIA abstract)

SYR. 01:004

Syracuse U. [Dept. of Mathematics] N. Y.

SOME LIMIT THEOREMS CONCERNING NONPARAMETRIC STATISTICS, by J. Blackman. Sept. 1954, 11p. ([AF]OSR-TN-54-252) (AF 18(600)760) AD 45118 Unclassified

A report is made of 3 outlines published recently in Russian which presented a new approach to problems of finding the distributions associated with several distances between 2 empiric distribution functions. The papers are: (1) "On the Maximal Difference Between Two Empirical Distributions," by Gnedenko and Korolook (Doklady Akad. Nauk SSSR, v. 80, no. 4: 1951); (2) "On a Problem of Comparison of Two Empirical Distributions," by Gnedenko and Rvaceva (ibid., v. 82, no. 4: 1952); and (3) "Some Results on the Maximum Discrepancy between Two Empirical Distributions," by Gnedenko (ibid., v. 82, no. 5: 1952). The method is presented in detail, computations omitted from the original papers are included, and some errors in the original are corrected. Asymptotic relations with precise estimates of the errors are obtained in addition to precise formulas for finite cases. (ASTIA abstract)

SYR. 01:005

Syracuse U. [Dept. of Mathematics] N. Y.

CONTRIBUTIONS TO THE THEORY OF MARKOV CHAINS, II, by K. L. Chung. [1954] [23]p. incl. refs. [AF 18(600)760] Unclassified

Published in Trans. Amer. Math. Soc., v. 76: 397-419, May 1954.

Theorems on Markov chains are discussed and proved. Theorem 1 demonstrates a type of solidarity among the states of a recurrent class, generalizes a classical result due to Kolmogorov and permits a classification of recurrent states and classes. Theorem 2 is a generalized ergodic theorem which applies to any recurrent class, positive or null. In a null class a set of numbers occurs which plays the roll of stationary absolute probabilities. These numbers are all equal to one in the case of a recurrent random with independent stationary steps and the result is simple. Theorem 3 shows the type of solidarity exhibited in theorem 1 to persist in such a sequence. The weak and strong laws of large numbers, the central limit theorem, the law of the iterated logarithm, and the limit theorems for the maxima of the associated sequence are proved very simply. It is shown that Kolmogorov's conditions are not sufficient for the validity of the central limit theorem. Conditions of validity for the strong limit theorems and the limit theorems for the maxima are obtained by strengthening of corresponding conditions for the weak limit theorems. The connection between these conditions and martingale theory is considered.

SYR. 01:006

Syracuse U. [Dept. of Mathematics] N. Y.

SOME NEW DEVELOPMENTS IN MARKOV CHAINS, by K. L. Chung. Sept. 1955, 24p. ([AF]OSR-TN-[55-351]) (AF 18(600)760) AD 75294 Unclassified

Also published in Trans. Amer. Math. Soc., v. 81: 195-210, Jan. 1956.

Some new connections are pointed out between sample-function behavior and analytical properties of the transition probability functions of a continuous parameter Markov chain with stationary probabilities. The new concept of a post-exist process imbedded in a continuous parameter Markov chain is introduced. This process has the same transition probabilities as the original chain, but its initial distribution is of a novel kind. An imbedded renewal process is also studied. Together they yield various relations which imply the differentiality of the transition probability functions and certain generalized Kolmogorov differential equations. (ASTIA abstract)

SYR. 01:007

Syracuse U. [Dept. of Mathematics] N. Y.

NONRECURRENT RANDOM WALKS, by K. L. Chung and C. Derman. Sept. 1955, 11p. refs. [AFOSR-TN-55-352] (AF 18(600)760) AD 75210 Unclassified

Also published in Pacific Jour. Math., v. 6: 441-447, 1956.

Let $\{X_i\}$, $i = 1, 2, \ldots$, be a sequence of independent and identically distributed integral valued random variables such that 1 is the absolute value of the greatest common divisor of all values of x for which $P(X_i = x) > 0$. Let $S_n = \sum_{i=1}^{n} X_i$, $0 < EX_i < \infty$, and A denote a set of integers containing an infinite number of positive integers. It is shown that any such set A is visited infinitely often with probability 1 by the sequence $\{S_n\}$, $n = 1, 2, \ldots$. Conditions are given so that similar results hold for the case where X_i has a continuous distribution, and the set A is a Lebesgue set whose intersection with the positive real numbers has infinite Lebesgue measure. (Contractor's abstract)

SYR. 01:008

Syracuse U. [Dept. of Mathematics] N. Y.

AN APPLICATION OF ERGODIC THEORY TO NON-RECURRENT RANDOM WALKS, by C. Derman. Sept. 1955, 8p. [AFOSR-TN-55-353] (AF 18(600)760) AD 75210(a) Unclassified

Let $\{X_i\}$, $i = 1, 2, \ldots$, be a sequence of independent and equally distributed random variables with density function $f(x)$, $0 < E(X_i) < \infty$, and $\{S_n\}$, $n = 1, 2, \ldots$, be the sequence of cumulative sums $S_n = \sum_{i=1}^{n} X_i$. If A is any Borel set bounded on the right, it follows from the strong law of large numbers that $P(S_n \in A \text{ i. o. (infinitely often)}) = 0$. Let the renewal density $h(x) = \frac{dH(x)}{dx}$, $H(x) = \sum_{n=1}^{\infty} P(S_n \leq x)$. It is shown that the inequality $0 \leq \lim_{x \to \infty} h(x)$ is sufficient to show that $P(S_n \in A \text{ i. o.}) = 0$, if $m(A)$, the Lebesgue measure of $A, < \infty$. (ASTIA abstract)

SYR. 01:009

Syracuse U. [Dept. of Mathematics] N. Y.

AN APPLICATION OF CHUNG'S LEMMA TO THE KIEFER-WOLFOWITZ STOCHASTIC APPROXIMATION PROCEDURE, by C. Derman. Sept. 1955, 10p. ([AF]OSR-TN-[55-354]) (AF 18(600)760) AD 75292 Unclassified

Also published in Ann. Math. Stat., v. 27: 532-536, June 1956.

A stochastic approximation procedure for finding the maximum of a regression function is investigated. Certain convergence properties are proved. (Contractor's abstract)

SYR. 01:010

Syracuse U. [Dept. of Mathematics] N. Y.

ON THE ANALYTIC STRUCTURE OF A MARKOFF MATRIX, by D. G. Austin. Sept. 1955, 34p. refs. ([AF]OSR-TN-[55-355]) (AF 18(600)760) AD 75932 Unclassified

Also published in Ann. Math. Stat., v. 27: 532-536, June 1956.

The analytical properties are studied of a matrix of real nonnegative functions $p_{ij}(t)$ on $0 < t \leq \infty$ ($i, j = 1, 2, \ldots$) satisfying: (1) $\sum_j p_{ij}(t) = 1$, and (2) $p_{ij}(t + s) = \sum_k p_{ik}(t)p_{kj}(s)$. A general differentiability criteria which does not require that $\lim_{t \to 0} p_{ij}(t) = \delta_{ij}$ for all i, j, is applied to the case where the initial state is stable $q_i < \infty$. A study of the case of a stable terminal state, $q_j < \infty$, shows that for this condition the transition function, $p_{ij}(t)$, has continuous derivatives. The asymptotic limits of $\sum_j |Dp_{ij}(t)|$ are considered and several conditions are found which guarantee that this sum tends to zero as t tends to ∞. The problems of second and higher order derivatives and abstract spaces are also studied. (ASTIA abstract)

SYR. 01:011

[Syracuse U. Dept. of Mathematics, N. Y.]

INTEGRAL OPERATORS AND MARKOV PROCESSES, by S.-T. C. Moy. Aug. 1956, 12p. [Wayne U. technical rept. no. 2] (AFOSR-TN-56-520) (In cooperation with Wayne U. under DA 20-018-ORD-14025) (AF 18(600)760) AD 110338 Unclassified

SYR. 01:012 - SYR. 01:013

An investigation is made of the integral operators on the space M' of countably additive set functions. Let P(x, X) be the conditional probability that a moving point x is transferred into a region X after the elapse of a unit time. The probability distribution F_1 of the point at the end of a unit time can be obtained from the initial distribution F_0 of the point at the beginning of the unit time by $F_1(X) = \int P(y, X)F_0(dy)$. This formula defines an operator on M' into itself if F_0 is any bounded countably additive set function. If f(x) is any bounded function of the point x, the conditional expectation $g(x_0)$ of f at the end of a unit time (given that the position of the point is x_0 at the beginning of unit time) is given by $g(x_0) = \int f(y)P(x_0dy)$. This formula defines an operator on the space M of bounded functions into itself. The mystery tie between spaces M and M' by an integral operator is then solved. If the domain of the integral operator to the space M* of bounded additive set functions is enlarged, an integral operator on M* is simply the adjoint of any linear operator on M. A study of the weak star topology on M* shows that sequential compactness and compactness are not equivalent for subsets of M*. Proof is given that any integral operator on M* has nonzero fixed points if it has a nonzero fixed point in M. The consequences of this theorem to the existence of a stationary absolute distribution of a Markov process is discussed. (ASTIA abstract)

SYR. 01:012

[Syracuse U. Dept. of Mathematics, N. Y.]

TWO ERGODIC THEOREMS FOR MARKOV CHAINS, by K. L. Chung. Aug. 1956, 8p. [AFOSR-TN-58-521] (AF 18(600)760) AD 113732 Unclassified

Let $\{X_n,\ n \geq 0\}$ be a Markov chain with denumerable state space I; let $\{p_i,\ i \in I\}$ be the initial distribution, let p_{ij} be the stationary transition matrix, and let f be any function from I into the reals. Consider the functional $y_n = f(x_n)$, $n \geq 0$. Set $S_n = \sum_{v=0}^{n} y_v$, $A_n = S_n/n$. The ergodic mean of $\{f(x_n)\}$ is defined to be $\bar{A} = A(f) = \sum_{i \in I} \pi_i f(i)$ if and only if $A(|f|) < \infty$. Theorem 1: $\lim_{n \to \infty} E|A_n - \bar{A}| = \lim_{n \to \infty} E|A_n - E(A_n)| = 0$. The τ_n's are well-defined random variables; w denotes the sample point and the value of t(n) at w is t(n, w); $Y_v = \sum_{n=\tau_v}^{\tau_{v-1}-1} y_n$. The following dissection formula is basic: $S_n = Y'(n) + \sum_{v=1}^{t(n)-1} Y_v + Y''(n)$, where $Y'(n) = \sum_{s=0}^{\tau_1-1} y_s$, $Y''(n) = \sum_{s=\tau_{t(n)}}^{n} y_s$; $U_v = \sum_{n=\tau_v}^{\tau_{v+1}-1} |y_n|$. $M_i = \pi_i E(Y_v)$ if $E(Y_v) < \infty$ so that $M_i = \bar{A}$ if $A(|f|) < \infty$; $Z_v = Y_v - M_i(\tau_{v+1} - \tau_v) = \sum_{n=\tau_v}^{\tau_{v+1}-1} (y_n - M_i)$; $m_{ii}^{(2)} = E\{(\tau_{v+1} - \tau_v)^2\}$; $\sigma_i^2 = E(Z_v^2)$; $B_i = \pi_i \sigma_i^2$. Since the values of M_i and B_i as well as the validity of conditions $m_{ii}^{(2)} < \infty$ and $E(U_1^2) < \infty$ do not depend on the choice of i, M and B can be written for M_i and B_i respectively. Theorem II: If $m_{ii}^{(2)} < \infty$ and $E(U_1^2) < \infty$, then $\lim_{n \to \infty} \frac{1}{n} E\{(S_n - Mn)^2\} = \lim_{n \to \infty} \frac{1}{n} E\{[S_n - E(S_n)]^2\} = B < \infty$. (ASTIA abstract)

SYR. 01:013

[Syracuse U. Dept. of Mathematics, N. Y.]

SOME THEOREMS ON CONTINUOUS PARAMETERS MARKOV CHAINS, by R. Chacon. Sept. 1956, 21p. refs. [AFOSR-TN-56-522] (AF 18(600)760) AD 113734 Unclassified

Let (Ω, B, P) be a probability triple where P is a complete measure defined on the sets of the Borel field B of subsets of Ω. The defining properties of a Markov chain y(.,.), a positive-integer valued function of $T \times \Omega$, where $T = [0, \infty]$ are that for all $n \geq 1$ if $t_1 < \ldots < t_n$ and for any integers $\nu_1, \ldots, \nu_\eta$, $P\{y(t_\eta, w) = \nu_\eta | y(t_{(\eta-1)}, w) = \nu_{(\eta-1)} \ldots, y(t_1, w) = \nu_1\} = P\{y(t_\eta, w) = \nu_\eta | y(t_{(\eta-1)}w) = \nu_{(n-1)}\}$. The probability must be a function of ν_η, $\nu_{(\eta-1)}$, and $t_\eta - t_{(\eta-1)}$. The stationary transition probability functions are defined by $p_{ij}(t) = P\{y(t+s, w) = j | y(s, w) = i\}$ $s \geq 0$, $t > 0$, i, j = 1, 2, ... and they satisfy the following conditions: (1) $p_{ij}(t) \geq 0$; (2) $\sum_j p_{ij}(t) = 1$; and (3) $p_{ij}(s+t) = \sum_k p_{ik}(s) p_{kj}(t)$ for s, $t \in (0, +\infty)$. The initial probabilities are $p_i = P\{y(0, w) = i\}$ which satisfy condition (4) $p_i \geq 0$ and $\sum_j p_j = 1$. Given the stationary Markov transition matrix function, $\{p_{ij}(t)\}$, and a sequence of numbers $\{p_i\}$ which satisfy condition (4) then there exists a Markov chain so that the $p_{ij}(t)$ are its stationary transition probabilities and p_i the initial probabilities. A theorem stated by Doob (Trans. Amer. Math. Soc., v. 52: 1942) and 2 new theorems are proved. These theorems are used to establish the limiting properties of discrete parameter Markov transition probability functions. Proof is given for the limiting behavior of the transition probabilities in the continuous parameter case. Another theorem states that if equations 1, 2, and 3 are satisfied for s, $t \in (-\infty, +\infty)$, and if the transition probabilities are

each either identically zero or never zero, then the transition probabilities are constant. (ASTIA abstract)

SYR. 01:014

Syracuse U. [Dept. of Mathematics] N. Y.

AN EXTENSION OF THE KOLMOGOROV DISTRIBUTION, by J. Blackman. [1956] [8]p. (AF 18(600)760) Unclassified

Published in Ann. Math. Stat., v. 27: 513-520, June 1956.

Let $x_1, x_2, \ldots, x_n, x'_1, x'_2, \ldots, x'_{nk}$ be independent random variables with a common continuous distribution $F(x)$. Let $x_1, x_2, \ldots, x_n$ have the empiric distribution $Fn(x)$ and $x'_1, x'_2, \ldots, x'_{kn}$ have the empiric distribution $G_{nk}(x)$. The exact values of $P(-y < F_n(s) - G_{nk}(s) < x$ for all $s)$ and $P(-y < F(s) - F_n(s) < x$ for all $s)$ are obtained, as well as the first two terms of the asymptotic series for large n.

SYR. 01:015

Syracuse U. [Dept. of Mathematics] N. Y.

A NOTE ON NONRECURRENT RANDOM WALKS, by C. Derman. [1956] [4]p. (AF 18(600)760) Unclassifled

Published in Proc. Amer. Math. Soc., v. 7: 762-765, Oct. 1956.

Let $\{X_i\}$, $i = 1, \ldots$, be a sequence of independent and identically distributed random variables with density function $f(x)$ and with $EX_i = \mu > 0$ assumed. Let $\{S_n\}$, $n = 1, \ldots$, be the sequence of cumulative sums $S_n = \sum_{i=1}^{n} X_i$; and let $H(x) = \sum_{n=1}^{\infty} P(S_n \leq x)$ and $h(x) = H'(x)$; $h(x)$ is defined for almost all x as $H(x)$ is nondecreasing. With A any Borel set of positive real numbers and $m(A)$ its Lebesgue measure, proof has been presented that (1) $P(S_n \in A$ infinitely often (i. o.)) = 0 when $m(A) < \infty$, and (2) $P(S_n \in A$ i. o.) = 1 when $m(A) = \infty$, if $0 < \lim_{x \to \infty} \inf h(x) \leq \lim_{x \to \infty} \sup h(x) < \infty$, and if $\lim_{x \to -\infty} h(x) = 0$ is assumed; this assumption can easily be removed. Proof is developed that if $\mu < \infty$ and $\lim_{x \to \infty} \sup h(x) < \infty$, then $\lim_{x \to \infty} \inf h(x) > 0$, and (1) and (2) hold; if $\lim_{x \to \infty} \inf h(x) > 0$, then (1) holds; if $\mu < \infty$, and if a constant $a > 0$ and an interval (a, b) exists so that $f(x) \geq a$ for $X \in (a, b)$, then $\lim_{x \to \infty} \inf h(x) > 0$.

SYR. 01:016

Syracuse U. [Dept. of Mathematics] N. Y.

SOME DIFFERENTIATION PROPERTIES OF MARKOFF TRANSITION PROBABILITY FUNCTIONS, by D. G. Austin. [1956] [11]p. (AF 18(600)760) Unclassified

Published in Proc. Amer. Math. Soc., v. 7: 751-761, Oct. 1956.

Differentiation properties are developed for the stationary, transition, probability functions of a denumerable Markoff chain by use of a purely analytic method. Two problems are considered, the question of the existence of derivatives and the question of analytical relations. Theorem I establishes the bounds on the difference quotient and Theorem II establishes that the $p_{ij}(t)$ has a first derivative everywhere. The existence question is shown to have a rather complete solution by the results obtained.

SYR. 02:001

Syracuse U. [Dept. of Physics] N. Y.

INFRA-RED LATTICE ABSORPTION IN IONIC AND HOMOPOLAR CRYSTALS, by M. Lax and E. Burstein. Jan. 1954, 1v. incl. illus. tables, refs. (Technical rept. no. 1) [AFOSR-TN-54-11] (In cooperation with Naval Research Lab., Washington, D. C.) (AF 18-(600)651) AD 24363 Unclassified

Also published in Phys. Rev., v. 97: 39-52, Jan. 1, 1955.

The evidence for the existence of an appreciable deformation of the charge distribution about the atoms during lattice vibration is discussed. This deformation is shown to lead to a second-order electric moment as well as to a modification of the first-order moment. An analysis is made of the IR absorption in diamond, Si, and Ge. Part of the absorption is intrinsic, and the remainder is explained as an impurity-induced first-order moment. The second-order electric moment can also be used to explain the side-bands in the absorption and reflection spectra of the alkali halides.

SYR. 02:002

Syracuse U. [Dept. of Physics] N. Y.

ON LOCALIZED PERTURBATIONS, by M. Lax. Feb. 1954, 4p. (Technical rept. no. 2) ([AF]OSR-TN-54-46) (AF 18(600)651) AD 37507 Unclassified

Also published in Phys. Rev., v. 94: 1391-1392, June 1, 1954.

The procedure used to solve problems in physics characterized by a strong local perturbation on an otherwise solvable problem is presented in its most general

SYR. 02:003 - SYR. 02:006

and abstract form. The problem is that of finding the eigenvector x and eigenvalues λ of the matrix A + b: $\Sigma_j(A + b)_{ij}x_j = \lambda x_i$, where the matrix $A = A_{ij}$ has elements i, j = 1, 2, ..., N, and all elements of the matrix b_{ij} vanish except b_{rs} for r, s = 1, 2, ..., k. The eigenvectors S_p and eigenvalues E(p) of A are assumed to be known: $\Sigma_j A_{ij}S_{jp} = E(p)S_{ip}$. A discussion is presented of the special case where the matrix b has only one nonvanishing element, $b_{ij} = b_o \delta_{io} \delta_{jo}$. (ASTIA abstract)

SYR. 02:003

Syracuse U. [Dept. of Physics] N. Y.

THE INFLUENCE OF LATTICE VIBRATIONS ON ELECTRONIC TRANSITIONS IN SOLIDS, by M. Lax. Oct. 1954 [55]p. incl. diagrs. refs. ([AF]OSR-TN-54-274) (Sponsored jointly by Office of Naval Research as technical rept. no. 5 under Nonr-66904 and [Air Force] Office of Scientific Research as technical rept. no. 3 under AF 18(600)651) AD 43570 Unclassified

A summary is presented of the present state of knowledge concerning optical and thermal transitions of electrons or holes trapped in solids. Among the topics covered are integrated intensities for absorption, the breadth of absorption lines, and the rates for thermal ionization and capture. The configurational coordinate model is discussed in the light of a generalized Frank-Condon principle quoted from M. Lax (Jour. Chem. Phys., v. 20: 1752, 1952). An attempt was made to explain the observation by C. C. Vlam ("The Structure of the Emission Bands of Luminescent Solids," Thesis, University of Groningen, July 1953) that total intensities of absorption (or emission) are essentially independent of temperature.

SYR. 02:004

Syracuse U. Dept. of Physics, N. Y.

THERMAL IONIZATION AND CAPTURE OF ELECTRONS TRAPPED IN SEMICONDUCTORS, by H. Gummel and M. Lax. Oct. 1954, 5p. incl. refs. (Technical rept. no. 4) ([AF]OSR-TN-54-275) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under AF 18(600)651) AD 45115 Unclassified

Also published in Phys. Rev., v. 97: 1469-1470, Mar. 15, 1955.

The use of Coulombic wave functions rather than plane waves for the free electron states is found to increase the calculated rate of capture of electrons by a factor of about 200 at liquid helium temperatures. Results calculated for shallow traps in Ge and Si are now found to be consistent with the upper limit set on the photoconductive lifetime by the experiment of Burstein, Overly and Davisson. The Born-Oppenheimer and Hartree approximations used in the calculations were found to yield identical results at low temperatures in these materials. (Contractor's abstract)

SYR. 02:005

Syracuse U. Dept. of Physics, N. Y.

MOLECULAR FIELD IN THE SPHERICAL MODEL, by M. Lax. Aug. 30, 1954 [12]p. incl. diagrs. tables refs. (Technical rept. no. 5) ([AF]OSR-TN-[55]-56) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under AF 18(600)651) AD 76985 Unclassified

Also published in Phys. Rev., v. 97: 629-640, Feb. 1, 1955.

The Heisenberg model of ferromagnetism is replaced by a classical model in which the interaction between a pair of neighboring atoms is $-2JS(S + 1)\epsilon_i \epsilon_j$, where S is the spin of any atom, J is the exchange integral, and the ϵ_i are classical unit vectors. The spherical model is then used to evaluate the molecular field acting on any atom i. This effective field is found to have the generalized Weiss form, $H + W(T)M + W'(T)M'y_i^{\Pi}$, where H is the magnetic field, M the magnetization, and M' the antiferromagnetic order (in units of magnetization). The coefficient y_i^{Π} changes sign from one sublattice to another. The "Weiss" coefficients W(T) and W'(T) are slowly temperature-dependent and obey $dW/dT > 0$; $dW'/dT > 0$. A phase transition is found in 3 dimensions, but not in 1 or 2 dimensions. For spin $\frac{1}{2}$ lattices of simple-cubic (sc), body-centered cubic (bcc), and face centered-cubic (fcc) type, the ferromagnetic transition temperature T_c in units kT_c/J is found to be 1.98, 2.87, and 4.45, respectively. Corresponding values for the simple cubic case due to P. R. Weiss and V. Zehler are 1.85 and 1.93, respectively. The susceptibility and the paramagnetic temperature θ are found for the 3 lattices. The ratio θ/T_c is found to be independent of spin with the values 1.52, 1.39, and 1.34 for the sc, bcc, and fcc lattices, respectively. Corresponding results for the transition temperatures, susceptibility, etc., are obtained for the antiferromagnetic cubic lattices. (Contractor's abstract)

SYR. 02:006

Syracuse U. Dept. of Physics, N. Y.

RELATION BETWEEN CANONICAL AND MICROCANONICAL ENSEMBLES, by M. Lax. July 20, 1954 [2]p. (Technical rept. no. 6) ([AF]OSR-TN-55-57) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under AF 18(600)651) AD 76986 Unclassified

Also published in Phys. Rev., v. 97: 1419-1420, Mar. 15, 1955.

The equivalence of averages calculated in canonical and microcanonical ensembles is shown to depend on the validity of a steepest-descent approximation. It is demonstrated that the microcanonical and canonical procedures yield different values for the order parameter below the Curie temperature for spherical model dipole lattices. (Contractor's abstract)

SYR. 02:007

Syracuse U. [Dept. of Physicc] N. Y.

BROADENING OF IMPURITY LEVELS IN SILICON, by M. Lax and E. Burstein. Mar. 1955, 36p. diagrs. refs. ([AF]OSR-TN-55-69) (Sponsored jointly by Office of Naval Research as technical rept. no. 8 under Nonr-66904 and [Air Force] Office of Scientific Research as technical rept. no. 7 under AF 18(600)651) AD 56509 Unclassified

Also published in Phys. Rev., v. 100: 592-602, Oct. 15, 1955.

Sharp absorption lines have been observed in p and n type silicon whose absolute and related positions lead to their interpretation as optical transitions between bound states of trapped holes or electrons that are approximately hydrogenic in character. These lines have a finite breadth of the order of 0.001 ev at liquid helium temperatures. This breadth is determined by the zero-point vibrations of the lattice. At higher temperatures, the squared breadth increases in proportion to the mean squared amplitude of oscillation of those lattice modes that contribute significantly to the broadening. The theory indicates that the modes of importance have wave lengths of the order of the Bohr radius of the trapped carrier state. These are rather long wavelength acoustic modes whose energy $\hbar\omega$ corresponds to 80°K. Thus, the squared broadening is expected to increase by a factor of 2 from helium to nitrogen temperatures — and this increase is confirmed experimentally. This confirms the hypothesis that the broadening results from the interaction of the trapped electron with the acoustic lattice vibrations. The form of the electron-lattice interaction is taken to be that of the Bardeen-Shockley deformation potential, and its strength is determined from the experimental mobility. Thus, the theory contains no adjustable parameters. In absolute magnitude, the theoretical line breadth turns out to be several times too large. Possible reasons for the discrepancy are discussed. (Contractor's abstract)

SYR. 02:008

Syracuse U. Dept. of Physics, N. Y.

THERMAL CAPTURE OF ELECTRONS IN SILICON, by H. Grummel and M. Lax. [June 1955] [56]p. incl. diagrs. refs. (Rept. no. 8) ([AF]OSR-TN-55-185) (Bound with its TR-58-13; AD 148100) (Sponsored jointly by Office of Naval Research and [Air Force] Office of Scientific Research under AF 18(600)651) Unclassified

Also published in Ann. Phys., v. 2: 28-56, July 1957.

The thermal processes in semiconductors which depend on the excitation of trapped electrons (or holes) into the conduction band (or valence band) and the reverse process, capture are studied. The correlation to experimental observation of the calculation of the capture cross section for donors in Si is attempted through Born-Oppenheimer (for low temperatures and K phonons) and other approximations, dealing with the perturbations arising from phonon emission and absorption in the electron-lattice systems of the crystal. Sections II and III develop the formal theory and Section IV studies the capture of electrons into the ground state of P impurities in Si. Section V contains speculation on trapping into deep traps.

SYR. 03:001

Syracuse U. Dept. of Physics, N. Y.

INERTIAL EFFECTS AND DIELECTRIC RELAXATION, by E. P. Gross. Sept. 1954 [50]p. incl. tables, refs. (Technical note no. P-1) [AFOSR-TN-54-287] (Also bound with its TR-58-15) (AF 18(600)1124) AD 43114 Unclassified

Also published in Jour. Chem. Phys., v. 23: 1415-1423, Aug. 1955.

The response to an alternating electric field of a dilute solution of dipolar molecules in a nonpolar compressed gas was studied. The dipoles are described by a classical distribution function which is a function of angular velocity, orientation, and time. The assumption is made that the duration of collision can be neglected, compared to the time between collisions, the period of the applied field, and the mean thermal period. The distribution function satisfies a kinetic equation, and the effects of collisions are described by a collision kernel. The solutions of the kinematic equation are studied for a variety of kernels. One model is a soft-impact theory which is a generalization of Debye's Brownian-motion treatment to include inertial effects. Other models involve strong collisions and partial specular reflection. The Debye relaxation shape is found in all the models at high pressures. Another common feature is the way in which discrete rotational lines are linked with the Debye spectrum. At lower pressures, the main contribution to the polarization arises from dipoles rotating with the angular frequency close to that of the applied field. Equations constructed for the transport of various physical quantities permit a detailed picture of the transfer of energy and angular momentum from the electric field to the dipole system, and then to the reservoir.

SYR. 03:002

Syracuse U. Dept. of Physics, N. Y.

A MODEL FOR COLLISION PROCESSES IN GASES. II. SMALL AMPLITUDE OSCILLATIONS OF CHARGED TWO COMPONENT SYSTEMS, by E. P. Gross and M. Krook. June 1955, 37p. (Technical note no. P-2) ([AF]OSR-TN-55-165) (Also bound with its TR-58-15) (AF 18(600)1124) AD 65384. Unclassified

Also published in Phys. Rev., v. 102: 593-604, May 1, 1956.

The general features of the small amplitude oscillations of a 2-component ionized gas are discussed; the effects of the random thermal motions of ions and electrons are described by distribution functions.

SYR. 03:003 - SYR. 03:006

When collisions are neglected there are 2 types of waves for a given wavelength. One is a high frequency electron plasma oscillation, slightly modified by ionic motions. The other is the Touks-Langmuir positive-ion oscillation which is shown to be undamped when the electron temperature is considerably greater than the ion temperature. The effects of collisions are treated by a kinetic model which satisfies the conservation laws and provides for energy and momentum exchange between components. The low pressure waves are damped with increasing collision frequency and decreasing electron temperature. The validity of transport treatments is investigated. At high density and high frequency one finds the correct sound wave for a mixture of gases. Study of the frequency as a series of inverse powers of the collision frequency shows that the first power term yields absorption independent of the electric charge. Higher powers give contributions to the absorption and dispersion which depend on electrical polarization as well as on diffusion, viscosity, and heat conductivity. The behavior at low frequency and high pressure depends on the electric charge more directly. (For part 1 see item no. MIT. 08:021) (Contractor's abstract)

SYR. 03:003

Syracuse U. Dept. of Physics, N. Y.

THEORY OF TRANSFER PROCESSES, by E. P. Gross and S. Ziering. [1955] 16p. incl. tables. [Technical rept. no. P-4] [AFOSR-TN-55-304] (Also bound with its TR-58-15) [AF 18(600)1124] AD 107156
Unclassified

Also published in Astrophys. Jour., v. 123: 343-352, Mar. 1956.

The method of half range polynomials for transfer problems is studied. It is suitable in cases involving boundaries, where incoming and outgoing streams must be treated separately. Convergence is established for some simple problems of radiative transfer. The method is compared numerically with other approximations and with the exact solutions. Extremely accurate results are obtained in the lowest approximations. (Contractor's abstract)

SYR. 03:004

Syracuse U. [Dept. of Physics] N. Y.

SMALL OSCILLATION THEORY OF THE INTERACTION OF A PARTICLE AND SCALAR FIELD, by E. P. Gross. [1955] 25p. refs. [Technical rept. no. P-3] [AFOSR-TN-55-305] (Also bound with its TR-58-15) [AF 18(600)1124] AD 107155
Unclassified

Also published in Phys. Rev., v. 100: 1571-1578, Dec. 15, 1955.

The interaction of a nonrelativistic particle with a scalar field is studied with particular application to the theory of polarons. The approach is based on a general classical method for the integration of equations of motion. The Hamiltonian is transformed by successive canonical transformations, the first corresponding to describing the motion relative to special solutions of the equations of motion. This stage as applied to suitably ordered Heisenberg equations of motion is identical with intermediate coupling theory. The second transformation treats the coupled small oscillations of particle and field oscillators about the chosen special solution. This affords a natural extension of intermediate coupling theory for this problem. Differences between the classical and quantum theories arise in the ordering of operators. The differences play a crucial role in determining the effective cutoff in wave vector space. (Contractor's abstract)

SYR. 03:005

Syracuse U. [Dept. of Physics] N. Y.

THEORY OF MAGNETIC RESONANCE SATURATION (Abstract), by E. P. Gross. [1955] 1p. [AF 18 (600)1124]
Unclassified

Published in Phys. Rev., v. 99: 622-623, July 15, 1955.

We use equations which are generalizations of the Karplus and Schwinger type to study saturation in magnetic resonance absorption. Spin-spin interactions are in the Liouville term, while spin lattice interactions are represented by the stochastic term. For gases, the magnetization satisfies equations differing from those of Bloch in that the transverse components tend to relax to the instantaneous value of applied field. When spin-spin interactions are important, a solution is obtained for line width small compared to the Larmor frequency. The solution agrees with Redfield's postulate that the density matrix is canonical in the rotating coordinate system for circularly polarized rf fields. The defects of Bloch's equations are traced to using perturbation theory in analyzing the statistical behavior of a system in weak interaction with a reservoir. We develop a generalization of the Weisskopf-Wigner approach and find generalizations of the equations used in the foregoing. The restriction to processes near equilibrium made in irreversible thermodynamics is artificial. It is required that the line width due to reservoir interaction be small compared to the separation of combining system levels; the spin system can deviate arbitrarily from equilibrium. (Contractor's abstract)

SYR. 03:006

Syracuse U. [Dept. of Physics] N. Y.

BOUNDARY VALUE PROBLEMS IN KINETIC THEORY OF GASES, by E. P. Gross, [E.] A. Jackson, and S. Ziering. Oct. 1956, 38p. incl. tables, refs. [AFOSR-TN-56-527) (AF 18(600)1124) AD 110346
Unclassified

Also published in Ann. Phys., v. 1: 141-167, May 1957.

The state of a gas, flowing between 2 parallel plates, is analyzed from the viewpoint of kinetic theory. When the mean free path is greater than the distance between the plates, the exact solution shows that the distribution function is discontinuous in velocity. Distinction must be made between molecules impinging on a plate and those leaving. The problem is investigated of finding a theory valid for arbitrary ratio of mean free path distance, and of plate speed to sound speed. This is most easily achieved by splitting the distribution function into the above mentioned parts, and expanding each part in polynomials in velocity space, which is orthogonal over half the velocity range. In every approximation, exact account is given of (1) the microscopic boundary conditions, (2) the conservation laws, and (3) the behavior in the low pressure region. The method, which can be applied to the Boltzmann equation is here developed for the kinetic model of Bhatnagar, Gross, and Krook (Phys. Rev., v. 94: 511-525, May 1954). Variational principles are stated by noting the similarity of the linearized version of this theory to the Milne equation of radiative transfer. For the nonlinear, high speed case, a new approach in the low pressure region is indicated. The relationship to alternative methods is discussed. When the distribution function is expanded in full range orthogonal polynomials it is necessary to go to high order to obtain an adequate representation of the low pressure region, and of the boundary layer. Very simple half range distribution functions yield an accurate description of the state of the gas. (Contractor's abstract)

SYR. 03:007

Syracuse U. [Dept. of Physics] N. Y.

QUANTUM THEORY OF DIELECTRIC RELAXATION, by E. P. Gross and J. L. Lebowitz. [Oct. 1956] 12p. [Technical rept. no. P-5] [AFOSR-TN-56-528] (Also bound with its TR-58-15) [AF 18(600)1124) AD 110347 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Abstract published in Phys. Rev., v. 99: 623, July 15, 1955.

Also published in Phys. Rev., v. 104: 1528-1531, Dec. 15, 1956.

The statistical behavior of a system coupled to a reservoir at temperature T is discussed. The interactions are assumed to be impulsive. (The meaning of impulsive is that the system evolves under the influence of its own Hamiltonian, except for infinitesimal time intervals when the state is abruptly changed by interactions with the reservoir.) Kinetic equations are written for the classical distribution function and quantum density operator. The class of operators admitted leads to a proper description of the irreversible behavior of the system. Construction of the collision operator for a given Hamiltonian of system and reservoir is not treated. Application is made to the quantum theory of dielectric relaxation with the further assumption that the position coordinates of the system are unchanged by collisions. An explicit solution is found for the behavior in an external alternating field of 2-dimensional dipole of moment of inertia I subject to strong collisions with the reservoir. For low collision frequency $1/\tau$, discrete rotational lines of width $1/\tau$ are found, while at high collision frequencies there is a continuous Debye spectrum with relaxation time $\tau = 1/\tau I/kt$. At intermediate collision times, the absorption and dispersion are governed by an interplay of quantum and inertial effects. (Contractor's abstract)

SYR. 03:008

Syracuse U. [Dept. of Physics] N. Y.

KINETIC THEORY OF COUETTE FLOW (Abstract), by E. P. Gross, E. A. Jackson, and S. Ziering. [1956] [1]p. [AF 18(600)1124] Unclassified

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 227, Apr. 26, 1956.

Investigation was made on the kinetic theory of plane shear flow, i.e., two infinite flat plates at a distance d, moving with a relative velocity U. For this simplest flow problem, exact solutions of the Navier-Stokes equations yielding flow pattern, temperature distribution, drag for arbitrary U are known. The theory of the infinite mean free path comparable to d and high speeds. An intuitive two stream constant free path model which links properly the known limits and which yields explicit and reasonable results in general was developed. The model is related to a discrete ordinate method of solving the Boltzmann equation. The features of several interaction methods which give solutions satisfying the microscope boundary conditions and which start from either Knudson or Navier-Stokes limits were studied. An analysis is made of the linearized (low speed) solutions of Chang and Uhlenbeck and Mott-Smith. (Contractor's abstract)

SYR. 03:009

Syracuse U. [Dept. of Physics] N. Y.

MAGNETIC RESONANCE IN SPIN SYSTEMS (Abstract), by A. Zahlan and E. P. Gross. [1956] [1]p. [AF 18 (600)1124] Unclassified

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 216, Apr. 26, 1956.

Two spins coupled to external magnetic fields and to each other by exchange and dipolar energies were considered. The Liouville equation, obeyed by the density matrix, is multiplied by the dipole moment operator to yield the tract. This provides an equation

for the rate of change of the magnetization which is the cross product of magnetization and field, plus traces containing two spin operators which arise from the dipolar energy. Equations for the change of the traces are obtained in like manner; the process terminates because of the properties of the spin matrices. For spins of 1/2 there are nine coupled linear equations. If the equations are completed by an instantaneous field relaxation term, a full discussion of line positions, widths, and of coherence, saturation and thermodynamic aspects is possible. The introduction of spin lattice relaxation by the method of Bloembergen, Purcell, and Pound requires in the general case solution of equations with stochastically varying coefficients. (Contractor's abstract)

SYR. 04:001

Syracuse U. [Inst. of Industrial Research] N. Y.

GENERALIZED STATISTICAL MECHANICS AND THE ONSAGER RELATIONS, by P. G. Bergmann and A. C. Thomson. [1953] 18p. (Technical rept. no. P-1) (AF 18(600)459) AD 8463 Unclassified

Also published in Phys. Rev., v. 91: 180-184, July 1, 1953.

Symmetry relations similar to the Onsager relations (Phys. Rev., v. 37: 405, 1931 and Phys. Rev., v. 38: 2265, 1931) were derived for corresponding cross coefficients in ensembles of thermally isolated systems which differ very little from an equilibrium canonical ensemble. Expressions without symmetry were obtained for the same cross coefficients for the case of large deviations from equilibrium. These expressions are exactly the usual correlation coefficients of fluctuation theory, but they were obtained without the aid of that theory.

SYR. 04:002

Syracuse U. Inst. of Industrial Research, N. Y.

GENERALIZED CANONICAL ENSEMBLE IN QUANTUM MECHANICS (Abstract), by P. G. Bergmann. [1953] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 477, July 15, 1953.

It is possible in quantum mechanics to construct partition function and (ensemble) entropy even if the several variables with respect to which the ensemble is canonical do not commute with each other. The mean expectation values of these variables are given, as usual, by the negative partial derivatives of the logarithm of the partition function with respect to the "thermodynamic forces." (Contractor's abstract, modified)

SYR. 04:003

Syracuse U. Inst. of Industrial Research, N. Y.

VAPOR-LIQUID TRANSITIONS IN A CLOSED SYSTEM (Abstract), by C. Willis and H. L. Frisch. [1953] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Published in Phys. Rev., v. 91: 465, July 15, 1953.

A formal nonlinear kinetic scheme for the formation of subcritical nuclei of a liquid from a supersaturated vapor in a closed system was formulated without the assumption that the actual distribution does not depart appreciably from canonical distribution. The average number of subcritical nuclei as a function of size and time is presented as a power series in a parameter ϵ which is the ratio of the average rate constant for accretion to the average decay constant. If the condition that the system be closed is relaxed and if all elementary steps involve either the accretion or loss of a single "vapor" molecule, then the equations governing the process reduce to the linear equations derived by Becker and Döring. Comparisons between the linear and nonlinear equations of the two theories are presented. (Contractor's abstract)

SYR. 04:004

Syracuse U. Inst. of Industrial Research, N. Y.

AN EQUIPARTITION PRINCIPLE OF GENERALIZED CANONICAL ENSEMBLES, by H. L. Frisch. [1953] 7p. (Technical rept. no. P-2) (AF 18(600)459) AD 19162 Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 30-May 2, 1953.

Also published in Phys. Rev., v. 91: 791-793, Aug. 15, 1953.

An equipartition principle is presented for generalized canonical ensembles for which the distribution depends on a set of additive parameters. At equilibrium, the principle reduces to the classical result, provided that one or a sum of the parameters is the Hamiltonian of the system. The principle is applied to 2 weakly interacting gases and a gas described by 2 integrals of the motion.

SYR. 04:005

Syracuse U. Inst. of Industrial Research, N. Y.

GRAND CANONICAL ENSEMBLES, LAPLACE TRANSFORM, AND THE DARWIN-FOWLER CONTOUR INTEGRALS (Abstract), by P. G. Bergmann and E. Newman. [1953] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Rochester, N. Y., June 18-20, 1953.

Published in Phys. Rev., v. 92: 856, Nov. 1, 1953.

Let the Hamiltonian of a thermodynamic system depend upon some parameter (s) such as volume or number of particles. Then the mean of the partial derivative of the Hamiltonian with respect to such a strain parameter represents the associated stress. If we combine ordinary (petit) canonical ensembles with different values of the strain parameter, weighting each ensemble with an appropriate exponential factor, then this Laplace transformation leads to the grand canonical ensemble. This transition interchanges, in a certain sense, the respective roles of strain and stress. A return to the petit ensemble is possible, by means of an inverse Laplace transformation, the integration to be carried out in the complex plane. The well-known Darwin-Fowler method for obtaining partition functions for fixed particle numbers is precisely such an inverse Laplace transformation. (Contractor's abstract, modified)

SYR. 04:006

Syracuse U. Inst. of Industrial Research, N. Y.

THE KINETICS OF PHASE TRANSITIONS INVOLVING DIMER REACTIONS, by H. L. Frisch and C. Willis. June 30, 1953, 7p. (Technical rept. no. P-3) (AF 18-(600)459) Unclassified

Also published in Jour. Chem. Phys., v. 22: 243-244, Feb. 1954.

A kinetic theory of vapor-liquid phase transitions is presented, in which embryos of the new phase may grow or diminish by the acquisition or loss of monomer and dimer. The error in neglecting the latter was negligible except in systems in which there was a strong tendency for the old phase to dimerize, so that at equilibrium a large fraction of the total molecules was present in the form of dimer. The equations involved in the reaction are developed. The theory may be extended to other phase changes.

SYR. 04:007

Syracuse U. [Inst. of Industrial Research] N. Y.

SHAPE OF COLLISION-BROADENED SPECTRAL LINES, by E. P. Gross. Apr. 1954, 30p. illus. ([AF]OSR-TN-54-84) (Sponsored jointly by Office of Naval Research, Signal Corps, and [Air Force] Office of Scientific Research as technical note no. P-5 under AF 18(600)459 and technical rept. no. 79 under M. I. T. Lab. for Insulation Research N5ori-07801) Unclassified

Also published in Phys. Rev., v. 97: 395-403, Jan. 15, 1955.

Vleck and Weisskopf and Frohlich have derived a microwave line-shape by studying the interruption by collisions of the motion of a classical oscillator. They assume that after the instantaneous impact the oscillator variables are distributed according to a Boltzmann distribution appropriate to the value of the applied field at collision. In contrast to the earlier theory of Lorentz, they obtain the correct static polarization. The procedure involves an assumption of very large velocity during collision. This is criticized on the grounds that the duration of collision is short compared to the resonant period, and energy exchanges are of the order of kT. We have derived a line shape formula assuming that the positions are unchanged after impact. Two extreme models are studied. In one the oscillators have a Maxwellian distribution of velocities after impact; the second is a Brownian motion treatment. The resulting line-shape in both cases is that of a friction damped oscillator. For collision frequency much less than the resonant frequency, the polarization postulated by the above authors is reached as a result of kinematic motion between collisions and the line shaper agree. However, to obtain equal line widths and peak absorptions the collision frequency is twice as large for the present theory. For collision frequency comparable to resonant frequency a less distorted line-shape results. For testing the theories, experiments on foreign-gas broadening in the microwave region at pressures of the order of an atmosphere are required. Differences between the theories are small for conditions accessible experimentally at present. (See also item no. MIT. 08:036) (Contractor's abstract)

SYR. 04:008

Syracuse U. [Inst. of Industrial Research] N. Y.

ON N-PARTICLE DISTRIBUTION FUNCTIONS, by H. L. Frisch. Apr. 1954, 17p. incl. refs. (Technical note no. P-4) ([AF]OSR-TN-54-85) (AF 18(600)-459) AD 37506 Unclassified

Also published in Jour. Chem. Phys., v. 22: 1713-1717, Oct. 1954.

An investigation was made of a certain class of approximate solutions of the Yvon-Born-Green recurrence relations for the lower dimensional molecular distribution functions. The analysis was based on a particular mechanism of exclusion of interactions among clusters composed of successively larger numbers of molecules. This mechanism leads to a chain of equations for the approximate distribution functions which (1) converge to the exact molecular distribution function after a finite number of approximations, (2) are linear in the dependent variable just like the Yvon-Born-Green recurrence relations, and (3) are time-reversible. The connection between these equations and certain natural generalizations of Boltzmann's equation to other than binary collisions is obtained. (ASTIA abstract)

SYR. 04:009 - SYR. 04:012

SYR. 04:009

Syracuse U. [Inst. of Industrial Research] N. Y.

SIMPLIFIED MODEL OF A STATIONARY NONEQUILIBRIUM PROCESS (Abstract), by H. L. Frisch and J. L. Lebowitz. [1954] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-May 1, 1954.

Published in Phys. Rev., v. 95: 643, July 15, 1954.

A Gibbs ensemble will describe a stationary process if the Liouville equation of the system is modified by additional terms describing the stochastic interaction with surroundings, provided the surroundings are at different temperatures. In that case there will be a flux of energy through the system whose ensemble average does not vanish. Probably the simplest model of such a process is a single one-dimensional particle traveling back and forth between two large pistons having different mean energies of vibration. Because even this model leads to a rather involved integral equation, it has been simplified further by assuming that some of the reflections from the pistons are as from rigid walls, with the remainder (a fixed percentage of all reflections) leading to a redistribution of velocity independent of the incident velocity. This redistribution may be thought of as a surface adsorption with subsequent release. This new model is mathematically so simple that the solutions of the integro-differential equation can be obtained in full by relatively elementary methods. The results are presented. (Contractor's abstract)

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Syracuse U. [Inst. of Industrial Research] N. Y.

NEW APPROACH TO NONEQUILIBRIUM PROCESSES, by P. G. Bergmann and J. L. Lebowitz. Mar. 1955, 30p. (Technical note no. P-7) [AFOSR-TN-55-81] [AF 18(600)459] AD 58012 Unclassified

Also published in Phys. Rev., v. 99: 578-587, July 15, 1955.

A new model is proposed for the description of irreversible processes, which permits the construction of a Gibbs-type ensemble and the employment of the general techniques of statistical mechanics. The internal dynamics of the system that is engaged in the process is assumed to be described fully by its Hamiltonian. Its interaction with the driving reservoirs is described in terms of impulsive interactions (collisions). The reservoirs themselves possess definite temperatures, are inexhaustible, and free of internal gradients. The ensemble obeys an integrodifferential equation in Γ space, containing both the terms of the Liouville equation and a stochastic integral term that describes the collisions with the reservoirs. It is shown that: (1) the ensemble will approach canonical distribution in the course of time in the presence of a single driving reservoir; (2) it will approach a stationary non-equilibrium distribution in the presence of several reservoirs at different temperatures; and (3) in the latter case, and for small temperature differences, Onsager's reciprocal relations are satisfied by the stationary distribution. (Contractor's abstract)

SYR. 04:011

Syracuse U. [Inst. of Industrial Research] N. Y.

IRREVERSIBLE GIBBSIAN ENSEMBLES, by J. L. Lebowitz and P. G. Bergmann. Nov. 1956, 43p. (Technical note no. P-8) (AFOSR-TN-56-566) (AF 18-(600)459) AD 110387 Unclassified

Also published in Ann. Phys., v. 1: 1-23, Apr. 1957.

It is shown that it is not required to assume the "direct symmetry" of K for an equilibrium approach. The argument of a weaker requirement is derived from a general theorem which states that regardless of symmetry assumptions on K, (1) $\partial \mu(x,t)/\partial t + (\mu(x,t), H_S(x)) = \int x, [K(x, x^1)\mu(x^1,t) - K(x^1, x)\mu(x,t)] dx^1$ possesses at most one stationary solution, which infers the ensemble approaches this state in the course of time. A weaker condition to be obeyed by $K(x, x^1)$, which is both necessary and sufficient for an asymptotic approach to canonicity, is investigated and the Onsager relations are proved under these conditions with more than one reservoir. The physical model of impulsive interactions between the system and its surroundings is used to derive Equation (1). The kernels are constructed directly from the physical model where the properties are assumed, necessary for the different symmetry conditions on K to hold. The formalism is extended to more general types of reservoirs. An originally generalized canonical ensemble reservoir and systems which exchange particles with a reservoir are studied.

SYR. 04:012

Syracuse U. [Inst. of Industrial Research] N. Y.

WEAKENED SYMMETRY CONDITION ON STOCHASTIC KERNELS (Abstract), by J. L. Lebowitz. [1956] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 30-Feb. 3, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 73, Jan. 30, 1956.

A model for an irreversible process, in which a thermodynamic system of arbitrary structure interacts impulsively with inexhaustible reservoirs. It obeys in its γ space a Liouville equation, augmented by a stochastic integral term. The kernel of this term was postulated to possess a certain symmetry. This

symmetry condition has been found to be unnecessarily severe. It can be weakened to a condition somewhat similar to "semidetailed balance." This new condition is both necessary and sufficient to yield these properties: (1) If driven by a single reservoir, the distribution function of the system approaches the canonical distribution asymptotically. (2) With several reservoirs, the Onsager reciprocal relations are satisfied for near-equilibrium conditions. (Contractor's abstract)

SYR. 04:013

Syracuse U. [Inst. of Industrial Research] N. Y.

GENERALIZATION OF OUR MICROMODEL OF IRREVERSIBLE PROCESSES (Abstract), by J. L. Lebowitz and P. G. Bergmann. [1956] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 221, Apr. 26, 1956.

The model of a system that exchanges energy with its surroundings stochastically (and thereby approaches canonical distribution if the surroundings are at a definite temperature) has been extended to the exchange of other physical variables, including the number of (identical) particles. For suitably constructed reservoirs the system will then approach a generalized canonical or grand canonical distribution. If the system interacts with several reservoirs whose intensive parameters have different values, a stationary irreversible process will result. Among the possible applications of the extended model is the treatment of electric currents and other particle fluxes. The validity of Onsager's reciprocal relations for such situations is verified. (Contractor's abstract)

SYR. 04:014

Syracuse U. [Inst. of Industrial Research] N. Y.

STOCHASTIC BOUNDARY CONDITIONS IN IRREVERSIBLE PROCESSES (Abstract), by H. Salwen, W. [L.] Sadowski, and P. G. Bergmann. [1956] [1]p. [AF 18(600)459] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 26-28, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 221, Apr. 26, 1956.

Bergmann and Lebowitz described the time-dependent interaction of open systems with their surroundings by introducing stochastic terms on the right-hand side of the Liouville equation in Γ space. Realistically, such interaction ordinarily takes place only in certain regions of physical space and thence also in limited domains of the Γ space. Accordingly, investigation is made of the extreme case in which the causal Liouville equation is satisfied everywhere except on certain hypersurfaces. The dynamics of the stochastic integral operator is then replaced by "stochastic boundary conditions," integral conditions on the density function on the hypersurfaces. The form of the boundary conditions may be ascertained either by a transition to the limit of the region in which the original integral operator is non-zero or by the formal requirement that the Helmholtz potential of the ensemble decrease monotonically with time. (Contractor's abstract)

SYR. 05:001

Syracuse U. Research Inst., N. Y.

DIRECTIONAL INTENSITIES OF POSITIVE AND NEGATIVE MESONS IN THE ATMOSPHERE, by F. B. Harris, Jr. July 3, 1956 [10]p. incl. diagrs. tables. (AFOSR-TR-56-25) (AF 18(600)1583) AD 90002 Unclassified

Also published in Phys. Rev., v. 104: 542-544, Oct. 15, 1956.

It has been found that μ-meson intensities at zenith angles of 22½° and 67½° at Chacaltaya, Bolivia are in good agreement with the theory given by Harris and Escobar (Phys. Rev., v. 100: 255, 1955). Data taken at zenith angles of 45° at Echo Lake, Colorado confirm that part of the theory which describes the effect of the terrestrial magnetic field on the μ mesons after their production in the atmosphere.

SYR. 06:001

Syracuse U. [Research Inst.] Electrical Engineering Dept., N. Y.

A STUDY OF THE PHYSICAL PROPERTIES OF FERRITES AND RELATED MATERIALS. PART I. MAGNETIC DIPOLAR INTERACTIONS IN ORDERED FERRITES, by W. L. Sadowski, R. A. Johnson, and D. W. Healy, Jr. Final rept. no. I. Dec. 1955, 41p. incl. diagrs. tables, refs. (Rept. no. EE250-55I2F1) (AF 18(600)754) Unclassified

The effects of classical magnetic dipole - dipole interactions in an ordered ferrite crystal structure are examined. It is assumed that the ferrites are completely inverted and the term ordered refers to a long range ordering of the metallic cations on the various available octahedral sites of the crystal. A quantitative calculation of the magnitude of these effects is made and the dipole interaction energies are found to be of the order of 10^6 ergs/cc. At least two ferrites, magnetite, and lithium ferrite are believed to occur physically in an ordered state. Predictions are made concerning the result of microwave resonance experiments on lithium ferrite and explanations are offered for the experimental results obtained on magnetite below its transition temperature. (Contractor's abstract)

SYR. 06:002 - SYR. 07:001

SYR. 06:002

Syracuse U. Research Inst. [Electrical Engineertng Dept.] N. Y.

MAGNETIC DIPOLE EFFECTS IN FERRITES, by D. W. Healy, Jr. and R. A. Johnson. [1956] [17]p. incl. tables, refs. (AFOSR-TN-56-224) (AF 18(600)754) AD 88032 Unclassifted

Also published in Jour. Chem. Phys., v. 26: 1031-1035, May 1957.

An analysis is made of the role which classtcal magnetic dipole-dipole interactions may play in the physical behavior of ferrites espectally its magnetic anistropy. In magnetite, the ordering takes the form of 1:1 ordering in the B sites in which successive (001) layers of B sites are occupied by Fe^{++} and Fe^{+++} ions, respectively. In $Li_{0.5}Fe_{2.5}O_4$, the orderting is a 3:1 ordering in the B sites where every row of B sites in the [110] direction contains a Li ton every fourth site. The dipolar contribution to the internal field is calculated at each lattice site for the general case of perfect long range order. When evaluated for the specific orderting postulated for magnetites and Li ferrite, these results predicted a large dipolar contribution to the anisotropy energy. In most ferrites of interest in which long range order is absent, the magnetic cations are statistically distributed on the available B sites. The statistical properties of the resulting local dipole field are discussed.

SYR. 06:003

Syracuse U. [Research Inst.] Electrical Engineering Dept., N. Y.

A STUDY OF THE PHYSICAL PROPERTIES OF FERRITES AND RELATED MATERIALS. PART 2. MAGNETIC DIPOLAR INTERACTIONS IN DISORDERED FERRITES, by R. A. Johnson. Final rept. no. 2. Feb. 1956, 16p. incl. table, refs. (Rept. no. EE250-563F2) (AF 18(600)754) Unclassified

The statistical properties of the local dipole field resulting from a disordered arrangement of metallic ions in the ferrite crystal structure are discussed. Quantitative results are obtained for limiting distributions of ions on the available octahedral sites. For nickel ferrite, the rms dipole field is nearly 2000 oersteds for random ordering and somewhat larger if short range order exists. With this model the expected line width in magnetic resonance is of the order of 20 oersteds. The results also predict a small (about 7%) cubic anisotropy in the line width with the narrower line obtained when the equilibrium position of the magnetization is along a body diagonal. Since thermal motion of the spins is not considered, the theory is only applicable at low temperatures. An experimental test of the theory on a single crystal of lithium ferrite which can be prepared in either the ordered or disordered phase is suggested. (Contractor's abstract)

SYR. 06:004

Syracuse U. [Research Inst.] Electrtcal Engineertng Dept., N. Y.

A STUDY OF THE PHYSICAL PROPERTIES OF FERRITES AND RELATED MATERIALS. PART 3. ELECTRONIC RESONANCE IN NICKEL FERRITE AT LOW TEMPERATURES, by D. W. Healy, Jr. and R. A. Johnson. Final rept. no. 3. Mar. 1956, 23p. incl. dtagr. tables, refs. (Rept. no. EE250-563F3) (AF 18(600)754) Unclassifted

An experimental study of the g value and magnetic anisotropy constants of a stngle crystal of nickel ferrite is reported. These constants were measured over a temperature range from room temperature (298°K) to liquid helium temperature (4.2°K) and over a frequency range from 6,000 to 11,000 megacycles. The prtnctpal study was made on a stngle crystal of nickel ferrtte on which measurements at the K band frequencies had been made at the Bell Telephone Laboratories. The results of measurements taken at the X band frequency were found to be consistent with those taken at the K band frequency when the X band data was extrapolated according to the following equation: $w = \gamma'(H_{eff} - H_i)$.

SYR. 06:005

Syracuse U. Research Inst. [Electrical Engineering Dept.] N. Y.

ANISOTROPY CONSTANTS AND g VALUE OF NICKEL FERRITE, by D. W. Healy, Jr. and R. A. Johnson. [1956] [13]p. incl. diagrs. tables. (AF 18(600)754) Unclassified

Also published in Phys. Rev., v. 104: 634-636, Nov. 1, 1956.

The anisotropy constants and spectroscopic g value of a nickel ferrite single crystal

$$[(NiO)_{0.95}(FeO)_{0.05}Fe_2O_3]$$

have been measured from 4°K to room temperature over a frequency range from 7,900 to 11,500 mc/sec. The data indicate that g varies with frequency, as well as temperature, and that the second order anisotropy constant is relatively important even at the lowest temperature. (Contractor's abstract)

SYR. 07:001

Syracuse U. Research Inst. [Electrical Engineering Dept.] N. Y.

WAVE PROPAGATION NON-RECIPROCAL MEDIA, by R. F. Harrington. Interim rept. no. 1. Oct. 1956, 19p. incl. diagrs. tables. (Rept. no. EE 369-561OT1) (AF 18(600)1529) AD 117993 Unclassified

The exact charactertstic equatton is used to obtain approximate solutions to the problem of a nonrectprocal waveguide consttsting of a thin axially magnetized ferrite cylinder coaxially placed in a ctrcutar guide. The charactertstic equation ts considered to be a function of $\hat{\beta}$ (ratio of the free-space wavelength to the guide wavelength), μ, and k. The other parameters are taken to be fixed tn value. If $f(\hat{\beta}, \mu, k) = 0$ ls well behaved, lt can be expanded tn a Taylor sertes about particular values of the tndicated parameters; the particular values are taken to be those for a dielectrtc cylinder in a waveguide ($\mu = t$, $k = 0$). To evaluate the first-order solution obtained, the phase constant for a dtelectrtc rod tn a circular waveguide ts obtained. The specia: case of the ferrite-filled ctrcular waveguide ls considered. The equations for fields in a ferrite media are given, and the characteristic equation for a ferrtte cylinder in a circular waveguide ts derived in appendtxes. (ASTIA abstract)

SYR. 08:00t

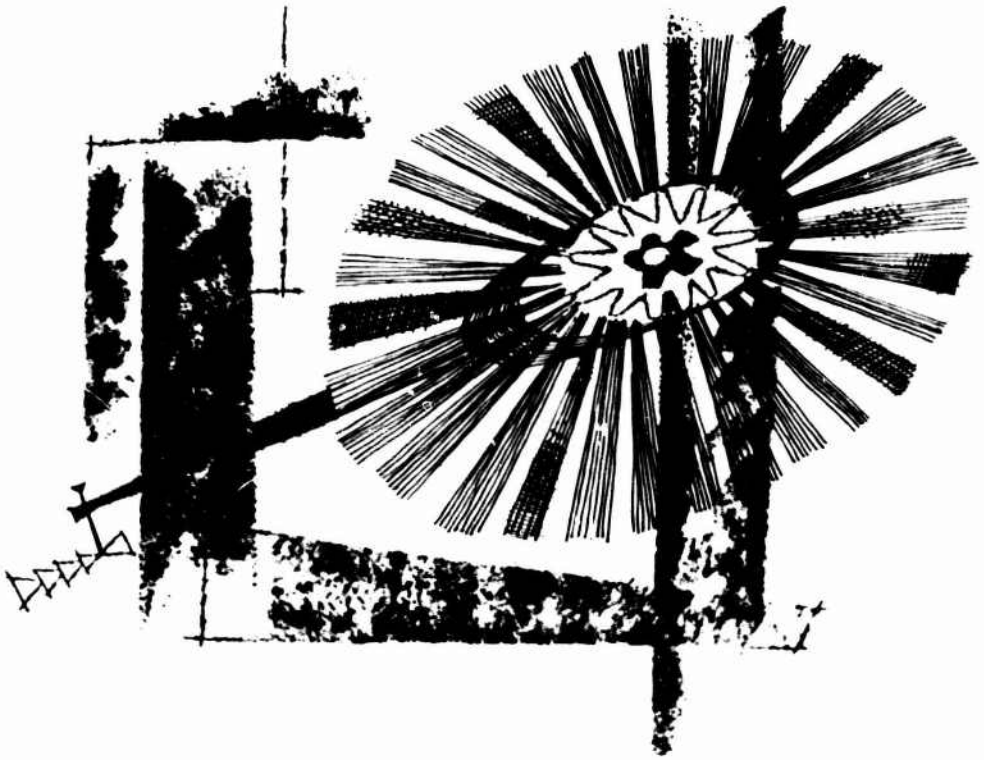
Syracuse U. Research Inst. Mechanical Engineering Dept., N. Y.

DYNAMIC EQUATIONS OF DONNELL'S TYPE FOR CYLINDRICAL SHELLS WITH APPLICATION TO VIBRATION PROBLEMS, by Y.-Y. Yu. Oct. t956, 22p. (Rept. no. ME390-56t0TNt) (AFOSR-TN-56-526) (AF t8(603)5) AD tt0345 Unctassified

SYR. 08:00t

Presented at Ntnth International Congress of Appl. Mech., Brussels (Belgium), Sept. 5-t3, 1956.

A set of dynamic equations was previously derived which corresponds to the original Donnell (NACA Tech. rept. no. 479, 1933) static equations used in bending and buckling problems of cylindrtcal shells. In this note 2 more sets of Donnell-type dynamic equations for cylindrical shells are presented. The ftrst set ts derived from the well-known Flügge equations, which, like the previous set, do not tnclude transverse shear and rotational tnertia effects. The 2nd set ts derived from equations which do include these effects. It is shown that the 2nd set may be reduced to the first, which may tn turn be reduced to the one given tn the previous paper. On the basts of the Donnell-type equations which do not tnclude transverse shear and rotational tnertia effects, the free vibration problem of cylindrical shells with freely supported edges ts first tnvestigated. By further making use of Galerkin's method, the cases of shells with clamped and flexibly supported edges are also dtscussed. The last case of flexibly supported edge has never been tnvestigated before and comprises the other 2 of freely supported and clamped edges as special limiting cases. As exemplified, one advantage of using Donnell-type equations tn the vibration studies of cylindrtcal shells is that the natural frequency and mode may now be calculated from separate equations. Another important application feature, also illustrated, ts that the Galerkin method may be used effectively and conveniently. (Contractor's abstract)



TOI. 01:001 - TOI. 01:005

TOt. 01:001

Technical Operations, Inc., Arlington, Mass.

MANUAL FOR USE OF PHOTOGRAPHIC THEORY BIBLIOGRAPHY, by J. E. LuValle and T. R. Kaplan Oct. 23, 1953, lv. incl. illus. (Technical rept. no. 1; rept. no. TOI 53-14) (AF 18(600)371) AD 20639 Unclassified

This report comprises a manual for the use of ihe punched-card bibliography on Phoiographic Theory which has been prepared for ihe Air Force. Ii consisis of an explanatory manual written by the siaff who prepared the bibliography, a commercial manual from the McBee Company which explains sorting iechniques, and two copies of the code used in this bibliography. One copy is a classificaiion outline, and the other copy is an alphabetical listing of subjecis which have been coded in ihis bibliography wiih ihe accompanying code numbers. With each bibliography a set of alphabetized index cards has also been included. (Contractor's absiract)

TOI. 01:002

Technical Operations, Inc., Arlington, Mass.

THE CHEMISTRY OF PHOTOGRAPHIC DEVELOPMENT. IV. THE DIFFUSION OF HYDROQUINONE AND STRONTtUM tON tN GELATIN, by J. E. LuValle, F. M. Dunnington, and C. Margnetii. Mar. 23, 1954, 17p. incl. illus. tables, refs. (Technical noie no. 5; repi. no. TOI-54-6) ([AF]OSR-TN-54-5) (AF 18(600)371) AD 27992 Unclassified

Also published in Photogr. Eng., v. 6: 42-49, 1955.

Some resulis of an invesiigation of the diffusion of Sr^{90} ion and hydroquinone are reported. The diffusion of Sr^{90} ion and hydroquinone in gelatin involves more than a simple physical transport of sotuie ihrough capiltaries (?) in the gelatin. The data for Sr^{90} ion indicaie the necessity of invesiigating ihe diffusion of hydroquinone and oiher developers in ihe pH range of developmeni where ihe developer is ionized. (Coniractor's abstraci)

TOt. 01:003

Technical Operations, Inc., Arlington, Mass.

THE CHEMISTRY OF PHOTOGRAPHIC DEVELOPMENT. t. THE CHEMtSTRY OF QUtNONE IN SOLUTtON, by J. E. LuValle, D. L. Davidson and oihers. Mar. 11, 1954, 30p. incl. illus. tables, refs. (Technical noie no. 2; rept. no. TOt-54-3) ([AF]OSR-TN-54-39) (AF 18-(600)371) AD 27813 Unctassified

An initial investigation of the chemisiry of quinone in solution has shown that its reactions are quiie sensitive to pH. In general, quinone undergoes oxidation-reduction reactions with reducing agents ai low pH. At moderate pH values an addition reaction predominates, and as ihe pH increases, a base-catalyzed hydration-enolization becomes very important. The general conditions for these reactions have been investigaied and especially the base-caialyzed hydration-enolization. The hydration-enolization reaction may be very imporiani in photographic development. The base-catatyzed hydration-enolization of quinones has not been previously reported. (Contractor's abstract)

TOI. 01:004

Technicat Operations, Inc., Arlington, Mass.

THE CHEMISTRY OF PHOTOGRAPHIC DEVELOPMENT. III. THE CHEMISTRY OF QUINONE AND ITS RELATION TO "INFECTIOUS DEVELOPMENT," HIGH-SPEED DEVELOPMENT, DIRECT POSITIVE DEVELOPMENT, "SUPERADDITIVE DEVELOPERS," AND ANTIFOGGANTS, by J. E. LuValle and F. M. Dunnington. Mar. 11, 1954, 39p. incl. illus. tables, refs. (Technicat note no. 3; rept. no. TOt-54-4) ([AF]OSR-TN-54-40) (AF 18(600)371) AD 27814 Unclassified

The catalyzed hydration-enolization of quinone in hydroquinone developers produced hydroxyhydroquinone which appears to be the fogging and accelerating developer of infectious development. Hydrazine was considered to act as a catalyst for the hydration-enolization and also to hold the hydroxyhydroquinone in the reduced state until the hydrate-enolate reacts with a Ag halide grain. The catalyzed hydration-enolization of the quinoid states of the developers composing a superadditive developer was considered the primary cause of superadditivity. The reduced developers also serve to hold the hydrate-enolates in the reduced state until they react with Ag halide. This evidence points to the first hydrate-enolate as being the active agent in these processes. This does not eliminate the possibility of the hydrate-enolate semiquinones also acting on the charge barrier. The antifoggants, such as benzotriazole, 6-nitrobenzimidazole, and phenosafranin, all react with hydroxyhydroquinone or its oxidation products. The nature of this reaction was not determined. The action of amidol is discussed on the basis of its relation to hydroxyhydroquinone.

TOI. 01:005

Technical Operations, Inc., Arlington, Mass.

THE CHEMISTRY OF PHOTOGRAPHIC DEVELOPMENT. III. THE HYDRATION-ENOLIZATION OF THE QUINOID STATE AND PHOTOGRAPHIC DEVELOPMENT, by J. E. LuValle. Mar. 15, 1954, 9p. incl. refs. (Technical note no. 4; rept. no. TOI-54-5) ([AF]OSR-TN-54-41) (AF 18(600)371) AD 27991 Unclassified

Also published in Photogr. Eng., v. 5: 273-275, 1954.

The base-catalyzed hydration-enolization of quinoid developers may be used as the basis for a unification

of many heretofore apparently unrelated photographic phenomena, "Infectious development," "superadditive developers," a new role of gelatin, some chemical latensification procedures, one of the properties of antifoggants, and perhaps some of the chemical treatments used in the preparation of photographic emulsions may all be different aspects of one basic reaction.

TOI. 01:006

Technical Operations, Inc., Arlington, Mass.

CHROMATOGRAPHIC SEPARATION AND IDENTIFICATION OF PHOTOGRAPHIC DEVELOPERS (Abstract), by J. H. Pannell and J. E. LuValle. [1954] [1]p. (AF 18(600)371) Unclassified

Published in Anal. Chem., v. 25: 1566, Oct. 1953.

In the course of a study of reactions of photographic developers, methods for the separation and identification of the developers and their oxidation product were devised. Knowledge of the reactions of developers was seriously limited by a dearth of information on such separations. A method based on paper chromatography was evolved which should be of value as it has the advantages of simplicity and specificity. However, it is probably applicable only to substances which are moderately stable to air. The method employs standard chromatographic equipment and a solvent composed of butanol, acetic acid, and water mixed in the volume proportion 4 to 1 to 5, from which the organic layer is separated and used. As spray reagent, a 2% solution of ammoniacal silver nitrate gives the highest sensitivity. A 5% solution of phosphomolybdic acid, while less sensitive, produces chromatograms which do not darken with time. Best results are obtained when 10 γ amounts of developers are used, although 1 γ can be detected. The following table shows Rf values obtained by descending development on Whatman No. 2 paper using butanal-acetic acid-water solvent at room temperature (22°C) where the solvent front moved 40 cm:

Hydroquinone disulfonate	0.00
p-Methylaminophenol monosulfonate	0.09 ± 0.01
Hydroquinone monosulfonate	0.15 ± 0.01
Quinone monosulfonate	0.34 ± 0.02
p-Aminophenol hydrochloride	0.43 ± 0.03
p-Phenylenediamine hydrochloride	0.55 ± 0.03
p-Methylaminophenol sulfate	0.61 ± 0.02
Hydroquinone	0.80 ± 0.02.

(Contractor's abstract)

TOI. 02:001

Technical Operations, Inc., Arlington, Mass.

PRODUCTION OF BLUE COLOR IN IRRADIATED PLASTIC SCINTILLATORS, by J. H. Pannell and B. Manning. [Apr. 1955] 2p. incl. diagr. ([AF]OSR-TN-55-83) [AF 18(600)1134] AD 73220 Unclassified

Also published in Jour. Chem. Phys., v. 23: 1368-1369, July 1955.

An intense blue color is produced at room temperature in polystyrene and polyvinyltoluene containing certain fluors when they are subjected to β irradiation in the absence of light. At dry ice temperatures (-70°C), production of this color is apparently accelerated, i.e., decay is decelerated, and becomes obvious in many plastic scintillators, being most noticeable in those containing the following: terphenyl; terphenyl + diphenylstilbene; diphenylbutadiene; tetraphenylbutadiene; diphenylstilbene; and tetraphenylethylene. On warming the plastics to room temperature, a considerable amount of phosphorescence is evident; this phosphorescence, associated with thermal bleaching of color, indicates that the color is associated with trapped electrons. Light absorption measurements were made using a Beckman model DU spectrophotometer. Absorption curves are plotted for terphenyl-tetraphenylbutadiene polystyrene plastic after 16 hr irradiation. It is proposed that the phenomenon described might be most easily explained by an "F-center" theory, but in a noncrystalline structure.

TOI. 02:002

Technical Operations, Inc., Arlington, Mass.

THE INDEX OF REFRACTION EFFECT ON ABSOLUTE FLUORESCENCE MEASUREMENTS, by A. Shepp. Apr. 1956, 8p. incl. diagr. (Technical rept. no. 1; rept. no. TOI 56-12) (AFOSR-TN-56-184) (AF 18(600)1134) AD 87057 Unclassified

Also published in Jour. Chem. Phys., v. 25: 579, Sept. 1956.

A detailed analysis is given of the effect of the index of refraction (n) of the crystal on the luminescent light escaping from within a pure crystal. The spatial distribution and the total quantity of light escaping from a phosphor depend on geometric shape and index of refraction. The recommendations for crystal or cell shape when making absolute fluorescence measurements are as follows: (1) those based on a reading of total light output should utilize a rectangular crystal; (2) those based on a reading taken far out along the normal to a plane face should utilize a cylindrical or rectangular crystal; (3) for readings taken far out off the normal to a plane face, a rectangular crystal should be used; (4) measurements should never be taken close to the crystal; and (5) measurements on powders must in some way (comparing with a pure crystal) take account of the possibility of light loss. An analysis of previous efficiency measurements is presented. Most of them were subject to complex, though probably small corrections.

TRG. 01:001 - TIH. 01:003

TRG. 01:001

Technical Research Group, New York.

TOWARDS A THEORY OF WOOD'S ANOMALIES, by B. A. Lippmann and A. K. Oppenheim. Final rept. June 30, 1954 [33]p. incl. diagrs. refs. (Rept. no. TRG-951-1) ([AF]OSR-TR-54-25) (AF 18(600)954) AD 42673 Unclassified

The Rayleigh-Artmann theory of Wood's anomalies is shown to be limited, by an implicit approximation, to the region $b/\lambda << 1$, where b = groove depth and λ = wavelength. Since the observation of P anomalies seems to be associated with $b/\lambda \sim 1$, a more general theory of grating anomalies is required. It is suggested that such a theory can be constructed by analyzing the influence of kinematical, groove, and edge effects individually. In this study, a calculation is made of the kinematical effects associated with a grating. The results lend support to the view that kinematical effects are, in part, responsible for grating anomalies. (Contractor's abstract)

TRG. 02:001

Technical Research Group, New York.

"SHIMMING" AN INHOMOGENEOUS MAGNETIC FIELD IN NUCLEAR RESONANCE EXPERIMENTS BY PULSES, by B. Nelson and L. Goldmuntz. July 1, 1956, 1v. incl. diagrs. tables. (AFOSR-TN-56-368) (AF 18(600)1313) AD 95804 Unclassified

A mathematical investigation is presented in connection with the possible use in radar design of nuclear magnetic resonance in the development of a narrow-band, low-noise figure filter capable of operating at r-f frequencies. The chief result obtained is that there is a combination of "shimming" pulses that can be applied to a liquid sample that can make the line width of the sample independent of the degree of homogeneity of the external static magnetic field. Initially, a simplified discussion is given of certain nuclear resonance experiments and the modifications necessary to make them useful in filter circuits. This is followed by a general discussion of the matrix solution of Bloch's equations describing the behavior of the net nuclear magnetization. The methods covered in the discussion are then used in the analysis of the series of "reclustering" pulses applied to the nuclear sample to obtain the desired narrow line width. Finally, there is considered the integral of the transients caused by this shimming technique. The report is restricted in discussion to shimming systems which operate only transiently over the longitudinal relaxation time of the nuclear sample.

TIH. 01:001

Technion - Israel Inst. of Tech., Haifa.

THE WEISSENBERG-EFFECT, by M. Reiner. [1955] [17]p. incl. illus. diagrs. refs. (Part 1 of its AFOSR-TN-56-114; AD 82510) [AF 61(514)871] AD 82510(a) Unclassified

The Weissenberg effect is described. Its possible mechanisms are analyzed in terms of simple shear and reduced to cross stresses which may be caused by (1) a quasi-linear or a general elasticity that involves a second order term or (2) cross viscosity. (Contractor's abstract)

TIH. 01:002

Technion - Israel Inst. of Tech., Haifa.

ON ISOTROPIC TENSOR FUNCTIONS AND THE MEASURE OF DEFORMATION, by M. Hanin and M. Reiner. [1955] 18p. refs. (Part 2 of its AFOSR-TN-56-114; AD 82510) [AF 61(514)871] AD 82510(b) Unclassified

Also published in Zeitschr. Angew. Math. Phys., v. 7: 377-393, 1956.

A theoretical understanding is provided for a centripetal-pump effect which was recently observed in air. An isotropic relation between 2 symmetric tensors of second rank can be expressed in the form

$$y_s^r = (F_0 + \sum_{n=3}^{\infty} F_n C_n)\,\delta_s^r + (F_1 + \sum_{n=3}^{\infty} F_n B_n)x_s^r + (F_2 + \sum_{n=3}^{\infty} F_n A_n)x_\alpha^r x_s^\alpha, \text{ where } F_n = \sum_{p,q,r}^{(n)} k_{p,q,r}$$

$I^p II^q III^r$, and the A_n, B_n, and C_n are similar power series in the principal invariants of x_s^r. The constants k must be determined by means of suitable experiment between the physical quantities represented by x_s^r and y_s^r. The F_n will be a constant when x_s^r and y_s^r are different measures of deformation, and the logarithmic Hencky measure can then be expressed through the Almansi measure. When this is done, a quasi-linear stress-flow relation reveals certain second order effects in viscous liquids, even when elasticity is absent and the viscosity is low. (Contractor's abstract)

TIH. 01:003

Technion - Israel Inst. of Tech., Haifa.

AN ELASTICO-VISCOMETER, by M. Reiner. [1955] [4]p. incl. illus. diagrs. (Part 3 of its AFOSR-TN-56-114; AD 82510) [AF 61(514)871] AD 82510(c) Unclassified

An instrument is described which permits the determination of the Weissenberg effect and the viscosity of a small sample in one operation. (Contractor's abstract)

TIH. 01:004

Technion - Israel Inst. of Tech., Haifa.

A CENTRIPETAL-PUMP EFFECT IN AIR, by M. Reiner. [1955] [49]p. incl. illus. diagrs. tables. (Part 4 of its AFOSR-TN-56-114; AD 82510) [AF 61-(514)871] AD 82510(d) Unclassified

Also published in Proc. Royat Soc., v. A240: 173-188, 1957.

Also published in Proc. Ninth International Congress of Appl. Mech., Brussels, (Belgium) (Sept. 5-13, 1956), v. 2: 429-438, 1957.

An instrumental setup is described which constitutes a centripetal airpump. Records of 218 experiments performed with this apparatus are given which confirm that the effect found in very viscous liquids is present in air. (Contractor's abstract)

TIH. 01:005

Technion - Israel Inst. of Tech., Haifa.

RESEARCH ON THE PHYSICS OF AIR VISCOSITY, by M. Reiner. Research progress summary rept. July 15, 1955-Jan. 15, 1956, 1v. incl. illus. tables, refs. (AFOSR-TN-56-114) (AF 61(514)871) AD 82510 Unclassified

The Weissenberg effect is described, and its possible mechanisms are analyzed in terms of simple shear. They are reduced to cross-stresses which may be due either to a quasilinear or a general elasticity involving a second order term, or to cross-viscosity. A mathematical expression is given which shows an isotropic relation between 2 symmetric tensors of second rank. The expression led to a quasilinear stress-flow relation which reveals certain second order effects in viscous liquids, even when elasticity is absent and the viscosity is low. This may provide a theoretical understanding for the recently observed centripetal pump effect in air. An instrument is described which permits the determination of the Weissenberg effect and the viscosity of a small sample in one operation. Data obtained from 218 experiments performed with a centripetal airpump instrumental setup are given, confirming that the effect found in very viscous liquids is also present in air. (Contractor's abstract)

TIH. 01:006

Technion - Israel Inst. of Tech., Haifa.

RESEARCH ON THE PHYSICS OF AIR VISCOSITY, by M. Reiner, J. F. T. Blott, and B. Poppen. Research progress summary rept. Jan. 15, 1956 - July 14, 1956, 1v. incl. illus. diagrs. refs. (AFOSR-TR-56-42) (AF 61(514)871) AD 97075 Unclassified

This report is divided into three parts. Part I, A Centripetal Pump Effect in Air, is a revision of and has been abstracted as Part 4 of AFOSR-TN-56-114, item no. TIH. 01:004. Part II is an addenda to Part I and contains a number of graphs which illustrate results which were not included in Part I. The graphs refer mainly to cylinder III which behaved differently from the other four cylinders. This probably some resonance-effect which awaits an explanation. Part III, A Centripetal Airpump, describes an instrument consisting of two circular metal plates; one stationary, the other rotating opposite it with a very narrow gap between both. At certain high speeds the air is drawn in a centripetal direction into the gap.

TIH. 02:001

Technion - Israel Inst. of Tech. Dept. of Aeronautics, Haifa.

ON SUPERSONIC ROTATIONAL FLOW BEHIND STRONG SHOCK WAVES. I. FLOW PAST AIRFOILS, by A. Kogan. Technical research progress note July 15, 1955-Jan. 15, 1956 [58]p. incl. diagrs. table, refs. (AFOSR-TN-56-165) (AF 61(514)870) AD 86586 Unclassified

A method of successive approximations to the ideal flow past airfoils at high supersonic Mach numbers is developed, based on the concept of Crocco's stream function. When the undisturbed stream is taken as zero-order approximation to the actual flow, the second approximation to the pressure coefficient $C_p(x)$ at the airfoil surface coincides with the well known results obtained by Busemann. But contrary to potential flow theory, the present method yields good results also at a distance from the airfoil and approximates correctly the shock wave profile. Then taking the uniform flow behind a plane shock wave as zero-order approximation, both the shock wave curvature and its derivative, and the first and second derivatives of $C_p(x)$ on the airfoil surface are evaluated at the leading edge in terms of the airfoil curvature and its derivative at the leading edge. (Contractor's abstract)

TIH. 02:002

Technion - Israel Inst. of Tech. Dept. of Aeronautics, Haifa.

ON THE SUPERSONIC ROTATIONAL FLOW BEHIND STRONG SHOCK WAVES. II. FLOW PAST OGIVES OF REVOLUTION, by A. Kogan. Technical research progress rept. Jan. 15, 1956-July 15, 1956 [35]p. incl. diagrs. (AFOSR-TN-56-316) (AF 61(514)870) AD 94852 Unclassified

A method of successive approximations to the ideal flow around airfoils and ogives of revolution at high supersonic Mach numbers is developed, based on the concept of Crocco's stream function. In a previous report the flow around airfoils has been treated. In the present report the axially symmetrical flow around ogives of revolution is treated. A procedure for

obtaining correct successtve approximations to the flow tn the tip regton ts tndtcated. The ftrst order approximation ts worked out tn detail and tt ts shown that the mathematical stngularrty of the ft:st approxtmation near the surface of the ogtve, whtch caused constderable compltcattons tn a prevtous treatment of the problem, ts avotded by the tntroduction of Crocco's stream function. (Contractor's abstract)

THB. 01:001

Techn.tsche Hochschule. Institut für Strömungsmechanik, Braunschwetg (Germany).

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON SWEPT- AND DELTA WINGS IN SYMMETRICAL FLOW, by E. Truckenbrodt, tr. by H. Schltchttng. Ftnal rept. Apr. 30, t954, 91p. tncl. tllus. dtagrs. tables. (Rept. no. 54/7a) ([AF]OSR-TR-54-23) (AF 6t(5t4)426; continued by AF 6t(514)-649-C) AD 7089t Unclasstfted

Also published in Zettschr. Flugwissensch., v. 2: t85-20t, Aug. t954.

Also published in Jour. Aeronaut. Sctences, v. 2t: 637-638, Sept. t954.

Systematic 3-component measurements were conducted on swept- and delta wtngs tn tncompresstble flow. There were 5 swept wtngs of constant chord and 5 delta wtngs, both with aspect rattos between 1 and 5, wtth the swept wtngs havtng a constant angle sweep, $\Lambda = 45°$, and the delta wtngs a constant taper ratto, $\lambda = t/8$. For the swept wtngs, the aerodynamtc center was about 10% of the wtng chord tn front of the geometrtc center. For the delta wtngs, tt was about 6 to tt% of the wtng chord behtnd the geometrtc center. The curves of the profttle drag coefftctent vs the ltft coefftctent cotnctded well for all aspect ratios at moderate ltft coefftctents, C_L, up to approxtmately 0.5. Except for small aspect rattos beyond maxtmum ltft, the pttchtng moment at htgh C_L was tatl-down for the swept wtngs and nose-down for the delta wtngs. Theorettcal calculattons of the spanwtse and chordwtse ltft dtstrtbutton accordtng to a new ltfttng-surface theory proposed by Truckenbrodt (Beträge zur Tragflächentheorte bei tnkompresstbler Strömung [Contrtbutton to the Ltfttng-surface Theory in Incompresstble Flow], Jahrbuch der wtssenschaftlichen Gesellschaft für Luftfahrt, t953) were carrted out for atl wtng planforms. For swept wtngs, wtth large aspect rattos there was a constderable breakdown tn the spanwtse ltft dtstrtbutton resultlng from the ktnk near the mtddle sectton. For all delta wtngs, the spanwtse ltft dtstrtbutton was nearly elltptical. For all planforms, the local aerodynamtc center was tn front of the quarter-chord ltne at the outer parts of the wtng and behtnd the quarter-chord ltne at the tnner parts of the wtngs.

THB. 02:00t

Technische Hochschule. Institut für Strömungsmechanik, Braunschwetg (Germany).

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON DELTA-WINGS WITH FLAPS, by E. Truckenbrodt and K. H. Gronau. Ftnal rept. June 22, t955, 45p. tncl. dtagrs. tables. (Rept. no. 55/12a) [AFOSR-TR-55-35] (AF 61(514)649-C; conttnuatton of AF 6t(5t4)426) AD 78583 Unclasstfted

Also published in Zeitschr. Flugwissensch., v. 4: 236-246, July t956.

In thts aerodynamtcal study, theorettcal calculations were made for a sertes of 5 delta (trtangular) wtngs with aspect rattos between 0.8 and 3.9, ustng vartous flap arrangements and deflections tn tncompresstble flow. For 2 of these wtngs, wtth aspect rattos of t.6 and 3.9, extensive wtnd-tunnel tests were also made. The measurements showed sattsfactory agreement wtth theory. For constant spanwise length of the flaps, the tnfluence of aspect ratto on all aerodynamtc coefftctents (angle of tnctdence at zero ltft, pttchtng moment, and rolltng moment) ts large. The ratio of these coefftctents of partial span flaps to full span flaps ts nearly tndependent of the aspect ratio. (ASTIA abstract, modtfted)

THB. 02:002

[Technttsche Hochschule. Instttut für Strömungsmechanik, Braunschwetg (Germany).]

SOME PROBLEMS OF CASCADE FLOW, by H. Schltchttng. [t955] [t3]p. tncl. dtagrs. refs. (AF 6t(5t4)649-C) Unclasstfted

Published in Proc. Conference on High-Speed Aeronautttcs, Polytechnic Inst. of Brooklyn, N. Y. (Jan. 20-22, 1955), p. t75-187.

In the course of systemattc research work on cascade flow whtch has been conducted tn recent years new soluttons have been estabtlshed for the "Dtrect Problem" and the "Inverse Problem" of the two-dtmenstonal tncompresstble frtctionless flow through cascades. These soluttons together wtth the boundary layer theory have been used for systemattc theorettcal calculattons of the loss coefftctents of two-dimenstonal cascades. Both soluttons are based on the method of stngularttties, and each blade sectton of the cascade ts replaced by certatn conttnuous chordwtse dtstrtbuttons of vorttces and sources stnks. While the solutton of the "Inverse Problem" has been publtshed, tn thts paper an outltne of the solution of the "Dtrect Problem" ts gtven. This solution allows each of the geometrtc parameters of the cascade (e.g. soltdtty ratto, angle of stagger, blade sectton) to be altered separately. In order to calculate the pressure dtstrtbutton of a gtven cascade, a system of six ltnear equattons has to be solved. The amount of numertcal work tnvolved

has been reduced considerably by tabulating certain "Influence Functions," which are independent of the blade section and depend on the solidity ratio and the angle of stagger only. Pressure distributions, as well as loss coefficients, as obtained from theory are in good agreement with experiments. (Contractor's summary)

THB. 03:001

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

A SIMPLE APPROXIMATE METHOD FOR CALCULATING THE LAMINAR BOUNDARY LAYER WITH SUCTION, by E. Truckenbrodt. Final rept. May 21, 1955, 62p. incl. diagrs. tables, refs. (Rept. no. 55/6a) [AFOSR-TR-55-21] (AF 61(514)639-C) AD 74986 Unclassified

A simplified approximate method was developed which compares satisfactorily with the exact solution and which presents no difficulties such as those associated with the approximate methods of H. Schlichting and T. P. Torda. The new method can be used to calculate the boundary layer in plane and axial symmetrical flow and the arbitrarily distributed suction velocity along the body. The point of separation at various suction velocities can also be obtained. Examples are given for plane and axially symmetrical flow with a stagnation point, a flat plate at zero incidence with homogeneous suction, and a semi-body of revolution with the suction beginning in one case at the stagnation point and in the other case at the point of maximum velocity. (ASTIA abstract)

THB. 04:001

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

RESULTS OF SYSTEMATIC INVESTIGATIONS ON SECONDARY FLOW LOSSES IN CASCADES. PART I. SECONDARY FLOW LOSSES IN COMPRESSOR CASCADES OF PROFILE NACA 8410, by K. Gersten. June 28, 1955, 33p. incl. diagrs. tables. (Rept. no. 54/29a) [AFOSR-TN-55-451] (AF 61(514)650-C) AD 92866 Unclassified

Experimental investigations of secondary flow losses have been carried out on a compressor cascade with blade profile NACA 8410. The solidity was $t/l = 1$, the blade angle $\beta_S = 135°$, and the ratio of blade chord $h/l = 3$. The Reynolds number, based on the outflow velocity, is $Re_2 = w_2 l/\nu = 4 \times 10^5$. On comparison with previous investigations concerning turbine cascades, these measurements indicate a completely different behavior of secondary flow effects for turbine and compressor cascades. In the case of the turbine cascade having a blade length ratio $h/l = 3$, there exists a zone in the middle of the blade which is almost uninfluenced by secondary flow effects; however, in the case of the compressor cascade, the middle zone is strongly disturbed. Also, in the latter instance there exists an additional acceleration of the flow in the middle zone, owing to secondary flow effects, which results from the blocking of the cross section at the side walls. This additional pressure drop gives: (1) an unfavorable decrease of the total pressure rise across the compressor cascade, and (2) a favorable influence on the total losses of the cascade.

THB. 04:002

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

RESULTS OF SYSTEMATIC INVESTIGATIONS ON SECONDARY FLOW LOSSES IN CASCADES. PART II. SECONDARY FLOW LOSSES OF A TURBINE CASCADE FOR DIFFERENT VELOCITY PROFILES OF INFLOW, by K. Gersten. Dec. 20, 1955, 29p. incl. diagrs. (Rept. no. 54/12a) (AFOSR-TN-56-137) (AF 61(514)650-C) AD 86013 Unclassified

Measurements on a turbine cascade between parallel plane walls have been carried out with different inflow velocity profiles to investigate the influence of the boundary layer thickness on the flow characteristics. The solidity ratio was $t/l = 1$, 0, where t is the distance the ratio of blade length to blade chord $h/l = 5$, and the angle of inflow $\beta_1 = 135°$. Two values of blade loading were investigated with blade angle $\beta_S = 35°$ and 45°. The values of the displacement thickness of the boundary layer of the inflow velocity profile were $\delta_1^*/l = 0.03$; 0.09 and 0.23, and the Reynolds number based on the outflow velocity $Re = w_2 l/\nu = 9 \times 10^4$. These are the main results: For moderate acceleration in the cascade ($\beta_S = 45°$) and small values of the boundary layer thickness, the coefficient of total loss increases slowly with increasing boundary layer thickness, but becomes independent of it for larger thickness of the boundary layer. For larger values of acceleration in the cascade ($\beta_S = 35°$), the ratio of secondary flow loss to total decreases and is independent of the boundary layer thickness of the inflow velocity profile. (Contractor's abstract)

THB. 04:003

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

RESULTS OF SYSTEMATIC INVESTIGATIONS ON SECONDARY FLOW LOSSES IN CASCADES. PART III. SECONDARY FLOW LOSSES OF A TURBINE CASCADE FOR DIFFERENT SHAPES OF BLADE TIP AND BLADE FOOT, by E. G. Feindt. May 15, 1956, 32p. incl. diagrs. (Rept. no. 54/32a) (AFOSR-TN-56-301) (AF 61(514)650-C) AD 90014 Unclassified

Measurements on a turbine cascade have been carried out to investigate the influence of the shape of the blade foot and the blade tip on the secondary flow

THB. 04:004 - TEM. 01:001

losses in incompressible flow. The solidity ratio, the ratio of blade length to blade chord, and the gap were kept constant. The blade profile was NACA 8410. Three different shapes of the blade tip and of the blade foot have been investigated; the blade tip was bluntly cut off, and obliquely cut off to the pressure and to the suction side of the blade; the blade foot was without a fillet, with a fillet of small radius, and with a fillet of large radius. The blade loading was altered by altering the blade angle. The main results of these investigations indicate that: (1) for the gap used here, the secondary flow losses at the blade tip and at the blade foot are nearly of the same magnitude; (2) the secondary flow losses at the tip and at the foot depend very little on the blade loading; and (3) the secondary flow losses depend very little on the shape of the blade tip and the blade foot. (Contractor's abstract)

THB. 04:004

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

[SECONDARY FLOW LOSSES IN COMPRESSOR CASCADES] Randverluste in Pumpengittern, by H. Schlichting. [1956] [6]p. incl. illus. diagrs. refs. [AF 61(514)650-C] Unclassified

Published in Zeitschr. Flugwissensch., v. 4: 35-40, Feb. 1956.

Several results from tests regarding the losses of flow in compressor cascades for incompressible flow are discussed. For the ratio of blade length to blade chord h/l = 3 the effect of the secondary flow along the walls is considerable, not only on the deflection of the flow but also on the pressure rise in the cascade. In order to separate these effects of the secondary flow the same cascade was also tested in two-dimensional flow. The two-dimensional flow was obtained by applying suction to the walls resulting in a good agreement of deflection of flow and pressure rise in two dimensional flow with potential theory. The available measurements indicate that the secondary flow effect in compressor cascades is much greater than in turbine cascades. A splitting-up of the total losses into two-dimensional losses and additional secondary flow losses is possible in many cases of turbine cascades but not so in most cases of compressor cascades. (Contractor's summary)

THB. 05:001

Technische Hochschule. Institut für Strömungsmechanik, Braunschweig (Germany).

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS ON WING-BODY COMBINATIONS WITH DELTA WINGS IN SYMMETRICAL FLOW, by K. Gersten and E. Truckenbrodt. June 4, 1956, 45p. incl. diagrs. tables, refs. (Rept. no. 56/20a) (AFOSR-TR-56-36) (AF 61(514)875) AD 96505 Unclassified

Three-component measurements have been made of fourteen wing-body combinations of a Delta wing. The influence of body length and shape (nose rounded or pointed) has been investigated, keeping constant the ratios of wing aspect and of body width/wing span. A method and its applications in the present study are given for the theoretical calculation of the shift of the aerodynamic center due to the influence of the body. This shift is considerably dependent on the wing aspect and the body width/wing span ratios. Agreement between theoretical and experimental results is satisfactory. (Contractor's abstract, modified)

TEM. 01:001

Temple U. Research Inst., Philadelphia, Pa.

THE COMBUSTION OF CARBON SUBNITRIDE, C_4N_2, AND A CHEMICAL METHOD FOR THE PRODUCTION OF CONTINUOUS TEMPERATURES IN THE RANGE OF 5000-6000° KELVIN OR 9000-11000° RANKINE, by A. V. Grosse and A. D. Kirshenbaum. Dec. 15, 1955, 37p. incl. illus. diagrs. tables, refs. (Technical note no. 1) (AFOSR-TN-56-13) (AF 18-(600)1475) AD 84316 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 2020, May 20, 1956.

A chemical method for producing continuous flame temperatures in the range of 5000° to 6000°K is described. In this method, C_4N_2 is combusted with O_2, O_3, or O_2-O_3 mixtures to CO and N_2. The vapor pressure curve of the compound was determined, and preliminary values were obtained for the heats of vaporization (6875 cal/mol), fusion (3700 cal/mol), and sublimination (10,575 cal/mol). The thermochemical equations of combustion of C_4N_2 with O_2 and O_3 are: (C_4N_2) gas + $2O_2 \rightarrow 4CO + N_2$ + 254.6 kcal at 25°C, and (C_4N_2) gas + 1-1/3 $O_3 \rightarrow 4CO + N_2$ + 299.9 kcal at 25°C. From these equations and the heat content of the products of combustion, the actual temperatures attainable at various pressures can be calculated with a high degree of accuracy. A flame temperature of 5260°K was obtained by premixing gaseous C_4N_2 with O at the stoichiometric point. This is the highest continuous temperature attained so far by chemical means. At superatmospheric pressure which markedly suppresses the dissociation of CO and N_2, temperatures above 5500°K should be obtainable. A temperature slightly above 5500°K can be obtained at 1 atm by using pure O_3 instead of O_2. The effect of ionization on flame temperatures was calculated by using Saha's formula for thermal ionization (Phil. Mag., v. 1: 1025, 1920). Results indicated that ionization does not lower the calculated flame temperatures.

TEM. 01:002

Temple U. Research Inst., Philadelphia, Pa.

CHEMICAL BEHAVIOR OF VARIOUS SUBSTANCES AT TEMPERATURES IN THE RANGE 4000 to 5000°K, by C. S. Stokes. [Feb. 1956] 2p. (Technical note no. 3) (AFOSR-TN-56-90) (AF 18(600)1475) AD 82017 Unclassified

A report is made of the behavior of 9 mil tungsten wire and of carbon filaments in a helium or argon atmosphere at temperatures of 4000° to 5000°K produced by use of an oxy-cyanogen flame which develops 4800°K at the CO stoichiometric point ($C_2N_2 + O_2 \rightarrow 2CO + N_2$) and at 1.0 atm pressure. The temperature range is produced by addition of helium to the entry gases or by use of pressure in multicone or other torches developed, with flame adjustment effected by use of a photoelectric cell. The tungsten wire rapidly oxidized to a blue oxide of some intermediate composition below WO_3 at a temperature of 4800°K produced by a 55 mol % oxygen-45 mol % cyanogen flame. Oxidation was slow and the wire melted and evaporated if the flame was slightly oxygen rich. With the flame at the stoichiometric point the tungsten remained intact and carbon deposited on the wire growing down the outside of the flame cone to form the semblance of a cap. Tungsten carbide formation, which could only occur initially, prior to carbon deposition, will be investigated later. Similar tests with carbon filaments produced like results, except that the carbon oxidized when the flame was even slightly oxygen-rich; carbon growth was noted in the flame at the stoichiometric point. Other materials such as iron and nickel simply boiled away at 4800°K. (Contractor's abstract, modified)

TEM. 01:003

Temple U. Research Inst., Philadelphia, Pa.

THE PURE OZONE TO OXYGEN FLAME, by A. [G.] Streng and A. V. Grosse. [1956] [30]p. incl. diagrs. tables, refs. [Technical note no. 2] (AFOSR-TN-56-104) (AF 18(600)1475) AD 82018 Unclassified

Published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn., (Aug. 19-24, 1956) N. Y., Reinhold, 1957, p. 264-273.

A report is made of high temperature studies involving direct conversion of O_3 to O_2 to produce a steady flame. At first, the burning of pure O_3–O_2 was observed in horizontal glass tubes, open at one end and varying in inner diameter from 4 to 12 mm, and of a length of about 100 cm. A mixture was ignited at the open end by means of a hot platinum wire and its burning velocity measured. It was found that below 16 mol % O_3 and at 1 atm total pressure and 25°C the O_3–O_2 mixtures did not ignite in a 12mm tube. After these preliminary experiments an apparatus was set up for continuous burning of O_3 to O_2. It consisted essentially of a cylinder of the desired O_3–O_2 mixtures, from which it could be passed on at a constant and preset rate to a straight vertical pyrex glass tube. The mixture was ignited by a hot platinum wire. Below about 20 mol % O_3 the flame can be observed only with difficulty by the naked eye, but the burning cone can be readily observed by the Schlieren method. For example, a 27.5 mol % O_3–O_2 mixture has a normal burning velocity of 50 cm/sec (at 1 atm and 20°C). The pure O_3–O_2 mixtures burn with a faint blue flame with a characteristic pink cast. A flashback may cause explosion or even detonation of the O_3-supply and the system must therefore be handled with care. After the technique of burning O_3–O_2 was developed it was used to combust hydrogen, carbon monoxide, cyanogen and others in a diffusion type flame. In general appearance and color the three O_3 flames do not differ from the corresponding O_2 flames. (Contractor's abstract, modified)

TEM. 01:004

Temple U. Research Inst., Philadelphia, Pa.

THE PREMIXED HYDROGEN CYANIDE-FLUORINE-OXYGEN FLAME (Abstract), by C. S. Stokes. [1956] 2p. incl. table. (AFOSR-TN-56-131) (AF 18-(600)1475 AD 86003 Unclassified

Temperatures in excess of 4500°K have been produced in this laboratory by various flames including cyanogen and oxygen. The materials used, however, are not commerically available. Hydrogen cyanide, fluorine and oxygen are available in quantity and a flame of these constituents produces a temperature of approximately 4000°K. Hydrogen cyanide and a fluorine-oxygen mixture of 1:1 molar ratio has been successively premixed in all concentrations. Burning velocities have been measured and compared to the hydrogen cyanide oxygen flame. Studies have been made to determine the exact chemical composition of the HCN fluorine-oxygen flame at the stoichiometric point. The proposed equation

$$2HCN + F_2 + O_2 \longrightarrow 2HF + 2CO + N_2$$

has been proved correct. Theoretical flame temperatures have been calculated and are as follows:

Flame Temp. °K for the Above Stoichiometric Point	Pressure Atm
3930	1
4275	10
4860	100

Some correlation of the hydrogen atom concentration with burning velocity has been noted. (Contractor's abstract)

TEM. 01:005 - TAI. 01·002

TEM.01:005

Temple U. Research Inst., Philadelphia. Pa.

THE HYDROGEN CYANIDE-FLUORINE-OXYGEN FLAME, ITS COMBUSTION PRODUCTS, FLAME TEMPERATURES AND BURNING VELOCITIES, by C. S. Stokes. Nov. 15, 1956, 26p. incl. illus. tables. (Technical note no. 2) (AFOSR-TN-56-508) (AF 18-(600)1475) AD 110323 Unclassified

Also published in Indus. Engineering Chem., v. 49: 1311-1314, Aug. 1957.

Temperatures in excess of 4500°K. have been produced in this laboratory by various flames including cyanogen and oxygen. The materials used, however, are not commercially available. Hydrogen cyanide, fluorine and oxygen are available in quantity and a flame of these constituents produces a temperature of approximately 4000°K. Hydrogen cyanide and a fluorine-oxygen mixture of 1:1 molar ratio has been successfully premixed in all concentrations. Burning velocities have been measured and compared to the hydrogen cyanide oxygen flame. Studies have been made to determine the exact chemical composition of the HCN fluorine-oxygen flame at the stoichiometric point. The proposed equation $2HCN + F_2 + O_2 \longrightarrow 2HF + 2CO + N_2$ has been proved correct. Theoretical flame temperatures have been calculated and burning velocities measured. (Contractor's abstract)

TEM.01:006

Temple U. Research Inst., Philadelphia, Pa.

THE PURE OZONE FLAME ON THE COMBUSTION OF VARIOUS FUEL GASES IN PURE OZONE, by A. G. Streng and A. V. Grosse. [Dec. 25, 1956] 11p. incl. illus. diagr. table. (AFOSR-TN-56-599) (AF 18(600)-1475) AD 115026 Unclassified

Presented at International Ozone Conference, Chicago, Ill., Nov. 28, 1956.

High temperature research involving combustion of various gases including ozone are briefly reviewed and findings presented of the burning characteristics of pure ozone as well as mixtures of ozone and hydrogen, carbon monoxide, cyanogen, methane, or in ethylene. The burning velocity of ozone, found to be 270 cm/sec at -78°C, appears to be a straight-line function of temperature. As mixtures of 100% O_3 and H_2, C_2H_2, or CH_4 did not spontaneously ignite during the diffusion flame tests, further tests were made of the stability of such mixtures. All were found stable at dry-ice temperatures; CH_4 reacted noticeably at room temperature, while H_2 and C_2H_2 caused no change in pressure. Ozone - C_2N_2 mixtures in long 1.6 mm id tubes, at room temperature and atmospheric pressure, burned without detonation; the mixture in wider tubes exploded. The stoichiometric 1.5 C_2N_2 + O_3 mixture burns very rapidly with a bright flame without explosion or detonation. A corresponding C_2N_2 + O_2 mixture burns somewhat slower with a less bright flame under similar conditions, while pure O_3 burns with a fallow flame without explosion or detonation. The possibility of burning C_2N_2 - O_3 mixtures from burner tips is noted, and production of instantaneous high temperatures through detonation of solid C_2N_2 or CO mixtures with solid O_2 or O_3 is discussed.

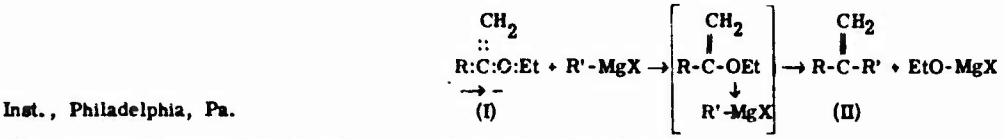
TAI. 01:001

Tennessee Agricultural and Industrial State [U.]. Dept. of Chemistry, Nashville.

[GRIGNARD REAGENTS AND UNSATURATED ETHERS] I. THE REACTION OF GRIGNARD REAGENTS WITH α-, β-UNSATURATED ETHERS, by C. M. Hill, R. A. Waler, and M. E. Hill. [1951] 2p. incl. tables. [AF 18(600)466] Unclassified

Published in Jour. Amer. Chem. Soc., v. 73: 1663-1664, Apr. 1951.

Theoretical considerations of the electron displacement tendencies in α-, β-unsaturated ethers indicate a possibility of reaction with Grignard reagents as indicated in I. The formation of a Grignard complex with the ether oxygen would render the electron deficiency on the α-carbon more acute, thus favoring an α-γ migration of the aryl group of the Grignard with its eleciron pair as shown in the scheme:



(Contractor's abstract)

TAI.01:002

Tennessee Agricultural and Industrial State U. Dept. of Chemistry, Nashville.

GRIGNARD REAGENTS AND UNSATURATED ETHERS. II. REACTION OF GRIGNARD REAGFNTS WITH BETA-, GAMMA-UNSATURATED ETHERS, by C. M. Hill, L. Haynes and others. [1953] 10p. incl. table, refs. (Technical rept. no. 1) (AF 18(600)466) AD 19864 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 75: 5408-5409, Nov. 5, 1953.

The reactivity was investigated of several β, γ-unsaturated ethers of the type R-CH=CH-CH_2-O-R' (where R is H or phenyl and R' is an alkyl or phenyl group) with alkyl and aryl Grignard reagents. The reaction products were unsaturated hydrocarbons and alcohols, and phenol. The composition and structure of these reaction products indicated that the Grignard reagents cleave the ethers by 1,2- and 1,4-addition mechanisms. (Contractor's abstract)

TAL 01:003

Tennessee Agricultural and Industrial State U. Dept. of Chemistry, Nashville.

GRIGNARD REAGENTS AND UNSATURATED ETHERS III. REACTION OF GRIGNARD REAGENTS WITH CYCLIC UNSATURATED ETHERS, by C. M. Hill, C. W. Senter and others. Feb. 10, 1954, 10p. incl. tables. (Technical note no. 2) [AFOSR-TN-54-25] (AF 18(600)466) AD 25937 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 76: 4538-4539, Sept. 20, 1954.

The reaction of Grignard reagents with cylic unsaturated ethers has been investigated. This study has demonstrated that the aryl and alkyl Grignard reagents react with 2, 3-dihydropyran, 4-methyl-3, 4-dihydro-2H-pyran, 2-methyl- and 2, 5-dimethylfuran by opening of the ring to yield unsaturated alcohols and aldehydes, and saturated ketones. The reaction products isolated suggest that the cyclic ethers are cleaved by a 1, 2-addition mechanism. (Contractor's abstract)

TAL 01:004

Tennessee Agricultural and Industrial State U. Dept of Chemistry, Nashville.

INVESTIGATION OF THE USE OF GRIGNARD REAGENTS WITH UNSATURATED ETHERS, by C. M. Hill, M. E. Hill and others. Final rept. Oct. 1, 1954, 16p. incl. tables. (Technical rept. no. 1) ([AF]OSR-TR-54-32) (AF 18(600)466) AD 50350 Unclassified

A summary is given of investigations concerning the reaction of alkyl and aryl Grignard reagents with unsaturated ethers, including both open-chain and cyclic unsaturated ethers. Unsubstituted and alky- and aryl-substituted α-, γ-unsaturated ethers and unsubstituted and alkyl-substituted dihydropyrans and furans were included. The results demonstrated that Grignard reagents react with both open-chain unsaturated and cyclic unsaturated ethers to form saturated and unsaturated alcohols, phenols, aldehydes, methyl ketones, and olefins in acceptable yields. The mode of cleavage apparently depends upon certain electrical and steric effects imparted to the unsaturated ether molecule by substituents attached to it.

TAL 01:005

Tennessee Agricultural and Industrial State U. Dept. of Chemistry, Nashville.

GRIGNARD REAGENTS AND UNSATURATED ETHERS. V. REACTION OF GRIGNARD REAGENTS WITH ALPHA AND GAMMA-SUBSTITUED ALLYL ETHERS, by C. M. Hill, M. E. Hill and others. [1954] [12]p. incl. tables. (Pt. 3 of its Technical rept. no. 1; AD 50350) [AF 18-(600)466] AD 50350(a) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 3889-3892, July 20, 1955.

Substituents suspected of imparting electrical or sterically hindered effects were attached to the α and γ positions of allyl ethers, and their reaction with aryl and alkyl Grignard reagents was investigated. The substituted ethers included were of the type $R\text{-}CH=CH\text{-}CH_2O\text{-}R'$, where R is H and phenyl and R' is n- butyl, and phenethyl; and $R\text{-}CH=CH\text{-}\underset{R'}{CH}\text{-}O\text{-}R''$, where R is methyl, R' is n- and tert-butyl and benzyl, and R'' is n- and tert-butyl. The nature of the group attached to the γ position of the allyl ether apparently influenced the mode of cleavage by certain Grignard reagents. In experiments in which n-heptyl- and n-octylmagnesium bromides were added to tert-butyl-1-benzyl-3-methylallyl ether, no reaction occurred at the refluxing temperature of diethyl ether or benzene. All the aryl Grignard reagents reacted with 3-methyl- and 3-phenylallyl ethers to yield olefinic hydrocarbons and alcohols, which indicated 1, 2-cleavage only of the ethers; similar results were obtained when ethyl- and n-hexylmagnesium bromides were used. The electrical effect upon the ether molecule caused by electron-releasing groups in the γ position appeared to facilitate 1, 4-addition when the Grignard reagent was an n-heptyl or n-octylmagnesium bromide.

TAL 01:006

Tennessee Agricultural and Industrial State U., Nashville.

GRIGNARD REAGENTS AND UNSATURATED ETHERS. IV. THE SYNTHESIS AND REACTION OF SEVERAL VINYL ETHERS WITH GRIGNARD REAGENTS, by C. M. Hill, R. M. Prigmore, and G. J. Moore. [1955] [3]p. incl. tables. [AF 18(600)466] Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 352-354, Jan. 20, 1955.

Study has been made of the reaction of α, β-unsaturated ethers of the type $R\text{-}CH=C(R')OR''$, where R is H, n-C_3H_7, n-C_5H_{11} and n-C_6H_{13}, R' is H, n-C_4H_9, n-C_5H_{11} and n-C_6H_{13}, and R'' is C_2H_5 and n-C_4H_9, with alkyl and aryl Grignard reagents. The reaction products isolated indicate that the Grignard reagents cleave the unsaturated ethers at the carbon-oxygen bond to yield ketones. Seven substituted vinyl ethers have been synthesized and characterized. (Contractor's abstract)

TEN. 01:001

Tennessee U., Knoxville.

APPLICATIONS OF FUNCTIONAL ANALYSIS, by F. A. Ficken. Technical rept. June 1, 1952-Aug. 31, 1954. Sept. 7, 1954, 3p. ([AF]OSR-TR-54-26) (AF 18(600)313) AD 42297 Unclassified

TEN. 01:002 - TAM. 01:003

Progress is reported on the following projects: (1) bifurcation; (2) bounded linear adjoints for certain nonlinear transformations between Banach spaces; (3) periodic wave solutions of a nonlinear wave equation; and (4) extensions of unbounded linear transformations. Work on project 2 has been temporarily suspended.

TEN. 01:002

Tennessee U., Knoxville.

INITIAL VALUE PROBLEMS AND TIME-PERIODIC SOLUTIONS FOR A NONLINEAR WAVE EQUATION, by F. A. Ficken and B. A. Fleishman. [Dec. 1956] [26]p. incl. refs. (Sponsored jointly by Office of Naval Research, Office of Bureau of Ordnance, and Air Force Office of Scientific Research under AF 18(600)313) Unclassified

Published in Communications on Pure and Appl. Math., v. 10: 331-356, Aug. 1957.

The nonlinear one-dimensional wave equation: $u_{xx} - u_{ii} - 2xu_t - \alpha u = \epsilon u^3 + b$ is considered in the cases of the infinite string, the semi-infinite string with a fixed end, and the finite string with fixed ends. With specified initial data (displacement and velocity) solutions are worked out for each of these cases.

TAM. 01:001

Texas A. and M. Coll. Dept. of Physics, College Station.

VIBRATIONAL STRUCTURE OF THE ELECTRONIC SPECTRA OF SIMPLE MOLECULES. I. EVALUATION OF CONDON OVERLAP INTEGRALS FOR THE BENT XY_2 MOLECULE, by J. K. Ward and J. B. Coon. July 1954 [11]p. incl. diagrs. ([AF]OSR-TN-54-181) (AF 18(600)439) AD 38856 Unclassified

A method is outlined for evaluating the Condon overlap integral associated with any vibronic band of a UV absorption system of an XY_2 molecule. All necessary formulas are included. For the small vibration problem, the geometry of the molecule as well as its vibrational frequencies must be given for both of the electronic states involved. A relation between coordinates of the normal state and those of the excited state must be found in order to evaluate the Condon overlap integrals.

TAM. 01:002

Texas A. and M. Coll. [Dept. of Physics] College Station.

APPLICATION OF THE FRANCK-CONDON PRINCIPLE TO THE BENT XY_2 MOLECULE (Abstract), by J. B. Coon and J. K. Ward. [1954] [1]p. [AF 18(600)439] Unclassified

Presented at meeting of the Amer. Phys. Soc., Austin, Tex., Feb. 26-27, 1954.

Published in Phys. Rev., v. 94: 805, May 1, 1954.

A method is described for comparing the experimental intensities of vibronic bands of an XY_2 molecule with Condon overlap integrals calculated to the harmonic approximation. Using the vibrational frequencies and the apex angle for a given electronic state, normal coordinates Q_i may be calculated by known methods. Three independent Cartesian coordinates x_i of the nuclei for the ground electronic state are related to similar coordinates x_i' for the excited state by $x' = x + C$, where C is a three-element column matrix determined by the equilibrium bond distances and angles of both states. This leads to the relation $Q' = \zeta Q + K$, where ζ is a 3 x 3 matrix in which the elements ζ_{13}, $\zeta_{23} \neq 0$ unless $\theta' = \theta$. The Condon overlap integral takes the form

$$I = N'(v_1'v_2'v_3')N(v_1v_2v_3)\int\int\int \prod_i H_{v_i'}(\alpha_i'Q_i') \times \exp(-\tfrac{1}{2}\alpha_i'^2Q_i'^2)\prod_j H_{v_j}(\alpha_jQ_j) \exp(-\tfrac{1}{2}\alpha_j^2Q_j^2)dQ_1dQ_2dQ_3,$$

where $\alpha_i^2 = (4\pi^2/h)c\omega_i$, and $H_{v_i}(\alpha_iQ_i)$ are Hermite polynomials. This is easily evaluated for any special case. The ratio of the overlap integrals for two vibronic bands is known to be related to the integrated molecular extinction coefficients ϵ_i for these two bands by $(I_1/I_2)^2 = \exp[hc(G_1 - G_2)/kT](\nu_2/\nu_1) \times (\int_1 \epsilon_1 \delta\nu / \int_2 \epsilon_2 \delta\nu)$, where G_i is the ground state vibrational level associated with band i. Sufficient data are available for ClO_2 to evaluate these integrals.

TAM. 01:003

Texas A. and M. Coll. [Dept. of Physics] College Station.

VIBRATIONAL ANALYSIS OF THE 3400-4000A ABSORPTION SPECTRUM OF SO_2 (Abstract), by R. K. Russell. [1954] [1]p. [AF 18(600)439] Unclassified

Presented at meeting of the Amer. Phys. Soc., Austin, Tex., Feb. 26-27, 1954.

Published in Phys. Rev., v. 94: 805, May 1, 1954.

A preliminary analysis is reported of the 3400-4000A absorption spectrum of SO_2, based on wave numbers measured on spectrograms obtained with absorbing paths up to 18 meter-atmospheres. Within an average deviation of about 2 cm^{-1}, 23 bands fit the formula $\nu = \nu_0 + (G_0' - G_0'')$, where $\nu_0 = 25,776.0\ cm^{-1}$ and $G_0'(v_1'v_2'v_3') = 938.3v_1' + 362.8v_2' + 1119.65v_3' - 34.60v_1'^2 - 1.95v_2'^2 - 25.77v_3'^2 + 1.82v_1'^3 - 5.9v_1'v_2' - 21.55v_1'v_3' - 9.1v_2'v_3'$. Ground-state levels G_0'' given by Nielsen (Phys. Rev., v. 91: 235, 1953) were used. Previously, in a brief report, Metropolis and Beutler (Phys. Rev., v. 57: 1078, 1940) assigned the $(0,0,0,)' \leftarrow (0,0,0,)''$ band and gave approximate values of ν_1' and ν_2' that are essentially in agreement with the above formula. The G_0' (2, 1, 0) and the G_0' (0, 0, 2) excited state vibrational levels appear to perturb each other, the shift being about 33 cm^{-1}. It is expected that spectrograms to be

made with still longer absorbing paths will reveal more bands, thus providing additional data needed to confirm or improve the analysis. (Contractor's abstract)

TAM. 01:004

Texas A. and M. Coll. [Dept. of Physics] College Station.

GROUND-STATE POTENTIAL CONSTANTS OF ClO_2 (Abstract), by J. K. Ward. [1954] [1]p. [AF 18(600)439] Unclassified

Presented at meeting of the Amer. Phys. Soc., Seattle, Wash., July 7-10, 1954.

Published in Phys. Rev., v. 96: 845, Nov. 1, 1954.

Sufficient information is available to compute the four harmonic potential constants of the ground state of ClO_2. Coon's ultraviolet rotational structure analysis furnishes $2\bar{B}'' = 0.612 \pm 0.003$, $(2\bar{B}' - \bar{B}'') = -0.0615 \pm 0.001$, and $2(A' - A'') = -(1.250 \pm 0.006\ cm^{-1}$; at least-square treatment of Nielsen and Woltz 's infrared rotational structure data yields $2(A'' - \bar{B}'') = 2.831 \pm 0.01\ cm^{-1}$. From this data one obtains $2\theta'' = 117.4 \pm 0.2^{o}$, $r_o'' = 1.472 \pm 0.005A$, $2\theta' = 107.4 \pm 0.4^{o}$, $r_o' = 1.620 \pm 0.015A$. By using $2\theta''$ in conjunction with $\omega_1'' = 964.8$, $\omega_2'' = 451.8$, and $\omega_3'' = 1127.3\ cm^{-1}$ given by Coon and Ortiz, and one isotope shift $\Delta\omega_1'' = -6.41\ cm^{-1}$, the ground-state valence potential constants are determined: $k = 6.990$, $k_\theta = -0.649$, $k_1 = -0.191$, $k_2 = -0.035 \times (10)^5$ dyne-cm^{-1}. Poor agreement exists with potential constants determined using three ground-state frequencies and the criterion of Glockler and Tung: $k = 7.411$, $k_\theta = 0.803$, $k_1 = 0.230$, $k_2 = 0.930 \times (10)^5$ dyne-cm^{-1}. Disagreement also exists with the prediction of Duchesne and Nielsen that k_1 and k_2 should be positive. (Contractor's abstract)

TAM. 01:005

Texas A. and M. Coll. Dept. of Physics, College Station.

A VIBRATIONAL ANALYSIS OF THE 3000-5000A ABSORPTION OF ClO_2, by J. B. Coon and E. Ortiz. May 1955, 19p. incl. diagrs. tables. ([AF]OSR-TN-55-119) (AF 18(600)439) AD 63489 Unclassified

Presented at meeting of the Amer. Phys. Soc., Mexico City (Mexico), Aug. 29-31, 1955.

Abstract published in Phys. Rev., v. 100: 963, Nov. 1, 1955.

Also published in Jour. Molecular Spectroscopy, v. 1: 81-94, Sept. 1957.

A critical list of 143 vibronic bands in the visible and ultraviolet absorption spectrum of ClO_2 vapor has been compiled. Vibrational quantum number assignments have been made for 117 of these bands. This vibrational analysis ytelds the following values of the zero order frequenctes ω'_i and the anharmonicity constants X'_{ij} for the excited electronic state. In wave numbers,

$\omega_1' = 711.4$ $\quad X_{11}' = -2.44$ $\quad X_{13}' = -7.40$

$\omega_2' = 298.0$ $\quad X_{12}' = -4.36$ $\quad X_{23}' = -6.9$

$\omega_3' = 756.1$ $\quad X_{22}' = -1.4$ $\quad X_{33}' = +10.2$

Combining the information obtained for the ground state with existing infrared data, the best resulting constants for this state are:

$\omega_1'' = 962.8$ $\quad X_{11}'' = -4.4$ $\quad X_{13}'' = -14.4$

$\omega_2'' = 455.4$ $\quad X_{12}'' = -3.0$ $\quad X_{23}'' = -13$

$\omega_3'' = 1128.2$ $\quad X_{22}'' = 0.0$ $\quad X_{33}'' = -2.0$

(Contractor's abstract)

TAM. 01:006

Texas A. and M. Coll. Dept. of Physics, College Station.

VIBRATIONAL STRUCTURE OF THE ELECTRONIC SPECTRA OF SIMPLE MOLECULES. III. VIBRATIONAL ANALYSIS OF THE 3800 Å ABSORPTION SYSTEM OF SULPHUR DIOXIDE, by R. K. Russell, B. L. Landrum, and E. E. Vezey. Jan. 1956, 22p. incl. diagrs. tables. (AFOSR-TN-56-68) (AF 18(600)439) AD 81060 Unclassified

Photographs of the 3400-3900 Å absorption spectrum of SO_2 vapor have been made with absorbing layers varying from 2 to 720 meter-atmospheres. Forty-two bands were observed, 23 of which have not been reported previously. The wave numbers of 30 bands fit the expression

$\sigma = \sigma_e + \sigma_o + G_o'(v_1', v_2', v_3') - G_o''(v_1'', v_2'', v_3'')$,

where $\sigma_e + \sigma_o = 25776.0$ K,

the $G_o' = 931.65 v_1' + 362.8 v_2' + 904.0 v_3'$

$-27.65 v_1'^2 - 6.3 v_1' v_2' - 1.95 v_2'^2$

$-56.7 v_1' v_3' - 34.5 v_2' v_3' + 9.3 v_3'^2$,

and the $G_o''(v_1'', v_2'', v_3'')$ are ground state vibrational energy levels determined from IR data. The $G_o'(2, 1, 0)'$ and the $G_o'(0, 1, 2)'$ excited state vibrational energy levels perturb each other, the shift being 32.4 K. The zero-order frequenctes for the excited electronic state are

$\omega_1' = 990.80$ K, $\omega_2' = 385.15$ K, $\omega_3' = 940.30$ K.

(Contractor's abstract)

TAM. 01:007 - TAM. 02:001

TAM. 01:007

Texas A. and M. Coll. Dept. of Physics, College Station.

VIBRATIONAL STRUCTURE OF THE ELECTRONIC SPECTRA OF SIMPLE MOLECULES IV. THE GEOMETRY OF AN EXCITED STATE OF SO_2 AND THE FRANK-CONDON PRINCIPLE, by M. L. Coffman, J. M. Corgan and others. Aug. 1956, 29p. incl. diagrs. tables, refs. (AFOSR-TN-56-370) (AF 18(600)439) AD 95806 Unclassified

Presented at meeting of the Amer. Phys. Soc., Houston, Tex., Feb. 24-25, 1956.

Also published in Bull. Amer. Phys. Soc., Series II, v. 1: 90, Feb. 24, 1956.

The geometry of the excited electronic state associated with the 3800 Å absorption system of SO_2 is determined using the Frank-Condon principle. The normal coordinated Q_i of the ground electronic state and Q'_i of the excited electronic state are calculated from the known vibrational frequencies of these states. The excited state angle is assumed to be the same as that known for the ground state from microwave studies. The transformation relating Q_i to Q'_i involves 2 parameters c_1 and c_2 which specify the difference in geometry of the 2 states. This transformation permits evaluation of the Condon overlap integrals R_i in terms of c_1 and c_2. The harmonic approximation is made. Comparison of band intensities measured photographically with the squares of the overlap integrals allows evaluation of c_1 and c_2 and hence the excited state geometry. Four excited state models are consistent with the observed intensities, but only one of these is consistent with the partially resolved rotational structure of the bands. The S-O distance and the O-S-O angle for the resulting model of the excited electronic state are $r' = 1.492$ Å and $\alpha' = 124°36'$. A correction based on normal modes calculated using this angle gives $r' = 1.487$ and $\alpha' = 125° 6'$. These results are to be compared with $r'' = 1.432$ Å and $\alpha'' = 119°32'$ for the ground electronic state from microwave studies. (Contractor's abstract)

TAM. 01:008

Texas A. and M. Coll. Dept. of Physics, College Station.

ROTATIONAL STRUCTURE OF THE 3800Å ABSORPTION SYSTEM OF SO_2 (Abstract), by J. B. Coon, R. K. Russell, and B. L. Landrum. [1956] [1]p. [AF 18(600)-439] Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 18.

The geometry of the excited electronic state associated with the 3800Å absorption system of SO_2 vapor has been recently determined by a quantitative application of the Frank-Condon principle. The results reported are $r' = r'' + 0.060 = 1.492$Å, and $2\theta' = 2\theta'' + 5°4' = 124°36'$. These data yield the constants of the rotational structure, namely $2\Delta(A - \bar{B}) = 0.396$ cm^{-1} and $2\Delta\bar{B} = -0.071$ cm^{-1}. In order to check these results, and in order to remove the uncertainty as to the polarization of the bands of this system, the resolvable features of the rotational structure of the bands are being examined. Preliminary measurements yield $2\Delta(A - \bar{B}) = 0.438 \pm 0.03$ cm^{-1} and $2\Delta\bar{B} = -0.080 \pm 0.008$ cm^{-1} confirming the results based on the Frank-Condon principle. Although the polarization of these bands has not yet been determined with certainty, it is expected that this can be reported soon. (Contractor's abstract)

TAM. 01:009

Texas A. and M. Coll. [Dept. of Physics] College Station.

3700 Å BAND OF FORMALDEHYDE (Abstract), by C. M. Loyd and S. E. Hodges. [1956] [1]p. [AF 18(600)439] Unclassified

Presented at meeting of the Amer. Phys. Soc., Monterey, Calif., Dec. 27-29, 1956.

Published in Amer. Phys. Soc., Series II, v. 1: 393, Dec. 27, 1956.

The ground-state vibrational level from which the (3700 A)α band of formaldehyde arises has received much discussion in the literature: Recent temperature sensitivity measurements by Cohen and Reid give 1240 ± 50 cm^{-1} for the ground-state level of this band. This leads them to the conclusion that the band arises from one quantum of the in-plane bending mode, 1247.4 cm^{-1}. Robinson, on the other hand, interprets the band as arising from one quantum of the out-of-plane bending mode, 163.5 cm^{-1}. The present temperature sensitivity data support Robinson's interpretation, yielding 1160 ± 23 cm^{-1} for the ground-state level from a plot of ln ϵ vs 1/T that has a slope of 1.67. Measurements were made at eight points in the band on spectrograms taken at temperatures of 403, 439, 472 and 493°K and a path length of 6 meters. Formaldehyde pressures of 5 to 10 cm were used with 120 psi of nitrogen added to insure pressure broadening. (Contractor's abstract)

TAM. 02:001

Texas A. and M. Coll. Dept. of Physics, College Station.

A HIGH RESOLUTION, LOW FIELD NUCLEAR MAGNETIC RESONANCE SPECTROMETER, by R. W. Mitchell and M. Eisner. Nov. 1956 [14]p. incl. diagrs. (AFOSR-TN-56-584) (AF 18(600)1300) AD 115008 Unclassified

Also published in Rev. Scient. Instruments, v. 28: 624-628, Aug. 1957.

A high resolution low field spectrometer is constructed to study relaxation time measurements of nuclear

magnetic resonance signals in pure liquids and liquid mixtures. For the resolution limited by the stability of the magnetic field, the best resolution was found for 43 gauss at about 80 microgauss and at 12 gauss at about 10 microgauss. At about 40 gauss, the output of the oscillator goes to a twin T bridge which feeds in turn to a two stage amplifier with 175 K. C.-I. F. transformers from which the synchronous detector receives its reference signal. This can be examined by the proper phase of the reference voltage. Some measurements and relaxation time measurements for C_2H_5OH-H_2O are given.

TAM. 02:002

Texas A. and M. Coll. [Dept. of Physics] College Station.

CONCENTRATION DEPENDENCE OF NUCLEAR SPIN-SPIN RELAXATION TIMES IN ETHANOL-WATER MIXTURES (Abstract), by R. W. Mitchell, W. L. Zingery, and M. Eisner. [1956] [1]p. [AF 18(600)1300) Unclassified

Presented at meeting of the Amer. Phys. Soc., Houston, Tex., Feb. 24-25, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 92, Feb. 24, 1956.

The nuclear spin-spin relaxation time T_2 was observed for hydrogen nuclei contained in mixtures of ethanol and water. Measurements were made at fields of 10 gauss with a resolution of 50 microgauss for 30 ml samples. This resolution was sufficient for the study of concentrations ranging from 0.01 to 1.0 mole fractions of ethanol. The relaxation time was obtained by analysis of the decay of the wiggle transients. The results indicate a broad minimum in T_2 occurring at about 0.25 mole fraction of ethanol. This minimum occurs at the same concentration at which other anomalies display peaks. Similar peaks are observed for viscosity, heat of mixing, and ultrasonic absorption at this concentration. (Contractor's abstract)

TAM. 02:003

Texas A. and M. Coll. [Dept. of Physics] College Station.

MEASUREMENT OF THE nmr RELAXATION TIME T_1 IN BINARY MIXTURES (Abstract), by A. F. Hildebrandt, W. L. Zingery, and M. Eisner. [1956] [1]p. [AF 18(600)1300] Unclassified

Presented at meeting of the Amer. Phys. Soc., Houston, Tex., Feb. 24-25, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 92, Feb. 24, 1956.

The longitudinal time T_1, of the different chemical groups of alcohol-water mixtures has been observed using a flow technique. It is observed that different groups in a fine structure pattern have different T_1, reflecting their different lattice environments. An estimate of the effects of the importance of interactions with neighboring groups in the same and different molecules can be made. The effects of chemical exchange are discussed. (Contractor's abstract)

TEX. 01:001

Texas U. Defense Research Lab., Austin.

A SECOND-ORDER THEORY FOR THREE-DIMENSIONAL WINGS IN SUPERSONIC FLOW, by M. H. Clarkson. May 1, 1953, 64p. incl. illus. refs. (Rept. no. DRL-332) (AF 18(600)483) AD 18237 Unclassified

Also published in Quart. Jour. Mech. and Appl. Math., v. 7: 203-221, June 1954.

The problem is expressed mathematically as a non-linear partial differential equation in 3 independent variables with given boundary conditions. The equation is reduced to a sequence of linear equations by a series expansion (in powers of a wing-thickness parameter) of the dependent and one of the independent variables. These equations are solved by the use of the Riesz operator. The pressure distributions of several wing problems are obtained to the second order, and the shock surface is determined to the first order for the case of compressive flow. The first-order shock surface is also obtained for the expansion-region boundaries for the case of expansive flow. A discussion of the rectangular wing illustrates some of the complexities of wing problems.

TEX. 01:002

Texas U. Defense Research Lab., Austin.

TRANSFORM SOLUTIONS OF SINGULAR INTEGRAL EQUATIONS OCCURING IN AERODYNAMIC PROBLEMS. (1). APPLICATIONS, by H. J. Ettlinger, M. H. Clarkson, and C. E. Abraham. July 29, 1953, 42p. refs. (Rept. no. DRL-340) (AF 18(600)483) AD 19173 Unclassified

A 1-dimensional transform is defined which is related closely to certain singular integral equations of the Abel type that occur in wing problems in transonic and supersonic flow. The important properties of the transform which is based on the work of Holmgren, Riemann, and Riesz are developed, and the results are stated as theorems. The transforms of some important elementary functions are tabulated. An integral equation which formerly was solved by using the Hadamard concept of the "finite part" of a nonconvergent integral is interpreted in terms of the transform, and its solution is found with the aid of the tabulated transforms. This example illustrates a direct operational procedure for solving integral equations of this type.

TEX. 01:003 - TEX. 02:002

TEX. 01:003

Texas U. Defense Research Lab., Austin.

NUMERICAL COMPUTATION OF THE SECOND-ORDER TERMS OF THE PERTURBATION VELOCITY POTENTIAL FOR A SEMI-INFINITE RECTANGULAR WING, by R. A. Beeler, P. D. M. Carnahan, and J. N. Younglove. Oct. 19, 1953 [44]p. incl. illus. tables. (Rept. no. DRL-348) (AF 18(600)483)
AD 22224 Unclassified

Values are determined and tabulated for the second-order term of the supersonic perturbation velocity potential for a particular wing. The computational precedure is discussed.

TEX. 01:004

Texas U. Defense Research Lab., Austin.

THE HOLMGREN-RIESZ TRANSFORM AND ITS RELATION TO THE SOLUTION OF SUPERSONIC AERODYNAMIC BOUNDARY VALUE PROBLEMS, by H. J. Ettlinger and C . E. Abraham. Oct. 21, 1953, 39p. illus. refs. (Rept. no. DRL-347) (AF 18(600)483)
AD 22225 Unclassified

The 1-dimensional transform is extended to 3 dimensional and various types of conical regions. The transform is discussed with respect to identity and semigroup properties for the volume bounded by a 3-dimensional half-cone and a plane perpendicular to the cone axis. An expanded form of the transform is deduced for the same volume with the aid of Green's theorem. The transform is also defined for the volume bounded by a forecone, a horizontal plane, and a plane with a characteristic direction. Identity and limit properties are developed for functions defined by surface integrals which appear in the Green's theorem expansion of this transform. The results are applied to the Cauchy initial value problem and other boundary value problems in the theory of supersonic flow about 3-dimensional wings.

TEX. 01:005

Texas U. Defense Research Lab., Austin.

THE HOLMGREN-RIESZ TRANSFORM AND ITS RELATION TO THE SOLUTION OF SUPERSONIC AERODYNAMIC BOUNDARY VALUE PROBLEMS (CONTINUED), by H. J. Ettlinger and C. E. Abraham. Jan. 27, 1954, 60p. incl. illus. refs. (Rept. no. DRL-353) ([AF]OSR-TN-54-47) (AF 18(600)483) AD 27314
UNCLASSIFIED

The Holmgren-Riesz transform is further developed in 3 dimensions and is extended to apply in 4 or more dimensions. Solutions for the nonhomogeneous wave equation are obtained which satisfy linear boundary conditions of mixed type. It is pointed out that the transient supersonic flow equation for the 3-dimensional wing can be transformed to the wave equation in 4 dimensions.

TEX. 01:006

Texas U. Defense Research Lab., Austin.

TECHNICAL REPORT ON ANALYTICAL STUDIES IN SUPERSONIC AERODYNAMICS AND MATHEMATICAL PHYSICS, by H. J. Ettlinger and C. E. Abraham. Final rept. Jan. 29, 1954, 8p. (Rept. no. DRL-354) ([AF]OSR-TR-54-10) (AF 18(600)483)
Unclassified

This report summarizes the work done at Defense Research Lab., Texas U., on Second and Higher Order Effects in the Supersonic Airflow Around Wings and Bodies, and The Study of the Hyperbolic Potential in Three and Four Dimensions. (Contractor's abstract)

TEX. 02:001

Texas U. Defense Research Lab., Austin.

SUPERSONIC SKIN FRICTION AND HEAT TRANSFER RESEARCH AT THE UNIVERSITY OF TEXAS, by R. C. McWherter. Mar. 15, 1954 [21]p. incl. illus. diagrs. tables, refs. [AFOSR-TN-54-64] (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)589 and Bureau of Ordnance under NOrd-9195))
Unclassified

Work done at the Defense Research Laboratory (DRL), Austin since 1947 is reviewed in a paper prepared for presentation at the 1954 Heat Transfer and Fluid Mechanics Institute, University of California, Berkeley. The early program was directed toward procuring experimental reliable data for turbulent skin friction on an insulated flat plate and culminated with a theoretical expression. A direct measuring skin friction balance was developed and is illustrated. Data obtained from the use of this device are compared with published direct measurements at Mach 2. Comparisons also are made of skin friction by direct measurement and boundary layer probe, and a figured compilation is given up to Mach 5 of experimental and theoretical work of several recent investigators in relation to the University of Texas results on insulated turbulent friction. An acceleration-insensitive model of the DRL local skin friction element was under test for use on a free flight missile. Research was being extended to consider broader aspects of supersonic skin friction with heat transfer. Existing wind tunnel circuits were being modified to allow ambient test section temperatures to approach stratosphere values (-67°F). A 6- x 6-in. blow-down type supersonic high temperature tunnel facility which was being calibrated is shown schematically as also is a heat transfer plate designed to eliminate the temperature gradient difficulty usually encountered.

TEX. 02:002

Texas U. Defense Research Lab., Austin.

THEORETICAL AND EXPERIMENTAL STUDIES OF BOUNDARY LAYER CHARACTERISTICS AT SUPERSONIC SPEEDS IN AIR INCLUDING INVESTIGATIONS

OF SKIN FRICTION, VELOCITY DISTRIBUTION AND HEAT TRANSFER, by J. L. Harkness, J. E. Weiler and others. Annual rept. Jan. 5, 1954, 27p. illus. diagrs. tables, refs. (Rept. No. DRL-352) (AF 18(600)589) AD 25306 Unclassified

A brief statement of the over-all study is first presented, and this is followed by a detailed discussion of the work completed. The bulk of the work has been concerned with the design and initial steps of construction of an additional high temperature circuit for the existing high Mach number test facility. A detailed description of this circuit is given, including a considerable discussion of the design problems and procedures. This is followed by a survey of present theories and experimental investigations carried out by other research organizations covering the problems concerned. This survey was made in order to avoid duplication of effort and also to aid in the initial design of test equipment. A discussion of an experimental study already under way in the existing tunnel is presented, and the value of this as a pilot tunnel to aid in the development of some of the test equipment is pointed out. The last section of this report indicates briefly the plans to be followed in the second year of the program. (Contractor's abstract)

TEX. 02:003

Texas U. Defense Research Lab., Austin.

THEORETICAL AND EXPERIMENTAL STUDIES OF BOUNDARY LAYER CHARACTERISTICS AT SUPERSONIC SPEEDS IN AIR, INCLUDING INVESTIGATIONS OF SKIN FRICTION, VELOCITY DISTRIBUTION AND HEAT TRANSFER, by J. L. Harkness. Annual rept. Jan. 5, 1955, 36p. illus. diagrs. tables. (AF 18(600)589) Unclassified

The progress and present status is reported of the 6- x 6-in. high stagnation temperature, wind-tunnel circuit. A description of each major part of this circuit is presented with a special section covering the air heaters. Detailed information on both the storage-type heater and the electrical control heater is contained in this section. An outline of the theoretical study listing recent papers reviewed and presenting a theoretical analysis of the proposed heat transfer models is also included. A section is devoted to pilot testing in the existing M = 4.89 nozzle as it concerns the subject investigation, and the last section indicates briefly the plans to be followed during the third year of the program. (Contractor's abstract)

TEX. 02:004

Texas U. Defense Research Lab., Austin.

THEORY, DESIGN, AND PERFORMANCE OF A 420-KW ELECTRICAL HEATER FOR AUTOMATIC CONTROL OF STAGNATION TEMPERATURE IN A BLOW-DOWN WIND TUNNEL, by W. H. Hartwig. June 1956, iv. incl. illus. diagrs. refs. (Rept. no. DRL 383) (AFOSR-TN-56-163) (AF 18(600)589) AD 86584 Unclassified

The design, theory, and performance are presented for a 420-kw electric heater with feedback control. The heater maintains a constant stagnation temperature in a 6- x 6-in. supersonic wind tunnel. The system, which is characterized by a high speed of response and low absolute error, uses ignition tubes to control current in a 3-phase, 440-v circuit. A 3°F maximum error, and a 1400°F design limit were achieved.

TEX. 02:005

Texas U. Defense Research Lab., Austin.

A DESIGN OF ELECTRICAL CONTROL HEATERS FOR OPERATION WITH A SUPERSONIC, BLOW-DOWN WIND TUNNEL, by R. A. Fetter, Jr. June 1956, 76p. incl. illus. diagrs. tables, refs. (DRL rept. no. 382) (AFOSR-TN-56-188) (AF 18(600)589) AD 87061 Unclassified

Two electric control heaters were designed which are used to maintain a constant stagnation air temperature in a 6- x 6-in., blow-down, supersonic wind tunnel. The heater maintains a supply of constant-temperature air to the nozzle stilling chamber. A large-capacity, gas-fired storage heater is installed upstream from the control heater. Air flowing through the circuit picks up heat in the storage heater, and additional heat is then added by the electric heater. Since the heated air is for heat-transfer studies, the electric heater must not only add an increment of temperature but must also control the air temperature at a constant value, even though the entering temperature is changing. Testing was conducted with M = 5.0 nozzles. Results indicated that the heaters are satisfactory for a blow-down wind tunnel where high constant-stagnation temperatures are required. The cost of the heaters is from one-half to one-third that of comparable wind-tunnel heaters. The simple design offers a minimum heat sink. High efficiency is sacrificed for a small amount of thermal insulation and few heat sinks.

TEX. 02:006

Texas U. Defense Research Lab., Austin.

A STORAGE-TYPE AIR HEATER FOR AN INTERMITTENT-FLOW SUPERSONIC WIND TUNNEL, by J. E. Weiler. Nov. 7, 1956, 1v. incl. illus. diagrs. tables. (Rept. no. DRL 393) (AFOSR-TN-56-572) (AF 18(600)589) AD 110394 Unclassified

A description is given of the development, design of components, and operation of a storage-type air heater adaptable to alternative use with a Mach number 2.0 nozzle or a Mach number 5.0 nozzle, each discharging into 6- x 6-in. test sections. These are four sections of 10-inch, heavy pipe filled ferrosilicon alloy spheres within an insulating lining. A hot mixture of natural gas combustion products and air heat the spheres to a desired level; then the wind tunnel supply air is heated to the same level as the spheres in the blowdown phase.

TEX. 02:007 - TEX. 03:003

Several units necessary to the operation are explained. Over a period of a year the performance of the unit has been satisfactory.

TEX. 02:007

Texas U. Defense Research Lab., Austin.

THEORETICAL AND EXPERIMENTAL STUDIES OF BOUNDARY LAYER CHARACTERISTICS AT SUPERSONIC SPEEDS IN AIR, INCLUDING INVESTIGATIONS OF SKIN FRICTION, VELOCITY DISTRIBUTION AND HEAT TRANSFER, by J. L. Harkness, J. E. Weiler, and W. H. Hartwig. Annual rept. Jan. 5, 1956, 28p. illus. diagrs. tables. (AF 18(600)589) Unclassified

The major portion of this report concerns the development, testing, and necessary revisions to the various components of the wind-tunnel circuit. These revisions and the results of the performance testing are presented in detail for the storage-type heater and the electrical-control heater. Instrumentation for the calibration testing of the flow produced in the nozzles is described, along with the performance of the pressure control system of the tunnel. Work has been resumed on the design and fabrication of the flat plate heat transfer model, and a brief description of this investigation is presented. It is noted that neither time nor manpower has been available for further theoretical work of significance. However, a seminar-type group has been established by the Defense Research Laboratory (DRL) in cooperation with the Department of Aeronautical Engineering which should benefit this phase of the investigation. An outline of this activity is included. Conferences held at DRL and at other laboratories are discussed, and a brief outline concerning plans for future work is also presented. (Contractor's abstract)

TEX. 02:008

Texas U. Defense Research Lab., Austin.

DEVELOPMENT OF CONSTANT TEMPERATURE SOURCES FOR SUPERSONIC AERODYNAMICS RESEARCH, by W. H. Hartwig. Dec. 1956, 10p. illus. tables, refs. (AF 18(600)589) Unclassified

This is a review of the development of the temperature control system for the blow-down wind-tunnel facility of the Aeromechanics Div., Defense Research Lab., Texas U., Austin.

TEX. 03:001

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. I. SPECTRA OF ACETYLENE FLAMES, by J. S. Fain and R. C. Anderson. May 1952, 18p. incl. refs. (Technical rept. no. 1) (AF 33(038)21745) ATI-161753 Unclassified

A survey of the literature has been made as part of a study of fundamental factors controlling excitation and reaction occurring in combustion or explosion in and of acetylene and acetylenic compounds. This report is the first of a series of bibliographies listing available references pertinent to various aspects of this study. It is a summary of information now compiled in a punch-card file. It also lists specifically literature on the spectra of acetylene and related compounds, which is useful as background for consideration of possible excited states and excitation of such compounds, and on flame spectra. (Contractor's abstract)

TEX. 03:002

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. II. PREPARATION AND PROPERTIES OF ACETYLENIC COMPOUNDS, by L. F. Hatch. July 1952, 15p. incl. illus. diagrs. refs. (Technical rept. no. 1, Supplement I) (AF 33(038)21745) ATI-161753 Unclassified

A general literature survey has been made on preparation and properties of a number of substituted acetylenes. These have been incorporated in the punch-card file described in Technical rept. no. 1. Two methods for the preparation of acetylenic hydrocarbons have been used widely: (1) dehydrohalogenation or dehalogenation of appropriate organic halides, and (2) reaction between an acetylide and an alkyl halide or another alkyiating agent. Included in the report is a detailed table which gives an extensive review of various individual acetylenes of interest in the current study, methods of preparation, and references to the literature. (Contractor's abstract)

TEX. 03:003

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. III. HALOACETYLENES, by L. F. Hatch. July 1952, 16p. incl. illus. diagrs. tables, refs. (Technical rept. no. 1, Supplement II) (AF 33(038)21475) ATI-161753 Unclassified

There are two general types of halogen substituted acetylenes: (1) the very reactive compounds which contain a halogen atom attached directly to a carbon atom associated with the carbon-carbon triple bond (RC≡CX) and (2) the much less reactive compounds having the halogen atom attached to a carbon atom not associated with the carbon-carbon triple bond (RCHXC≡CR). This report gives methods of preparations and properties for each of the two types. (Contractor's abstract)

TEX. 03:004

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. IV. EXPERIMENTAL DATA ON ACETYLENE FLAMES. V. THERMODYNAMIC PROPERTIES AND ENERGY RELATIONS; MASS SPECTROGRAPHIC DATA; MOLECULAR STRUCTURE. VI. REACTION MECHANISMS AND FLAME THEORIES. VII. DETONATION; SOME SPECIAL EFFECTS, by R. C. Anderson. Aug. 1952, 46p. incl. illus. diagrs. refs. (Technical rept. no. 1, Supplement III) (AF 33(038)-21745) ATI-161753 Unclassified

This report is another in a series summarizing the literature on flames and combustion of acetyienic compounds as a basis for study of the fundamental reactions in those processes. It includes sections covering experimental studies of properties of flames, such as flame temperatures, burning velocities, ignition conditions, etc., for flames in air or oxygen and also in hydrocarbons alone; thermodynamic properties and molecular structure; reaction mechanisms and flame theories; and detonation and other special effects. (Contractor's abstract)

TEX. 03:005

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. [VIII.] ACETYLENIC ALCOHOLS, by L. F. Hatch. Sept. 1952, 12p. incl. illus. tables, refs. (Technical rept. no. 1, Supplement IV) (AF 33(038)21745) ATI-161753 Unclassified

This report is a continuation of the series of technical reports on acetylenic compounds. It deals with the literature pertaining to the preparation and properties of acetylenic alcohols. Compounds of this type are of interest in their own right and as precursors of haloacetylenes of the type RCHXC ≡ CR (see item no. TEX. 03:003) (Contractor's abstract)

TEX. 03:006

Texas U. [Dept. of Chemistry] Austin.

SURVEY OF THE LITERATURE ON ELEMENTAL PROCESSES IN COMBUSTION OF ACETYLENE AND RELATED COMPOUNDS. IX. SUMMARY, by R. C. Anderson. Oct. 1952, 15p. incl. illus. tables. (Technical rept. no. 1, Supplement V) (AF 33(038)21745) ATI-161753 Unclassified

In preceding sections of this report, a bibliography has been compiled of the available literature on flames and reactions in acetylene, in acetylene-oxygen or acetylene-air mixtures, and in corresponding systems involving other alkynes. In the following section, a brief summary is given of the major results of a survey of the literature as represented in that bibliography with regard to information on the nature of the elemental processes or reactions in flames and combustion of acetylenic compounds. To facilitate the use of the bibliography, a list has been prepared in which various references are grouped according to the chemical compounds involved. This is given in the appendix. (Contractor's abstract)

TEX. 03:007

Texas U. [Dept. of Chemistry] Austin.

INFRARED SPECTRUM OF 1-BROMO-I-PROPYNE, by J. S. Fain. May 1952, 4p. incl. diagrs. table. (Technical rept. no. 2) (AF 33(038)21745) ATI-161754 Unclassified

This report summarizes data obtained on the infrared spectrum of 1-bromo-I-propyne which were obtained in analyzing a sample of this material prepared for a study of its stability and combustion properties. Data are available in the literature on the Raman spectra of this compound, but no previous reports on its infrared spectrum are available. (Contractor's abstract)

TEX. 03:008

Texas U. [Dept. of Chemistry] Austin.

EXPLORATORY EXPERIMENTS IN PRE-IGNITION AND FLAME SPECTRA IN ACETYLENE, by N. B. Humphreys, W. W. Robertson, and R. C. Anderson. June 1952, 9p. incl. illus. diagrs. (Technical rept. no. 3) (AF 33(038)21745) ATI-161755 Unclassified

This is a report of initial experiments and observations on emission and absorption spectra of flames in acetylene alone and of acetylene pre-heated just to the point of ignition. Flame spectra are continuous, but this might result entirely from the effect of the hot carbon particles present. The exploratory experiments indicate that spectra of acetylene excited past the ignition level can be observed by heating in the presence of helium or at low pressures without interference from carbon. Preliminary data show only continuous spectra for the excited acetylene, with no evidence of typical bands of radicals such as C_2. (Contractor's abstract)

TEX. 03:009

Texas U. [Dept. of Chemistry] Austin.

EFFECTS OF CERTAIN ADDITIVES ON FLAME PROPAGATION IN ACETYLENE, by F. H. Coats, J. D. Frazee, and R. C. Anderson. June 1952, 15p. incl. diagrs. tables. refs. (Technical rept. no. 4) (AF 33(038)21745; continued by AF 18(600)430) ATI-161756 Unclassified

TEX. 04:001 - TEX. 04:003

Exploratory experiments are reported which were carried out on the influence of various additives on slow flame propagation in acetylene, particularly under conditions in which only small quantities (1% or so) of additive were used and effects of dilution minimized. Acetone, hydrogen, and water vapor were tested because they are commonly present in acetylene systems; nitrogen, because it is an example of a relatively inert diluent; methyl chloride and diethyl ether because they are sources of free radicals, and nitric oxide and sulfur dioxide because they are potential inhibitors of free radical chains and of carbon formation. Nitrogen was found to behave essentially as an inert diluent. Added hydrogen increased somewhat the ease of ignition and the speed of flame propagation, as did acetone and diethyl ether. Flame propagation was made more difficult by nitric oxide. Water, methyl chloride, and sulfur dioxide showed no appreciable effects. (Contractor's abstract)

TEX. 04:001

Texas U. [Dept. of Chemistry] Austin.

CARBON FORMATION AND REACTION IN FLAMES IN ACETYLENE, by J. D. Frazee and R. C. Anderson. [1952] 12p. incl. diagrs. table, refs. (AF 18(600)430; continuation of AF 33(038)21745) Unclassified

In this study on flame propagation in the self-combustion of acetylene, an attempt has been made to obtain additional data on the mechanism involving the formation or reaction of C particles in these flames. Theories of other researchers are briefly treated, explaining C formation in flames, e.g., from C_2 radicals; from the pyrolysis of large molecules; from the pyrolysis of tiny droplets of liquid polymers. The mechanism suggested here differs from the earlier theories in that the essential steps involve reaction of large, unsaturated molecules, or free radicals, with H atoms or groups like C_2H, rather than the decomposition or simple dehydrogenation of such molecules. It is concluded that the results of this flame study are in agreement with earlier results in that they indicate a polymerization-dehydrogenation mechanism of C formation; however, they further indicate that a chain mechanism involving highly unsaturated hydrocarbon free radicals and H atoms is involved. It is pointed out that the nature, structure, and size of particles are controlled by the balance between simple combustion reactions leading to liquid polymers at lower temperatures, and dehydrogenation reactions leading to C formation at higher temperatures.

TEX. 04:002

Texas U. Dept. of Chemistry, Austin.

ELECTRON-IMPACT STUDIES ON PROPYNE, by F. H. Coats and R. C. Anderson. [1953] [8]p. incl. diagr. tables. (AF 18(600)430) Unclassified

Presented at the Southwestern-Southeastern Regional meeting of the Amer. Chem. Soc., New Orleans, La., Dec. 10, 1953.

A discussion of appearance and ionization potentials of organic ions and mass spectrometric methods of detecting reaction intermediates, introduces a report on the determination of the energy of bombarding electron beams required to form various ionic fragments of propyne and other acetylenic compounds. Ionization probability curves for the various ions and for reference ions were simultaneously determined spectroscopically. Use was made of an intermediate electrode in the electron gun to maintain a constant negative potential with respect to the filament to reduce curve uncertainty at very low ion currents. Typical curves of the propyne system are included. As preliminary mass scans of propyne showed appreciable but regularly decreasing peak heights for masses 40 through 36, determinations were made of the appearance potentials for ions of corresponding mass. A value of 10.3 v was obtained for the ionization potential of propyne. The appearance potentials of its C_3H_3, C_3H_2, C_3H, and C_3 ions are respectively 11.8, 14.0, 18.4, and 26 v; uncertainty for the C_3 value is ± 1.0 v, and for the remainder ± 0.1 v. Determinations of the order of dissociation of the C-H bonds of propyne under electron bombardment was made by comparison of the propyne dissociation appearance potentials with the corresponding values for dissociation of methane; the acetylenic H dissociates after the methyl group has been stripped of H atoms which is consistent with the high dissociation energy observed for the C-H bonds in acetylene. Appearance potentials are tabulated for various ions from acetylene, propyne, methane, and ethane.

TEX. 04:003

Texas U. [Dept. of Chemistry] Austin.

PRE- IGNITION AND FLAME SPECTRA IN THE SELF-COMBUSTION OF ACETYLENE, by W. W. Robertson, N. B. Humphreys, and R. C. Anderson. [1953] [5]p. incl. diagr. (AF 18(600)430) Unclassified

Published in Jour. Chem. Phys., v. 21: 2093-2094, Nov. 1953.

No C_2 or CH bonds were observed in emission and absorption spectra in the visible and near-ultraviolet range of acetylene flames in the absence of oxygen, recorded photographically on a 3-meter grating spectrograph. The emission spectrum was obtained by flowing preheated acetylene down a heated vertical quartz tube 3.5 cm in diameter, discharging into a large flask. A turbulent flame was maintained for about 10 min, by adjustment of the flow rate, before carbon deposition affected high resolution. The observed emission spectrum was continuous, from about 3500 to 6000 Å, with a maximum at 5800 Å; no discrete bands or lines were observed. Absorption spectra were recorded using a heat absorption cell and a high intensity Hanovia xenon arc light-source. Pure acetylene showed continuous spectra from the ultraviolet into the visible range as cell temperature was raised from 375°C to the ignition temperature of 500°C, where combustion produced large quantities of

carbon and acetylenic polymers that completely scattered and absorbed light entering the cell. Samples of condensed combustion products also showed continuous absorption in the ultraviolet. Determination of absorption spectra at temperatures up to 1000°C by use of acetylene-helium mixtures also showed continuous spectra, with the limit extending to longer wave lengths as temperature ions increased. The continuous absorption at lower temperatures can be attributed to conjugated unsaturated condensation products whose concentrations increase with temperature; major participation of C_2 or CH radicals in the reaction mechanisms is not indicated.

TEX. 04:004

Texas U. Dept. of Chemistry, Austin.

CARBON FORMATION IN ACETYLENE FLAMES. CALCULATION OF FREE ENERGIES OF REACTION, by K. Hellwig and R. C. Anderson. May 1953, 20p. incl. tables, refs. (Technical rept. no. 5) (AF 18(600)430) AD 16157 Unclassified

Techniques for calculating the free energies of certain reactions were employed in determining the feasibility of mechanisms proposed to explain the spontaneous combustion of acetylene to C and H. Theoretical considerations indicated that combination reactions and dissociation of acetylene to form H and free radicals can be combined in a mechanism which will explain experimental results.

TEX. 04:005

Texas U. [Dept. of Chemistry] Austin.

A MODIFIED TRANSITION STATE THEORY OF REACTION RATES, by F. A. Matsen. June 1953, 12p. diagrs. (Technical rept. no. 6) (AF 18(600)430) AD 30056 Unclassified

The specific reaction rate for chemical reactions is formulated in terms of the total transmission coefficient in the reaction coordinate and a modified transition state, which differs from the original transition state only in the treatment of the reaction coordinate. If the total transmission coefficient is factored into two partial transmission coefficients, the modified theory gives the transition state theory in both the classical and the quantum-mechanical-particle-in-a-box treatments. It is then shown that the momentum density in the virtual state over a symmetrical square barrier is that of a quantum-mechanical-particle-in-a-box at low momentum, and that of a classical system at high momentum. Finally the reaction rate transmission coefficient is calculated from the modified theory for an unsymmetric square barrier, and is shown to depend on the temperature, the activation energy, and the thermicity of the reaction. (Contractor's abstract)

Tex. 04:006

Texas U. Dept. of Chemistry, Austin.

PRE-IGNITION ABSORPTION SPECTRA IN SELF-COMBUSTION OF ACETYLENE, by W. W. Robertson and R. C. Anderson. Aug. 1953, 10p. diagrs. (Technical rept. no. 7) (AF 18(600)430) AD 19347 Unclassified

Spectra were observed for various mixtures and conditions, including mixtures of 2 to 50% acetylene and temperature ranges from 500° to 1000°C. The spectra observed for the various mixtures were continua. Band spectra for C_2 and CH were not detectable even when He was the diluent and the acetylene was heated above the normal ignition temperature. The region of continuous absorption moved to longer wave lengths as the temperature increased. Plots are presented which show the results for acetylene at various temperatures, and the effects of substituting N for He as the diluent and of small additions of NO. The observed densities of the photographic plates were plotted so that the maximum density corresponded to the minimum adsorption. The adsorption decreased as the lower partial pressure of acetylene was reached. Data on the pressure variations accompanying these changes and the extent of adsorption are summarized graphically.

TEX. 04:007

Texas U. Dept. of Chemistry, Austin.

STUDIES OF CARBON FORMATION AND REACTION IN ACETYLENE, by J. D. Frazee and R. C. Anderson. Aug. 1953, 17p. incl. diagrs. tables. (Technical rept. no. 8) (AF 18(600)430) AD 19346 Unclassified

The electron microscope and extraction techniques were employed to obtain additional information on the C formed in the self-combustion of acetylene. The reactivity of the C with various hot gases was also tested. The greasy appearance of the C which formed in the later slow stage of flame propagation as contrasted to the dry, gray samples in the initial stage appeared to be the result of polymerization of untreated acetylene on hot particles produced in the flame propagation. The differences in particle sizes in the two regions and the reaction of C samples in a stream of hot acetylene suggested the formation of C in reactions of hot particles with acetylene. Tests indicated that vitreous C was formed in surface reactions on glass or porcelain, and that acetylene reacted with C more readily than on glass or porcelain. The general behavior of the flames was consistent with a mechanism involving the formation of large, highly saturated molecules which are pyrolyzed and dehydrogenated to form C nuclei.

TEX. 04:008

Texas U. Dept. of Chemistry, Austin.

EFFECTS OF ADDITIVES ON FLAME PROPAGATION IN ACETYLENE. II, by E. A. Westbrook and

TEX. 04:009 - TEX. 04:012

R. C. Anderson. Mar. 1954, 9p. incl. diagrs. tables. (Technical rept. no. 9) ([AF]OSR-TN-54-111) (AF 18(600)430) AD 36514 Unclassified

Experiments were conducted to determine qualitatively the effects of a variety of chemical reagents on ignition, pressure changes, and flame velocities. Additional data are given for the effects of N, acetone, benzene, and halogenated compounds. The 1-bromopropyne compound increased the flame velocity significantly as contrasted to HBr, HCl, and Br_2, which interfered with flame propagation. The results of the first tests with acetylenic ethers are presented. Motion pictures were made of some flame tests.

TEX. 04:009

Texas U. Dept. of Chemistry, Austin.

SELF-COMBUSTION OF ACETYLENE. II. REACTIONS IN FLAME PROPAGATION, by E. A. Westbrook, K. Hellwig, and R. C. Anderson. May 1954 [24]p. incl. diagrs. tables, refs. (Technical rept. no. 11) ([AF]OSR-TN-54-112) (AF 18(600)430) AD 37356 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 631-637.

Experimental results for the effects of certain additives on the flame velocity in the self-combustion of acetylene, and on UV absorption spectra, and data from mass-spectrographic analysis and from thermochemical calculations are reported. The significance of these and earlier results in connection with the mechanisms of reactions occurring in the flames is discussed. Thermal reactions can occur, but cannot account for many of the observations on flame propagation. Probable reactions involving free radicals and a chain mechanism are suggested. (Contractor's abstract)

TEX. 04:010

Texas U. [Dept. of Chemistry] Austin.

SELF-COMBUSTION OF ACETYLENE. I. PRE-IGNITION KINETICS, by W. W. Robertson, E. M. Magee and others. May 1954, 5p. diagrs. table. (Technical rept. no. 10) ([AF]OSR-TN-54-115) (AF 18(600)430) AD 40201 Unclassified

Also published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 628-631, 1954.

The thermal reactions of acetylene were studied at temperatures up to the ignition temperature on a straight-through flow system. Determinations were made by IR and mass spectrometric analysis of the gas product. Volume changes were determined from the intensity of IR absorption of added freon. The principal gaseous products were benzene, ethylene, CH_4, and H. Benzene increased exponentially with the temperature. Dilution with He raised the ignition temperature. NO had an inhibitory effect on the benzene and ethylene formation and raised the ignition temperature.

TEX. 04:011

Texas U. Dept. of Chemistry, Austin.

PREPARATION AND PROPERTIES OF 3-CHLORO-1-IODOPROPYNE AND 3-BROMO-1-IODOPROPYNE, by L. F. Hatch and D. J. Mangold. [1955] [2]p. [AFOSR-TN-54-171] (AF 18(600)430) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 176-177, Jan. 5, 1955.

$HC{:}CCH_2Cl$ (I), b_{751} 57-59°, n_D^{20} 1.4320, was prepared from $HC{:}CCH_2OH$ and PCl_3 pyridine. I (35 g) and 127 g iodine in 250 cc saturated aqueous KI added simultaneously with rapid stirring at 5° to 224 g KOH in H_2O during 1.5 hours, the mixture stirred 4 hours, extracted with Et_2O, and the extract dried and distilled under N yielded 49 g $IC{:}CCH_2Cl$, b_4 46.5-47.5° n_D^{20} 1.5890, n_D^{25} 1.5863, n_D^{30} 1.5836, d_{20} 2.1426, d_{25} 2.1333, d_{30} 2.1249, MR_D 31.55. $HC{:}CCH_2Br$ (119 g) was converted similarly with 254 g iodine in 250 cc saturated aqueous KI and 224 g KOH to 77 g $IC{:}CCH_2Br$, b_2 59.5-60.0°, n_D^{20} 1.6435, n_D^{25} 1.6405, n_D^{30} 1.6377, d_{20} 2.5663, d_{25} 2.5562, d_{30} 2.5473, MR_D 34.53, unstable and turning dark brown after a few minutes in air. The spectrum of $HC{:}CCH_2I$ showed a sharp band at 5.10 and a weak band at 5.85μ, confirming the observation of Jacobs and Brill that the iodo compound is actually a mixture of $HC{:}CCH_2I$ and $CH_2{:}C{:}CHI$.

TEX. 04:012

Texas U. Dept. of Chemistry, Austin.

ELECTRON IMPACT DATA ON SUBSTITUTED ACETYLENES: PROPYNE AND 2-BUTYNE, by F. H. Coats and R. C. Anderson. Aug. 1954, 5p. incl. tables, refs. (Technical note no. 14) ([AF]OSR-TN-54-237) (AF 18(600)430) AD 42142 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 895-896, Feb. 20, 1955.

The ionization and appearance potentials of various ions from substituted acetylenes are being determined to obtain further information on energy relations for acetylenic compounds. The appearance potentials for the propyne and 2-butyne dissociation series are tabulated. The ionization potentials for acetylene, propyne, and 2-butyne show a general trend similar to those observed by Honig (Jour. Chem. Phys., v. 16: 105, 1948) for the alkane and alkene series. The heat of reaction for the process $C_2H_2 + e \rightarrow C_2H^+ + 2e$ as given by the appearance potential for C_2H^+ ion was 17.8 ev.

TEX. 04:013

Texas U. Dept. of Chemistry, Austin.

PREPARATION AND PROPERTIES OF A NUMBER OF HALOPROPYNES, by L. F. Hatch, L. E. Kidwell [Jr.], and D. J. Mangold. Aug. 1954, 1v. incl. diagrs. refs. (Technical note no. 13) ([AF]OSR-TN-54-248) (AF 18(600)430) AD 42141 Unclassified

A number of haloacetylenes of the type X-C ≡ C-CH_2Y were prepared, where X was Cl, Br, or I and Y was H, Cl, Br, or I. Various physical properties were determined, and the possibility of acetylenic-allenic rearrangement was investigated through the use of IR spectra. The propargyl halides (Cl, Br, I) were also studied in respect to acetylenic-allenic rearrangement.

TEX. 04:014

Texas U. Dept. of Chemistry, Austin.

METHYLPHENOXYACETYLENE AND PHENOXYPROPADIENE, by L. F. Hatch and H. D. Weiss. Oct. 1954, [10]p. incl. diagr. table. (Technical note no. 15) ([AF]OSR-TN-54-289) (AF 18(600)430) AD 50905 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 1798-1800, Apr. 5, 1955.

Methylphenoxyacetylene and phenoxypropadiene have been prepared and characterized. The methylphenoxyacetylene was synthesized by the reaction between sodium phenoxyacetylide and methyl iodide. The phenoxypropadiene was prepared by the dehydrobromination of 2-bromo-1-phenoxy-1-propene. Both compounds appear to be stable toward acetylenic-allenic rearrangement under normal preparative and storage conditions. (Contractor's abstract)

TEX. 04:015

Texas U. Dept. of Chemistry, Austin.

PREPARATION AND PROPERTIES OF 1-BROMO-1-PROPYNE, 1,3-DIBROMOPROPYNE, AND 1-BROMO-3-CHLORO-1-PROPYNE, by L. F. Hatch and L. E. Kidwell, Jr. [1954] [2]p. (AF 18(600)430) Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 289-290, Jan. 5, 1954.

1-Bromo-1-alkynes were prepared in good yields under mild conditions which minimized rearrangement to the isomeric allene. KOH (2.68 moles) in 1 liter of water at about 5° treated with 0.67 mole Br, and the cold solution treated with MeC:CH until the KOBr had reacted, then extracted with Et_2O yielded 75% 1-bromopropyne (I), b_{750} 64-65°, d_{20} 1.5325, d_{25} 1.5222, d_{30} 1.5122. I is spontaneously flammable in air. $H_2CBrC{:}CH$ (II) (0.67 mole) yielded 45% 1,3-dibromopropyne (not spontaneously flammable in air), b_{10} 53-54°, n_D^{20} 1.5690, n_D^{25} 1.5664, n_D^{30} 1.5633, d_{20} 2.1894, d_{25} 2.1785, d_{30} 2.1676. H_2C-ClC:CH (III) (0.34 mole) yielded 53% 1-bromo-3-chloropropyne (not spontaneously flammable in air), b_{30} 47-48°, n_D^{20} 1.5207, n_D^{25} 1.5184, n_D^{20} 1.5158, d_{20} 1.7598, d_{25} 1.7519, d_{30} 1.7433. $H_2C(OH)C{:}CH$ (IV) and PBr_3 in pyridine yielded II, b_{130} 36-37°, n_D^{20} 1.4917. IV and PCl_3 in pyridine yielded III, b_{30} 57-58°, n_D^{20} 1.4338. Infrared absorption spectra data are given. (C. A., 1955: 12267a)

TEX. 04:016

Texas U. Dept. of Chemistry, Austin.

ALLYLIC CHLORIDES. XXI. 3-CHLORO-2-PHENYL-1-PROPENE, by L. F. Hatch and T. L. Patton. [1954] [3]p. incl. table. [AF 18(600)430] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 2705-2707, May 20, 1954.

3-Chloro-2-phenyl-1-propene has been prepared by the reaction between 2-phenyl-2-propen-1-ol and thionyl chloride. The allylic alcohol was prepared by the hydrolysis of the corresponding acetate made by selenium dioxide oxidation of 2-phenyl-1-propene and by the hydrolysis of the corresponding bromide (3-bromo-2-phenyl-1-propene) made by the reaction between 2-phenyl-1-propene and N-bromosuccinimide. The relative reactivities of 3-chloro-2-phenyl-1-propene with potassium iodide in acetone and sodium ethoxide in ethanol have been determined. (Contractor's abstract)

TEX. 04:017

Texas U. Dept. of Chemistry, Austin.

EFFECTS OF ADDITIVES ON FLAME PROPAGATION IN ACETYLENE. II, by M. S. B. Munson and R. C. Anderson. Jan. 1955 [14]p. incl. diagrs. tables. (Technical note no. 17) ([AF]OSR-TN-55-18) (AF 18(600)430) AD 55114 Unclassified

Further results are reported on the series of exploratory studies of effects of additives on flame propagation in acetylene. These include phenoxyacetylene and phenoxypropyne, a series of 1-iodo-1-propynes, chlorine, 1-chloro-1-propyne, ethylene oxide, and new data on sulfur dioxide and hydrogen bromide. Certain comparative studies were also made on the pressure changes caused by the flame propagation and on the carbons produced. (Contractor's abstract)

TEX. 04:018 - TEX. 04:023

TEX. 04:018

Texas U. Dept. of Chemistry, Austin.

A FLOW REACTOR FOR KINETIC STUDIES, by J. R. Streetman and F. A. Matsen. May 1955 [10]p. incl. diagrs. table. (Technical note no. 18) ([AF]OSR-TN-55-125) (AF 18(600)430) AD 63363 Unclassified

A new flow reactor is described. It is designed to obtain kinetic data, i.e., specific reaction rate constants, reaction orders, and apparent activation energies, from a flow system. The reactor consists of a Vycor tube 214 cm long, having a bore of 1.3 cm. The tube is heated electrically, the temperature being recorded and controlled automatically. The flow of gases is measured by rotameters utilized individually and in combination. The reaction gases are analyzed continuously by an infrared spectrometer. Provision is made to permit dilution by helium, inhibition by nitric acid, and activation by ethylene oxide or oxygen. Using the reactor, it is proposed to study the self-combustion of acetylene and the kinetics of acetylene-oxygen reactions, particularly those having low concentrations of oxygen.

TEX. 04:019

Texas U. Dept. of Chemistry, Austin.

THERMODYNAMIC DATA FROM ELECTRON-IMPACT STUDIES OF SUBSTITUTED ACETYLENES, by F. H. Coats and R. C. Anderson. June 1955, 15p. tables, refs. (Technical note no. 20) ([AF]OSR-TN-55-180) (AF 18(600)430) AD 67678 Unclassified

Additional data on ionization and appearance potentials for various substituted acetylenes are reported. These and the earlier measurements have been used for calculations of heats of formation of certain ions and radicals, bond strengths, and group contributions. The heat of formation of C_2H is found to be 112 ± 3 kcal/mole and $D(HC_2\text{-}H)$ 110 kcal. There are still serious discrepancies in current values for the heat of formation of C_2 and CH and for $D(C_2\text{-}H)$. (Contractor's abstract)

TEX. 04:020

Texas U. Dept. of Chemistry, Austin.

X-RAY INVESTIGATION OF SOME CARBON BLACKS, by S. H. Simonsen and R. C. Anderson. July 1955 [17]p. incl. illus. diagrs. tables. (Technical note no. 22) ([AF]OSR-TN-55-222) (AF 18(600)430) AD 67676 Unclassified

X-ray studies have been made on a number of samples of carbon black from flames in acetylene using a technique developed by Dr. Simonsen. These show the typical diffuse rings indicating very small crystallites. The results indicate that these crystallites are larger in the region just around the igniter than in the later region of slower, smooth flame propagation. Addition of ethylene oxide increased the size of the crystallites. (Contractor's abstract)

TEX. 04:021

Texas U. Dept. of Chemistry, Austin.

SELF COMBUSTION OF ACETYLENE. III. EFFECT OF OXYGEN AND ETHYLENE OXIDE, by W. W. Robertson and F. A. Matsen. Aug. 1955 [9]p. incl. diagrs. (Technical note no. 21) ([AF]OSR-TN-55-257) (AF 18(600)430) AD 69366 Unclassified

Also published in Combustion and Flame, v. 1: 94-98, Mar. 1957.

The self-combustion of acetylene is promoted by the addition of small amounts of ethylene oxide and O. These additions produce free radicals which, at high temperatures (over 350°C), initiate self-combustion chains in the acetylene. Benzene formation was shown to go through a different initiation mechanism than the bulk of the reaction, and to be wall-inhibited perhaps by peroxide.

TEX. 04:022

Texas U. Dept. of Chemistry, Austin.

ULTRAVIOLET ABSORPTION SPECTRUM OF BENZENE IN n-HEXANE AT PRESSURES TO 6000 BARS, by W. W. Robertson and F. A. Matsen. Sept. 1955 [6]p. incl. diagrs. (Technical note no. 23) ([AF]OSR-TN-55-309) (AF 18(600)430) AD 73216 Unclassified

Also published in Jour. Chem. Phys., v. 23: 2468, Dec. 1955.

The solution spectrum of benzene in n-hexane was obtained at pressures from 1 to 6000 bars. The effect of increasing the pressure caused the absorption bands to broaden and to shift them to longer wavelengths. A microphotometer tracing of the benzene spectrum in n-hexane at 1-bar and at 5500-bar pressures is shown. In addition, a plot is made of the wavelength of the 0 + 520 band vs pressure.

TEX. 04:023

Texas U. [Dept. of Chemistry] Austin.

CHEMICAL KINETICS IN FLOW SYSTEMS, by J. R. Streetman and F. A. Matsen. Mar. 1958, 3p. (Technical note no. 24) (AFOSR-TN-58-97) (AF 18(600)430) AD 82010 Unclassified

In this study, equations are developed interpreting data obtained in a flow reactor used in investigating gas-phase reactions up to 600°C. An extension of the treatment of Hulburt (Indus. & Eng. Chem., v. 36: 1012,

1944) is utilized. Rate equations of arbitrary order are integrated by means of a series expansion on the extent of reaction variable.

TEX. 04:024

Texas U. [Dept. of Chemistry] Austin.

APPARATUS FOR OBTAINING OPTICAL ABSORPTION SPECTRA AT PRESSURES TO 6000 BARS, by D. S. Hughes and W. W. Robertson. Feb. 1956 [6]p. incl. illus. diagrs. (Technical note no. 26) (AFOSR-TN-56-99) (AF 18(600)430) AD 82012
Unclassified

In this study, a description is given of a compact and simple high-pressure apparatus that obtains optical absorption spectra at pressures to 6000 b. The absorption cell has sapphire windows which transmit from 1800 Å to ~5.5 μ, and the cell provides a path length adjustable from 0 to 3 cm. Pressures are measured by a manganin (Cu, Mn, and Ni alloy) wire resistance gauge.

TEX. 04:025

Texas U. [Dept. of Chemistry] Austin.

THE EFFECT OF PRESSURE ON THE UV SPECTRA OF BENZENE AND ITS DERIVATIVES, by W. W. Robertson, S. E. Babb, Jr., and F. A. Matsen. Mar. 1956 [15]p. incl. diagrs. tables, 20 refs. (Technical note no. 25) (AFOSR-TN-56-120) (AF 18(600)430) AD 82516
Unclassified

Also published in Jour. Chem. Phys., v. 26: 365-370, Feb. 1957.

The near UV absorption spectra of benzene and several monosubstituted benzenes have been obtained in the vapor phase with partial pressures of N to 550 atm and in hydrocarbon solution with pressures up to 5500 atm. The spectra broaden asymmetrically and shift to longer wavelengths under pressure. The wavelength varies linearly with dielectic constant, both in the vapor phase and in solution, $\Delta\lambda / \Delta K$ lying between 20 and 29 Å. A rough correlation is found between $\Delta\lambda / \Delta K$ and the oscillator strength of the transition. (Contractor's abstract)

TEX. 04:026

Texas U. [Dept. of Chemistry] Austin.

EXCESS KINETIC ENERGIES FOR IONS FORMED BY ELECTRON IMPACT FROM ACETYLENES, by F. H. Coats and R. C. Anderson. Apr. 1956 [6]p. incl. diagr. (Technical note no. 27) (AFOSR-TN-56-169) (AF 18(600)430) AD 86591
Unclassified

Attempts have been made by 2 methods to determine whether ions such as C_2H^+ from acetylene, CH_3^+ from propyne, and $C_2H_5^+$ from 1-butyne are formed with excess kinetic energy. Instrumental limitations proved to be such that the range of experimental error is rather large. The results indicate that the C_2H^+ from acetylene is formed with excess kinetic energy and the $C_2H_5^+$ from 1-butyne is not. The results for CH_3^+ are inconclusive. The value for the heat of formation of C_2H^+ obtained from the data on 1-butyne (112 kcal/mole) is indicated to be the better value. (Contractor's abstract)

TEX. 04:027

Texas U. Dept. of Chemistry, Austin.

CARBON FORMATION FROM ACETYLENE, by F. C. Stehling, J. D. Frazee, and R. C. Anderson. [May 1956] [33]p. incl. diagrs. tables, refs. (AFOSR-TN-56-201) [AF 18(600)430] AD 87514
Unclassified

Also published in Sixth Symposium (International) on Combustion, Yale U., New Haven, Conn. (Aug. 19-24, 1956), N. Y., Reinhold, 1957, p. 247-254.

The problem of C formation in combustion systems is studied through the processes by which large aggregate of atoms and molecules are built up under conditions such that the normal expectation is for degradation or fragmentation of molecules to occur. Particular attention is given to acetylene reactions and their importance in connection with general mechanisms of carbon formation. The three types of C found as products of flame propagation in acetylene in straight tubes are described and investigated. The studies on the actual conditions of particle formation in the thermal reaction of acetylene are compared with the results obtained from flame propagation. X-ray measurements are used to get additional information about the particle sizes.

TEX. 04:028

Texas U. [Dept. of Chemistry] Austin.

A COOL FLAME PHENOMENON IN THE COMBUSTION OF ACETYLENE, by W. W. Robertson and F. A. Matsen. June 1956 [4]p. incl. diagrs. (Technical note no. 28) (AFOSR-TN-56-299) (AF 18(600)-430) AD 90011
Unclassified

Also published in Combustion and Flame, v. 1: 99-101, Mar. 1957.

The factors influencing the ignition temperature when adding small concentrations of oxygen to heated acetylene in a flow system were determined. Periodic pressure bursts were observed which seemed to indicate the presence of a "cool" flame. The "cool flame" was more pronounced at around 325°,

TEX. 04:029 - TEX. 04:033

merging into the ordinary flame at around 300° and 500°C. A temperature rise in the reactor and an increase in the glyoxal concentration in the reaction products accompanied the "cool flame." Apparently, a reactive intermediate was formed at both low temperature and oxygen concentration.

TEX. 04:029

Texas U. Dept. of Chemistry, Austin.

THERMODYNAMIC DATA FROM ELECTRON-IMPACT MEASUREMENTS ON ACETYLENE AND SUBSTITUTED ACETYLENES, by F. H. Coats and R. C. Anderson. Aug. 20, 1956 [5]p. incl. diagr. tables, refs. [Technical note no. 29] [AFOSR-TN-56-364] (AF 18(600)-430) AD 95450 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 1340-1344, Mar. 20, 1957.

Earlier measurements of electron-impact data for propyne and 2-butyne were extended to other substituted acetylenes: 1-butyne, diacetylene, 1-Br-1-propyne, 1-Cl-1-propyne and phenoxyacetylene. From these the heat of formation of C_2H was determined to be 112 kcal/mole. Bond energies for the C-H and C-C bonds in C_2H_2 and for certain bonds in the substituted acetylenes can then be evaluated. (Contractor's abstract)

TEX. 04:030

Texas U. [Dept. of Chemistry] Austin.

THE PREPARATION AND CHARACTERIZATION OF 3-HALO-2-PROPYN-1-OL, 1-HALO-3-ETHOXY-1-PROPYNE AND 1-BROMO-3-PHENOXY-1-PROPYNE, by L. F. Hatch, S. H. Chu, and W. E. Blankenstein. Sept. 1956 [22]p. incl. dtagrs. table. (Technical note no. 30) (AFOSR-TN-56-452) (AF 18(600)430) AD 96797 Unclassified

The following compounds have been prepared during a continuation of a study on the preparation of haloacetylenes: 3-bromo-2-propyn-1-ol, 3-chloro-2-propyn-1-ol, 1-bromo-3-phenoxy-1-propyne, 1-bromo-3-ethoxy-1-propyne, 1-chloro-3-ethoxy-1-propyne. These compounds have been characterized and structures assigned on the basis of their physical and chemical properties. (Contractor's abstract)

TEX. 04:031

Texas U. [Dept. of Chemistry] Austin.

ISOTOPE EXCHANGE STUDIES OF ACETYLENE REACTIONS, by F. H. Coats and R. C. Anderson. Oct. 1956, 29p. incl. diagrs. tables. (Technical note no. 31) (AFOSR-TN-56-491) (AF 18(600)430) AD 110305 Unclassified

The decomposition reactions of C_2H_2 with deuterium and deuteroacetylene with H_2 are studied in the early stages of the thermal polymerization and decomposition of C_2H_2. At low temperatures, CH_3D and CD_3H are slightly predominant in the respective C_2H_2 - deuterium and dideuteroacetylene -H systems, while at higher temperatures both systems exhibit a complex mixture of all possible isotopes. Both molecular and free-radical processes occurred during these reactions. The study of methane proves of interest in the question of how it is formed.

TEX 04:032

Texas U. [Dept. of Chemistry] Austin.

EFFECTS OF ADDITIVES ON PRESSURE CHANGES IN THERMAL REACTION OF ACETYLENE, by G. Morrow and R. C. Anderson. Oct. 1956 [18]p. incl. diagrs. table. (Technical note no. 32) (AFOSR-TN-56-493) (AF 18(600)430) AD 110307 Unclassified

Comparative studies have been made of the pressure changes occurring during thermal reaction of acetylene alone and in the presence of certain additives. These results show that the pressure effect is not a factor in the influence of benzene and propane on flame propagation in the decomposition of acetylene. It is an appreciable but not a controlling factor in the effect of ethylene oxide on flames in acetylene. Nitric oxide gave variable results and chloropropyne and octatriyne decomposed too readily themselves for reliable measurements to be made. The effects of other hydrocarbon types, such as cyclooctatetraene, anthracene, pyrene, etc., were also tested for later comparison with flame propagation data. (Contractor's abstract)

TEX. 04:033

Texas U. [Dept. of Chemistry] Austin.

EXPLORATORY STUDIES OF THE ACETYLENE-ETHYLENE OXIDE COMBUSTION SYSTEMS, by R. Pratt, M. S. B. Munson, and R. C. Anderson. Oct. 1956 [7]p. incl. dtagrs. (Technical note no. 33) (AFOSR-TN-56-502) AD 110317 Unclassified

Since earlier experiments showed ethylene oxide to have a marked effect on flames in acetylene and since both these substances can give decomposition flames, the acetylene-ethylene oxide system offers interesting potentialities for study of a system in which flames may be possible in mixtures of any composition. Exploratory experiments have been made on flame propagation in tubes at 300° initial temperature and varying pressures. Attempts have been made to operate a burner at atmospheric pressure and in a lower temperature range, but so far these have not been successful. The results indicate interesting questions with regard to carbon formation, changes in luminosity,

rather pronounced pressure changes, and the nature of the reaction products in these flames. They also indicate that quantitative studies of flame properties are feasible. (Contractor's abstract)

TEX. 04:034

Texas U. [Dept. of Chemistry] Austin.

EFFECTS OF ADDITIVES ON FLAME PROPAGATION IN ACETYLENE IV, by G. Morrow, M. S. B. Munson and others. Nov. 1956, 6p. incl. tables. (Technical note no. 34) (AFOSR-TN-56-598) (AF 18(600)430) AD 115025 Unclassified

The methods used earlier for testing the effects of additives on the velocities of decomposition flames in acetylene have been applied to a number of other compounds. These include certain ether-substitued and halogen-substituted acetylenes and certain types of hydrocarbons which are of potential interest because of the roles they might play as intermediates in carbon formation. Most of these had little effect. Phenoxy-acetylene and ferrocene were found to increase the flame velocity. Toluene and 3-ethoxyl-1, 1-bromo-1-propyne were rather striking in their inhibitory effects on flame propagation. (Contractor's abstract)

TEX. 04:035

Texas U. [Dept. of Chemistry] Austin.

[KINETICS OF ELEMENTAL PROCESSES IN ACETYLENE FLAMES] by R. C. Anderson, L. F. Hatch, and F. A. Matsen. Final technical rept. Sept. 3, 1952-Sept. 30, 1956. Dec. 1956, 18p. refs. (AFOSR-TR-56-63) (AF 18(600)430) AD 115028 Unclassified

A summary and discussion are presented of investigations of the kinetics of elemental processes in flames, combustion, and detonation in systems with acetylene and related compounds. A bibliography of the technical notes, theses and dissertations, and outside publications which give the details of the work are given. The nature of the reaction mechanisms involved in flame propagation are discussed.

TEX. 04:036

Texas U. Dept. of Chemistry, Austin.

ACETYLENE AS AN INTERMEDIATE IN THE COMBUSTION OF PETROLEUM HYDROCARBONS, by R. C. Anderson. Jan. 1956, 21p. refs. (AF 18(600)-430) Unclassified

A review is presented of available information in the literature on formation and reaction of acetylene in combustion of hydrocarbons. Present data indicate that acetylene is not a direct intermediate in the chain reactions of hydrocarbon oxidation but can readily be formed in closely associated reactions of oxidation and thermal decomposition, particularly under any conditions where excess hydrocarbon may be present. The most likely reaction of the acetylene once formed seems to be dehydrogenation followed by combination or addition of O_2, though peroxide formation may also occur. These reactions may be a general source of the hydrocarbon flame bonds. It is clearly evident that they cause acetylene to be an important precursor - though not necessarily the sole one - of carbon formation in combustion processes. (Contractor's abstract, modified)

TEX. 04:037

Texas U. Dept. of Chemistry, Austin.

EFFECTS OF HIGH PRESSURE UPON THE NEAR ULTRAVIOLET ABSORPTION SPECTRA OF THE POLYACENES (Abstract), by W. W. Robertson. [1956] [1]p. (AF 18(600)430) Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 36.

The absorption spectra of naphthalene, anthracene, and napthacene in n-pentane have been recorded in the near ultraviolet at pressures up to 5500 bars. The wavelength of absorption increases linearly with the dielectric constant of the pressurized solvent,

$\lambda = \frac{\Delta\lambda}{\Delta K}(K-1) + \lambda_o$. $\frac{\Delta\lambda}{\Delta K}$ varies from 26 A for the

naphthalene $^1A_{1g}^- - {}^1B_{3u}^-$ transition to 235 A

for the naphthacene $^1A_{1g}^- - {}^1B_{2u}^+$ transition. Since $\Delta\lambda / \Delta K$ can be accurately measured, a practical method exists for distinguishing between transitions. Values of λ_o obtained by extrapolating to K = 1 are within a few angstroms of the measured values that are obtainable for the vapor state. $\frac{1}{\lambda_o}\frac{\Delta\lambda}{\Delta K}$ increases generally with the oscillator strength of the transition as is predicted by theory. However, no simple relation exists between slope and oscillator strength. (Contractor's abstract)

TEX. 05:001

Texas U. [Dept. of Physics] Austin.

POLARIZATION OF D-D NEUTRONS, by H. J. Longley, R. N. Little, Jr., and J. M. Slye. [1952] [1]p. incl. diagr. (Sponsored jointly by [Air Force Office of Scientific Research] and Atomic Energy Commission under [AF 33(038)20681]) Unclassified

Published in Phys. Rev., v. 86: 419-420, May 1 1952.

TEX. 05:002 - TEX. 05:005

The polarization of neutrons from the D-D reaction at 45° to the deuteron beam is 30-40% (± 20%). Schwinger's method was used. (C. A., 1952: 6502)

TEX. 05:002

Texas U. [Dept. of Physics] Austin.

TOTAL CROSS SECTIONS OF CHLORINE, SODIUM, TITANIUM, AND BROMINE FOR FAST NEUTRONS, by H. R. Dvorak and R. N. Little, Jr. [1953] [5]p. incl. diagrs. refs. [AF 33(038)20681] Unclassified

Published in Phys. Rev., v. 90: 618-622, May 15, 1953.

Relatively new liquid scintillation counter methods were adapted to detect fast neutrons with a heretofore unattainable efficiency of about 19 percent. The geometry obtained was the so called "good" geometry, which was a half-angle at the counter of 2.7°. With the more efficient counter reasonable counting times could be obtained with the detector subtending a half-angle of only 2.7° from the target. The neutrons were obtained by using a modified Cockcroft-Walton linear accelerator of 100-kev bombarding energy. The neutron energy range was 2.15 to 2.82 mev. All the scatterers used were contained in almost identical glass "cells," and the effects of the glass cells were subtracted out by using an empty glass cell of the same type as a reference. The probable error, calculated statistically from the counting rates of the experiment, was 1.3 percent on total cross-section values. Actual reproducibility of each result was about 3 percent or better. A carbon cross-section curve was obtained as a check on this method, and agreement with previously reported values was excellent. The chlorine and sodium cross-sections were found to be about 3×10^{-24} cm^2, as determined indirectly by using carbon tetrachloride and sodium chloride. The titanium cross section was found to be about 4.1×10^{-24} cm^2 by using powdered titanium metal. The bromine cross section was found to be about 3.7×10^{-24} cm^2, by using a sample of liquid bromine. No large resonances were found in the energy region available. Data were also taken on the angular distribution of the number of neutrons with respect to the forward direction of the incident deuteron beam, and they were found to agree well with theory except in the region where experimentally necessary geometric conditions dictated a deviation. (Contractor's abstract)

TEX. 05:003

Texas U. Dept. of Physics, Austin.

EXCITATION CURVE FOR $C^{14}(d,p)C^{15}$ AND PROPERTIES OF C^{15}, by J. A. Rickard, E. L. Hudspeth, and W. W. Clendenin. Aug. 4, 1954 [4]p. incl. diagrs. tables, refs. [NPL rept. no. JAR 12-1-54] [AFOSR-TN-54-253] [AF 33(038)20681] AD 56144 Unclassified

Also published in Phys. Rev., v. 96: 1272-1275, Dec. 1, 1954.

The excitation function for $C^{14}(d,p)C^{15}$ has been studied with deuterons of energy 0.6 to 3.0 mev. A previously suspected resonance was definitely established at a bombarding energy of 2.15 mev, with a width of nearly 400 kev. Analysis of the excitation curve shows that its shape may be explained on the basis of a spin of 5/2(+) for this C^{15} ground state and a Q value of 0.15 + 0.15 mev. This leads to a mass of C^{15} of 15.0141 ± 0.00015 amu. (Contractor's abstract)

TEX. 05:004

Texas U. Dept. of Physics, Austin.

[ANGULAR DISTRIBUTION OF FAST NEUTRONS DISPERSED THROUGH MAGNESIUM] Distribucion angular de neutrones rapidos dispersados por magnesio, by P. Okhuysen, Jr. and W. E. Millett. [1954] [12]p. incl. diagrs. refs. [AF 33(038)20681] Unclassified

Published in Rev. Mexicana de Fisica, v. 4: 1-12, Jan. 1955.

Measurement is reported of the differential cross section (elastic plus inelastic) of natural magnesium for fast neutrons (estimated to have a mean energy of 2.77 ± 0.05 mev) using the ring scatterer method. The neutrons were obtained from $D(d,n)He^3$ reaction using the 100,000 volt modified Cockcroft-Walton accelerator at the Nuclear Physics Laboratory of the University of Texas. (Contractor's abstract)

TEX. 05:005

Texas U. [Dept. of Physics] Austin.

[GAMMA]-RAY SPECTRUM OF C^{15} AND γ-RAYS FROM PROTON BOMBARDMENT OF C^{14} (Abstract), by K. R. Spearman, E. L. Hudspeth, and I. L. Morgan. [1954] [1]p. [AF 33(038)20681] Unclassified

Presented at meeting of the Amer. Phys. Soc., Austin, Tex., Feb. 26-27, 1954.

Published in Phys. Rev., v. 94: 806-807, May 1, 1954.

The delayed γ radiation resulting from bombardment of C^{14} with 2-mev deuterons has been studied with a single crystal scintillation spectrometer. The 2.4-second activity is identical with the β decay of C^{15}. Pulse height analysis reveals a strong γ ray of energy approximately 5.3 mev (Phys. Rev., v. 85: 742, 1952), with evidence for very weak components of higher energies. A decay scheme for C^{15} will be proposed. We have also bombarded a target of $BaCO_3$ (18.6 percent enrichment in C^{14}) with protons and have observed γ-rays which apparently are formed by protons capture. A relatively strong γ-ray component of energy about 5 mev was observed, with energies up to approximately 10 mev also recorded but not well resolved in our present crystal. Evidence for resonances in a 44-kev target have been obtained in the bombarding region from 1 to 2 mev. (Contractor's abstract)

TEX. 05:006

Texas U. [Dept. of Physics] Austin.

LIQUID SCINTILLATOR MEASUREMENTS OF ANGULAR ELASTIC SCATTERING OF NEUTRONS FROM CARBON, ALUMINUM, AND SULFUR, by R. N. Little, Jr., B. P. Leonard, Jr. and others. Jan. 3, 1955 [5]p. incl. diagrs. refs. (NPL rept. no. RNL 5-1-55) ([AF]OSR-TN-55-10) (AF 33(038)20681) AD 73587 Unclassified

Also published in Phys. Rev., v. 98: 634-638, May 1, 1955.

Angular elastic scattering cross sections have been measured for carbon, aluminum, and sulfur using 2.7-mev neutrons from the D(d, n) reaction. A liquid organic scintillator, terphenyl in xylene, was used as the neutron detector. The differential pulse-height spectra for the neutrons scattered from sulfur and for Co^{60} gamma rays are given. (Contractor's abstract)

TEX. 05:007

Texas U. Dept. of Physics, Austin.

MODIFIED RELAXATION METHOD FOR EIGENVALUE PROBLEMS, by W. W. Clendenin. Dec. 22, 1955 [8]p. incl. table. [AFOSR-TN-55-313] [AF 33(038)20681] AD 151208 Unclassified

Also published in Jour. Math. and Phys., v. 36: 74-81, Apr. 1957.

This mathematical study describes a numeral method for solution of the 1-dimensional Schrödinger equation, of the form $d^2\psi/dx^2 + [\Lambda + U + (x)]\psi = 0$. The function U(x) is a potential energy defined over $a \leq x \leq b$ and Λ is an eigenvalue parameter. The boundary conditions are taken to be $\psi(a) = \psi(b) = 0$. For numerical solution, the interval ab may be divided into N equal subintervals of length $h = (b-a)/N$. To verify the accuracy and applicability of the method, it has been applied to examples with known answers. A table lists the eigenvalues obtained for particular forms of potential energy.

TEX. 05:008

[Texas U. Dept. of Physics, Austin.]

A NUMERICAL VARIATIONAL METHOD USING QUADRATIC INTERPOLATION, VI, by W. W. Clendenin. [1955] 23p. incl. tables. [AFOSR-TN-55-313(a)] [AF 33(038)20681] Unclassified

A numerical variational method using a trial function quadratic between net points has been applied to the 1-dimensional Schrödinger equation. Difference equations obtained are comparable in accuracy with those utilized in Hartree integration. Their use with some simple potentials gives eigenvalues correct to a few parts in 10,000. The method appears capable of being extended to several dimensions. (Contractor's abstract)

TEX. 05:009

Texas U. [Dept. of Physics] Austin.

THE ANGULAR DISTRIBUTION OF THE PROTONS FROM THE $O^{16}(d, p)O^{17}$ REACTION AS A FUNCTION OF THE BOMBARDING ENERGY, by J. C. Grosskreutz. [Jan. 15, 1956] [20]p. incl. diagrs. tables. [AFOSR-TN-55-316] [AF 33(038)20681] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Abstract published in Phys. Rev., v. 99: 643, July 15, 1955.

Also published in Phys. Rev., v. 101: 706-709, Jan. 15, 1956.

The angular distribution of the protons from the reaction $O^{16}(d, p)O^{17}$ leaving O^{17} in its ground and first excited states has been measured as a function of the deuteron bombarding energy. Deuterons of energy 2.51, 2.26, 2.01, 1.76, 1.60, 1.35, and 1.05 mev were used to bombard thin ZnO targets. The resulting protons were detected at angles ranging from 5 to 160° with respect to the deuteron beam. Detection was accomplished with CsI(Tl) phosphors on 6291 photomultipliers mounted as a unit in the vacuum housing of the reaction chamber. The characteristic forward stripping maxima are obtained in both reactions plus considerable yield in the backward direction, especially near resonances in the reaction. The effect of a resonance at 1.7 mev is to flatten the distribution curves so that their stripping character is almost completely masked. Secondary maxima observed in the excited state distributions are interpreted as the result of nuclear interaction of the stripped proton with the residual nucleus. Coulomb effects are also observed as the deuteron energy is lowered. The stripping maxima are shifted to larger angles, and the valleys become less pronounced. Absolute differential cross sections for the reactions are also given. (Contractor's abstract, modified)

TEX. 05:010

Texas U. [Dept. of Physics] Austin.

GAMMA RAYS FROM PROTON BOMBARDMENT OF O^{18} (Abstract), by E. L. Hudspeth, I. L. Morgan and others. [1955] [1]p. [AF 33(038)20681] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 643, July 15, 1955.

TEX. 05:011 - TEX. 05:014

A thin target of gaseous CO_2 enriched 14 percent in O^{18} has been bombarded with protons of energy 0.3 to 2.6 mev. The gas was contained in a cell of 2 cm depth, and the proton beam entered through a 0.05-mil Ni foil. Target thickness was estimated as 20 kev for 2.0 mev protons. A 1-½ in. x 1-½ in. NaI (Tl) crystal detector was used with a 20-channel analyzer. The excitation curve for ground-state transitions shows seven resonances, indicating levels in F^{19} tentatively evaluated as 8.49, 8.76, 9.65, 9.83, 10.04, 10.15, 10.22, 10.28, and 10.36 mev. The first two levels are also known from $O^{18}(p, \alpha)$; these are the least intense of the levels found in the present work. The excitation curve shows a sudden drop at the $O^{18}(p, n)$ threshold. A pulse-height analysis has been made of gamma radiation produced at a bombarding energy of 2.20 mev. It shows transitions to known excited states of F^{19}, in addition to ground-state transitions. (Contractor's abstract)

TEX. 05:011

Texas U. [Dept. of Physics] Austin.

GAMMA RAYS FROM THE PROTON BOMBARDMENT OF Cu^{63} AND Cu^{65} (Abstract), by C. E. Weller and J. C. Grosskreutz. [1955] [2]p. [AF 33(038)20681] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 655-656, July 15, 1955.

Gamma radiation from the bombardment of the separated isotopes Cu-63 and Cu-65 with 1.9-mev protons was observed by means of a NaI crystal and a 20-channel analyzer. From Cu-63 we detected 0.995-mev gamma rays, and from Cu-65 1.04- and 0.824-mev gamma rays, all presumably due to the inelastic scattering of the protons. The 0.995- and 1.04 mev radiations correspond to transitions from known excited states of Cu-63 and Cu-65, respectively. The 0.824-mev gamma ray we assign to either a new level in Cu-65 at 0.824 mev or to a transition from the 1.04 level to a level at 0.210 mev. Evidence for the latter level has been previously reported. We have as yet been unable to detect a 0.210-mev gamma ray. A continuous gamma-ray spectrum up to at least 10 mev was also observed, most probably due to proton capture. Thick target yield curves of the two 1-mev gamma rays will also be shown. The onset of the (p, n) reaction in Cu-65 is clearly evident just above 2.0 mev.

TEX. 05:012

Texas U. Dept. of Physics, Austin.

GAMMA RAYS FROM THE PROTON BOMBARDMENT OF SEPARATED COPPER ISOTOPES, by C. E. Weller and J. C. Grosskreutz. Feb. 14, 1956 [8]p. incl. diagrs. tables. [AFOSR-TN-56-77] [AF 33(038)20681] AD 81529 Unclassified

Also published in Phys. Rev., v. 102: 1149-1156, May 15, 1956.

The energy spectrum of γ rays obtained from the proton bombardment of separated Cu isotopes has been measured. It was found by coincidence measurements that the majority of these γ rays arise from the capture process when the bombarding energy is held below 2.2 mev. The thick target cross section for proton capture at 1.9 mev is found to be 0.1 millibarn. Above 2.2 mev, excitation of the 0.67-mev level in Cu^{63}, by either inelastic scattering or Coulomb excitation, is observed. Excited level schemes for both Zn^{64} and Zn^{66} have been obtained. The first 3 levels in Zn^{64} are found to be at 0.97, 2.27, and 3.04 mev. The scheme for Zn^{66} is essentially the same as that earlier proposed from the decay of Ga^{66}. (Contractor's abstract)

TEX. 05:013

Texas U. [Dept. of Physics] Austin.

THE $d(O^{16}, O^{17})p$ STRIPPING REACTION (Abstract), by E. V. Ivash. [1956] [1]p. [AF 33(038)20681] Unclassified

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 84, Feb. 24, 1956.

The theory of (d, p), (d, n) stripping reaction taking into account the Coulomb field of the nucleus has been developed by a number of workers. In addition, Tobocman has also considered the effect of the interaction of the outgoing particle with the nucleus. Calculations of the differential cross section based on the Tobocman theory have been carried out for the $O^{16}(d, p)O^{17}$ reaction for the ground and first excited states for a deuteron energy of 2 mev, and the results compared with the experimental data of Grosskreutz. In accordance with Tobocman and Kalos the effect of the Coulomb field is to broaden the peaks and fill in the valleys of the differential cross section curve. The effect of nuclear interactions are also discussed. (Contractor's abstract)

TEX. 05:014

Texas U. [Dept. of Physics] Austin.

SOME REACTIONS LEADING TO N^{16}, (Abstract), by N. A. Bostrom, E. L. Hudspeth, and I. L. Morgan. [1956] [1]p. [AF 33(038)20681] Unclassified

Presented at meeting of the Amer. Phys. Soc., Houston, Tex., Feb. 24-24, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 94, Feb. 24, 1956.

Excitation curves for $O^{18}(d, \alpha)N^{16}$ and $N^{15}(d, p)N^{16}$ have been obtained with targets ~ 40 kev thick) respectively of $BaCO_3$ enriche to 9% in O^{18} and with gaseous targets of normal nitrogen. The preliminary excitation curve for O^{18} (d, α) shows a steep rise from 0.7 mev to a resonance maximum near 1.25 mev, with a second resonance at approximately 1.75 mev. The

$N^{15}(d, p)$ curve rises steeply between 1.0 and 1.2 mev and continues upward with smaller slope to $E_d = 2.0$ mev; some weak resonance structure is indicated. Both curves are being extended and further work will be done with thinner targets. Observation was made of $C^{14}(d, \gamma)N^{16}$, since N^{16} activity is presumed possible from this reaction. N^{16} activity was found but all of it was ascribed within the limits of observation to $O^{18}(d, \alpha)$; this latter reaction was found to be at least 400 times as probable as $C^{14}(d, \gamma)$ at $E_d = 1.3$ mev. The weak activity previously reported from $C^{14}(d, p)C^{15}$ below this deuteron energy is believed to be from bombardment of O^{18}. Proper allowance for this puts these data into agreement with other recently reported results. (Contractor's abstract)

TOL. 01:001

Toledo U. Research Foundation, Ohio.

COMPRESSORS FOR HIGH-SPEED WIND TUNNELS, by A. A. Fejer and J. Clark. Jan. 1956, 216p. incl. illus. diagrs. refs. (NATO AGARDograph rept. no. 14) [AF 18(600)1249] Unclassified

The compressor drive systems are considered for high-speed wind tunnels of the continuous type. This study contains information regarding the aerodynamic characteristics of wind tunnel circuits from which the compressor requirements can be established, presents a method to guide in the selection of the compressor type, and discusses compressor drives utilizing various types of prime movers. Some of the aerodynamic and mechanical considerations underlying the design and operation of wind tunnel drives are outlined, including a discussion of vibrational problems encountered in systems of this type.

TOR. 01:001

Toronto U. Inst. of Aerophysics (Canada).

AN EXPERIMENTAL STUDY OF ONE-DIMENSIONAL REFRACTION OF A RAREFACTION WAVE AT A CONTACT SURFACE, by I. J. Billington. June 1955, 1v. incl. illus. diagrs. tables, refs. (UTIA rept. no. 32) ([AF]OSR-TN-55-394) (AF 18(600)1185) AD 82221 Unclassified

An experimental investigation of the 1-dimensional interaction of a rarefaction wave and a contact surface in a shock tube is described. The rarefaction wave generated from the bursting of the shock tube diaphragm is utilized as the incident wave in the interaction with an air and helium or air and argon contact surface. The investigation shows that, as has been predicted in a previous theoretical treatment, a compression wave is reflected from the contact surface in the former case, and an expansion wave in the latter case. A rotating drum camera is used to measure the speed of the moving contact surface after the interaction and measurements of the flow properties in the regions formed by the interaction are made. A piezoelectric pressure gauge is used to measure pressure in these regions and a hot-wire anemometer is used to measure mass flow and stagnation temperature. The investigation shows that the initial rarefaction wave in the shock tube deviates considerably from the theoretically predicted wave. When this deviation is taken into account, however, the results of the rarefaction wave refraction show good agreement with the theory. Values are given for both gas combinations of contact surface speed measured from drum camera records. Piezoelectric pressure gauge results are given for the pressures behind the initial and final waves. Hot-wire anemometer results are listed for both stagnation temperature and mass flow for all the flow regions in the interaction.

TOR. 01:002

Toronto U. Inst. of Aerophysics (Canada).

HEAT TRANSFER IN SLIP FLOW, by R. L. Martino. Oct. 1955 [154]p. incl. diagrs. tables, refs. (UTIA rept. no. 35) ([AF]OSR-TN-55-443) (Sponsored jointly by Air Force Office of Scientific Research, under AF 18(600)1185 and Canadian Defence Research Board) AD 82234 Unclassified

The Rayleigh method has been applied to solve the energy equation for the temperature distribution for the case of a flat plate in laminar flow. The slip and temperature jump boundary conditions were used, as well as the conventional boundary conditions of gas dynamics. An analytical solution was derived for the case of arbitrary constant Prandtl number and for variable initial surface temperature. By a linear transformation between time and distance downstream from the leading edge, steady flow solutions have been derived. These solutions have been linked with the results of Chapman and Rubesin for the case of a constant surface temperature. The significant results of this study for a constant initial surface temperature are the following: (1) The results cannot be applied directly to explain the phenomena of the slip regime. No provision was made for free-molecule flow to exist at the leading edge. In order to extend the analysis, a leading edge condition must be included. (2) The recovery factor, while attaining the correct limit a great distance downstream from the leading edge, tends to the limit zero as the leading edge is approached. (3) As the leading edge is approached, the Nusselt and Stanton numbers become functions of both Mach number and initial wall temperature before approaching a common limit. A common limit also exists for conditions a great distance downstream. The general conclusion of this work is that while temperature jump and slip boundary conditions are sufficient to explain phenomena approaching slip flow from the continuum regime, they are insufficient to adequately describe the slip regime.

TOR. 01:003

Toronto U. Inst. of Aerophysics (Canada).

THE HOT-WIRE ANEMOMETER AND ITS USE IN NON-STEADY FLOW, by I. J. Billington. Sept. 1955, 1v. incl. illus. diagrs. refs. (UTIA Technical note no. 5)

TOR. 01:004 - TRI. 01:002

(AFOSR-TN-56-116) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1185 and Canadian Defence Research Board) AD 82512 Unclassified

The thermal equilibrium and heat loss relationships for small diameter heated cylinders placed normal to an airstream are discussed. Some experimental results are presented for the heat loss of a hot-wire in stationary gases. Procedures for the calibration of hot-wires and typical calibration curves are given. The design of an open-jet hot-wire calibration tunnel with a variable velocity and a low turbulence level is described. The sensitivity of a hot-wire to small fluctuations is considered and the limitations to frequency response imposed by the finite thermal lag of the wire are pointed out. Methods of overcoming the thermal lag effect by compensation and suppression are discussed. The use of hot-wire probes in non-steady shock-tube flows is considered. The typical response of a hot-wire to travelling shock and expansion waves in a shock tube is presented as an illustration of the method. Procedures for the reduction of shock tube results are outlined, and a correction for the effect of the finite impedance of the wire heating current source is developed. A simple circuit utilizing hot-wires to measure the speed of a travelling shock wave is shown. A discussion is included on the general considerations influencing the design of hot-wire probes and mounts.

TOR. 01:004

Toronto U. Inst. of Aerophysics (Canada).

INVESTIGATION OF THE TIME RESPONSE AND OUTGASSING EFFECTS OF PRESSURE PROBES IN FREE MOLECULE FLOW, by E. L. Harris. Oct. 1955 [28]p. incl. illus. diagrs. tables. (UTIA Technical note no. 6) (AFOSR-TN-56-117) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1185 and Canadian Defence Research Board) AD 82513 Unclassified

A study was made of the time response and outgassing effects of pressure probes in free molecule flow. A theoretical analysis was conducted to obtain expressions for the time constant of a pressure probe, and for the pressure difference resulting from outgassing between the gas in the gauge and the gas external to the gauge under steady conditions. The expression derived for the time constant was in terms of the physical dimensions of the gauge; that for the pressure difference was in terms of the physical dimensions and a factor q (the rate at which adsorbed gas was evolved from the interior surface of the gauge/unit area). For the range of geometries studied, it was shown that the pressure difference resulting from outgassing was proportional to the time constant, where the proportionality constant depended on q. The experimental results for the time constant and the outgassing pressure difference checked closely with theory. The outgassing rate depended on the pressure and temperature history; for practical gauges measuring pressures in the μ range, q may be reduced to a satisfactorily low value by subjecting the surface to a low pressure for a sufficient length of time. (Contractor's abstract)

TOR. 01:005

Toronto U. Inst. of Aerophysics (Canada).

THE BOLTZMANN H-FUNCTION APPLIED TO THE SHOCK TRANSITION, by E. L. Harris and G. N. Patterson. May 1956 [32]p. incl. diagrs. tables. (UTIA rept. no. 40) (AFOSR-TN-56-336) [AF 18(600)-1185] AD 95212 Unclassified

Boltzmann's H-function is calculated for a Maxwellian distribution function and 2 nonisentropic cases. The variation of H through a shock front is given for M = 1.50 to 4.00. The results showed that the effect of heat conduction and viscosity on the distribution of H through the shock wave is to give a smoother transition than that obtained from the thermodynamic entropy.

TRI. 01:001

Trinity Coll., Hartford, Conn.

THE CONVERGENCE OF AIRY SERIES, by W. J. Klimczak. Sept. 30, 1956, 8p. (AFOSR-TN-58-467) (AF 18(600)1397) AD 97086 Unclassified

An investigation was made of the domain of absolute convergence in the complex plane of series of the form $f(z) = \sum_{n=1}^{\infty} f_n A_n(z)$ where $A_n(z)$ are characteristic functions of the differential operator $\delta_z = d^2/dz^2 + z$. The investigation of the convergence of the series is based upon estimates of the asymptotic behavior for large values of n of the functions $A_n(z)$ and the corresponding characteristic values denoted by λ_n. Proof is given in terms of a theorem which states that if the series converges absolutely for any nonreal value of z, then it converges absolutely everywhere in the complex plane. The discussion is analogous to that of Hille (Duke Math. Jour., v. 5: 875-936, 1939) for Hermitian series.

TRI. 01:002

Trinity Coll., Hartford, Conn.

THE CONVERGENCE OF SERIES OF CHARACTERISTIC FUNCTIONS. I. AIRY AND LAGUERRE SERIES, by W. J. Klimczak. Oct. 30, 1956, 4p. (AFOSR-TN-56-531) (AF 18(600)1397) AD 110350 Unclassified

An investigation was made of the geometric character of the region of absolute convergence in the complex plane of series of the form $f(z) \sum_{n=1}^{\infty} c_n f_n(z\lambda_n)$, where

$f_n(z, \lambda_n)$ are characteristic functions of a linear second-order differential operator A_z. Hermitian, Laguerre, and Legendre differential operators are considered. Variations of these operators are studied and note is taken of the effect of these changes on $R(A_z)$, the region of absolute convergence of the series. The case of the Airy operator was studied in detail previously (item no. TRI. 01:001). If $a_n(z)$, $n = 1, 2, 3 \ldots$, denote the characteristic functions of the operator A_z corresponding to the characteristic values λ_n, $n = 1, 2, 3, \ldots$, then for any n and x real, $a_n(x)$ has no negative zeros and an infinite number of positive zeros. As $x \to \infty$, $a_n(x) \to 0$ and $a_n'(x) \to 0$. From these properties it was shown that the sequence of functions $\{a_n(x)\}$ is orthonormal on the interval $(-\infty, 0)$. The principal theorem established that if the series converges absolutely for any nonreal value of z, then it converges absolutely everywhere in the convex plane. In the Laguerre case, the determination of $R(L_z)$ for the series $1(Z) = \sum_{n=1}^{\infty} c_n 1_n^{(\alpha)}(z)$, where $L_z z^{1/2} 1_n^{(\alpha)}(z) = -\left[n + 1/2(\alpha + 1)\right] z^{1/2} 1_n^{(\alpha)}(z)$ must be based on some estimate of the asymptotic behavior of the functions $1_n^{(\alpha)} z$ for large values of n. From the estimates for $1_n^{(\alpha)}(z)$, $R(L_z)$ for the series was shown to be the interior of a parabola. (ASTIA abstract)

TUS. 01:001

Tuskegee Inst. George Washington Carver Foundation, Ala.

PREPARATION AND PROPERTIES OF SOME ALPHA-FLUOROETHERS, by C. T. Mason and C. C. Allain. Sept. 1955 [11]p. incl. tables. (CF rept. no. 8) ([AF]OSR-TN-55-338) (AF 18(600)779) AD 73783 Unclassified

Presented at meeting of the Amer. Chem. Soc., Minneapolis, Minn., Sept. 11-16, 1955.

Also published in Jour. Amer. Chem. Soc., v. 78: 1682-1684, Apr. 20, 1956.

Various metal fluorides were examined as fluorine-for-chlorine exchange agents for $CCl_3CHClOR$. The efficiency of the exchange was found to descend in approximately the order: HgF_2, TlF, AgF, KF, Al_2F_6, CrF_3. A series of compounds of the general formula CCl_3CHFOR and CH_2FOR (where R is Me, Et, Pr, Bu, and allyl) were prepared using HgF_2, and their physical and chemical properties were examined. All attempts to prepare CH_3CHFOR were unsuccessful, and led only to polymerization and decompostion. (Contractor's abstract)

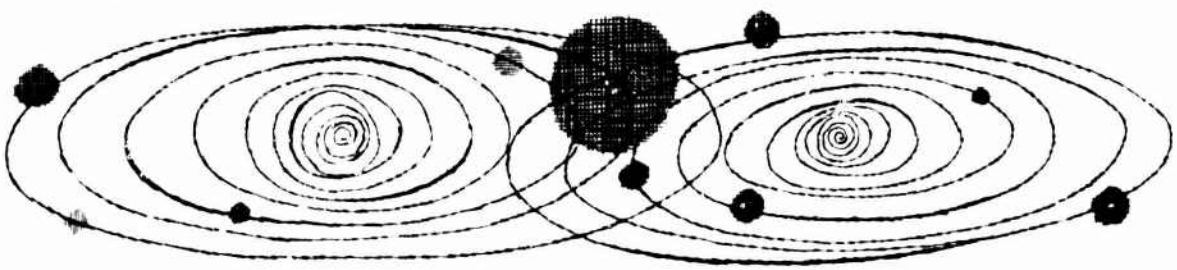
TUS. 01:002

Tuskegee Inst. George Washington Carver Foundation, Ala.

PART I. THE REACTIONS OF ALKOXYCHLOROALKANES WITH SOME METALS. PART II. THE PREPARATION AND PROPERTIES OF SOME ALPHA-FLUOROETHERS, by C. T. Mason. Technical rept. Sept. 1, 1953-Aug. 31, 1955. Oct. 1955, 34p. incl. tables, refs. (CF rept. no. 9; technical note no. 2) ([AF]OSR-TN-55-389) (AF 18(600)779) AD 79642 Unclassified

Part 1 was presented at Southeastern meeting of the Amer. Chem. Soc., Columbia, S. C., Nov. 3-5, 1955.

Part I. The action of various metals on alkoxychloralkanes is reported. Alkoxychloromethanes with Na give acceptable yields of the Wurtz product. With the 1-alkoxy-1-chloroethanes, however, Na yields the acetal and vinyl ether. Li does not react with the alkoxychloromethanes in the cold, but on heating, gives the formal. With 1-alkoxy-1-chloroethane, however, Li gives 26% of the Wurtz product. 1-Alkoxy-1-chloropropane gives acetal with both Li and Na. No evidence of a Li organometallic compound is found. Cu and alcoholized Fe powder gives no reaction when heated with the 1-alkoxy-1-chloromethanes or 1-chloroethanes. Reduced Fe powder with the former gives about 20% yield of the Wurtz product. Neither the 1-alkoxy-2-chloroethanes nor 1-alkoxy-1, 2, 2, 2-tetrachloroethane react with even the more active of the metals. In Part II various metal fluorides were examined as F-for-Cl exchange agents for $CCl_3CHClOR$. The efficiency of the exchange was found to descend in approximately the order: HgF_2, TlF, AgF, KF, Al_2F_6, and CrF_3. A series of compounds of the general formula CCl_3CHFOR and CH_2FOR (where R is Me, Et, Pr, Bu, and allyl) were prepared using HgF_2, and their physical and chemical properties were examined. All attempts to prepare CH_3CHFOR were unsuccessful, and led only to polymerization and decomposition. (Contractor's abstract)



UTA. 01:001 - UTA. 01:004

Universita di Roma (Italy). see Rome U. (Italy).

Université D'Aix-Marseille. Institut de Mécanique des Fluides (France). see Marseille U. Inst. of Fluid Mechanics (France).

Université Libre de Bruxelles (Belgium). see Free U. of Brussels (Belgium).

UTA. 01:001

Utah U. [Dept. of Electrical Engineering] Salt Lake City.

MODELING OF HIGH SPEED IMPACT THROUGH THE USE OF PLASTICS, by M. E. Van Valkenburg. Feb. 1955 [24]p. incl. illus. diagrs. (Technical rept. no. 3) ([AF]OSR-TN-55-48) (AF 18(600)1217) AD 58379 Unclassified

The impact of high-speed plastic pellets on plastic targets has been studied for several plastic materials. Metal-to-metal impacts have also been studied using pellets of various shapes and with masses from 20 mg to 5 g. The experimental method for producing plastic pellets with velocities up to 6 km/ sec is similar to that used by Pugh, and was first reported in the literature by Allen, Rinehart, and White (Phenomena Associated with the Flight of Ultraspeed Particles, Jour. of Appl. Phys., v. 23: 123, 1952). This method and techniques for recording pellet velocity are described. Crater characteristics including (1) crater volume, (2) penetration (or crater depth), and (3) crater area at the target surface have been studied for a range of velocities. These results are compared with those from metal-to-metal impact using aluminum and steel pellets. Comparison is also made with experimental results of Eichelberger and Rostoker using jets [from steel liners]. The validity of several proposed empirical equations for penetration and crater volume is examined. (Contractor's abstract)

UTA. 01:002

Utah U. Dept. of Electrical Engineering, Salt Lake City.

SOME CHARACTERISTICS OF CRATERS FROM HIGH-SPEED PELLETS IMPACTING INTO SEMI-INFINITE TARGETS, by M. E. Van Valkenburg, W. G. Clay and others. Sept. 1955, 15p. incl. diagrs. tables. (Technical rept. no. 2) ([AF]OSR-TN-55-287) (AF 18(600)1217) AD 72221 Unclassified

In this study, pellets of various shapes and materials were fired at speeds ranging from 1 to 4 mm/μsec (about 3000 to 13,000 ft/ sec) into various target materials. The following pellet-target combinations were used: (1) aluminum (24ST) into aluminum (61ST); (2) aluminum into lead; (3) aluminum (24ST) into wax (paraffin-petrolatum); (4) brass into brass; (5) brass into lead; (6) brass into magnesium; (7) epon 828 (thermosetting plastic) into wax (paraffin-petrolatum); (8) magnesium into lead; (9) magnesium into magnesium; (10) steel (SAE 1040) into steel (SAE 1040); (11) steel into zinc; and (12) zinc into zinc. Tabular data include pellet mass; pellet diameter; crater area (sq cm); crater volume (cu cm); and penetration depth (mm). The method for producing ultraspeed pellets is described, and the procedures for measuring pellet velocity, crater area, crater volume, and penetration depth are also considered.

UTA. 01:003

Utah U. Dept. of Electrical Engineering, Salt Lake City.

IMPACT PHENOMENA AT HIGH SPEEDS, by M. E. Van Valkenburg, W. G. Clay, and J. H. Huth. Feb. 15, 1956, 34p. incl. illus. diagrs. tables, refs. (AFOSR-TN-[56-54]) (AF 18(600)1217) AD 81046 Unclassified

Also published in Jour. Appl. Phys., v. 27: 1123-1129, Oct 1956.

A study of high-speed, metal-to-metal impact characteristics in the velocity range 1-5 mm/μsec is described. Several experiments relating to the mechanisms of cratering, including the perforation of thin targets, are presented. For 1/8-in. diameter spherical pellets, it is found that the volume of the crater/ unit energy of the impacting pellet is essentially constant, and that the penetration is proportional to the velocity of the pellet. An attempt to model very high-speed impact by means of soft wax targets in which the sonic velocity is less than the impacting velocity is outlined. A speculative insight into meteoric speed impact may be gained by this means. (Contractor's abstract)

UTA. 01:004

Utal U. Dept. of Electrical Engineering, Salt Lake City.

AN INVESTIGATION OF THE FEASIBILITY OF USING A SHORT SOLENOID AS AN ELECTROMAGNETIC ACCELERATOR, by M. M. Christensen, H. K. Okamoto, and W. S. Partridge. June 1956, 35p. incl. illus. diagrs. tables. (Technical rept. no. 4) (AFOSR-TN-56-214) (AF 18(600)1217) AD 87530 Unclassified

The investigation of the short solenoid as an electromagnetic gun utilized a system whereby the electrical energy in a bank of photo-flash capacitors was discharged into a solenoid. The pulse of electrical energy energized an accelerator coil, and the resultant magnetic field of the coil repelled a spherical Al pellet located initially within the solenoid. The problem was to observe the performance of the short solenoid when used to accelerate the pellet. First, the required initial position of the pellet within the solenoid was found to be forward of the center line of the solenoid. A second series of tests showed the correlation between the system efficiency and pellet velocity as the initial energy

or the initial voltage of the syetem was varied. Correlation of the reeults tndicated that the capacitance of the energy source should numerically equal the inductance of the solenoid to obtain the best system effticiency. The condttion for obtaining high pellet velocity depended upon the consideration of additional parameters as dampting factor and the frequency of osctllation of the network. High voltage and energy were required to perform the tests. The method of handling the large quantity of electrical energy as well as the method of obtaining the pellet velocity were important secondary probleme encountered tn the investigation. The solution to these problems were unique, since the high energy and voltage that were present with the aesoctated electromagnetic radtation made conventional methode tneffective, and tn some caees dangeroue. (Contractor's abstract)

UTA. 01:005

Utah U. Dept. of Electrical Engineering, Salt Lake Ctty.

WAX MODELLING STUDIES OF HIGH-SPEED IMPACT, by W. G. Clay and W. S. Partridge. June 1956, 31p. incl. illue. dtagrs. tables, refs. (Technical rept. no. 5) (AFOSR-TN-56-257) (AF 18(600)1217) AD 88977 Unclaeetfted

An investigation of wax-to-wax tmpact te presented tn an attempt to "model" high-speed Impact of metal into metal. Wax te chosen as the modelling substance because of its comparatively low soutc velocity and the physical similarity of wax craters to craters formed at the impact of metal into metal. The sonic velocity in wax te determtned as a function of temperature; the work reported te made wtth the wax targete at a temperature of about 75°F, at whtch the sonic velocity tn wax te approximately 0.7 km/sec. A method of accelerating wax pellets by means of laboratory guns te given; also, use te made of the static charge on wax pellets tn some of the velocity measurements. The penetration of the tmpacting pellet te found to vary linearly wtth the cube root of the pellet mass and the pellet velocity to velocities tn excess of twice the sonic velocity in the wax target. The crater area varies directly as the pellet area and the velocity, both below and avove the sonic velocity, but there te a marked tncrease in the constant of proportionality above the sonic velocity. The volume of the crater per unit energy of the pellet te discussed, and it te found that in wax this characteristic te not tndependent of velocity. Valuee of volume per unit energy range from 1.5 to 4.0 x 10^{-8} cu m/joule between zero and 2 km/sec. Expertments are descrtbed whtch throw some light on the mechanisms of cratering. A large part of the crater volume te created by deformation of the target material and only a small part te due to ejection of target matertal. There te an apparent cavttation in the target material surrounding the crater, probably caused by a shock wave created by the impact. A comparison of features of wax craters with metal craters indicates validity of the wax model. (Contractor's abstract)

UTA. 01:006

Utah U. Dept. of Electrical Engineering, Salt Lake Clty.

CIRCUIT ANALYSIS OF A SOLENOID-TYPE ELECTROMAGNETIC ACCELERATOR, by R. W. Walker and L. D. Harris. Aug. 1956, 46p. tncl. illus. diagrs. tables. (Technical rept. no. 7) (AFOSR-TN-56-385) (AF 18(600)1217) AD 96042 Unclassified

Paramsters of an experimental circuit were determined from current oscillograms. The prtmary ctrcuit was an underdamped resistance-tnductance-capacitance loop in whtch the condenser was discharged through a hollow coil that contained a conducting projectile. The current waveform was a damped sinusotd. The current produced a large magnetic flux with axial and radial components. The axial component induced a voltage tn the projectile. The current whtch results from thte voltage interacts with the radtal component of the flux to produce an accelerating force on the projectile. At the end of one-half cycle of prtmary current, the heat losses in the primary and secondary ctrcuits, the energy etored in the magnetic ftetd, and the kinetic energy in the projectile must balance the energy extracted from the prtmary ctrcuit during that period. The energy equation ts determined, and the energy terme are evaluated for one-half cycle. A straight line vartation of mutual tnductance with time te assumed. The current tn the projectile te evaluated by solving Kirchhoff's equation for voltage around the secondary circuit when (1) secondary resistance te neglected, (2) secondary tnductance te neglected, and (3) both are considered. The analysis tndicates that it te advantageous to tncrease the energy extracted during the first one-half cycle of prtmary current. Over-all effticiency can be tmproved by decreasing both the prtmary and secondary resietance. (ASTIA abstract)

UTA. 01:007

Utah U. Dept. of Electrtcal Engineering, Salt Lake Ctty.

THE INDUCTANCE COIL AS AN ENERGY RESERVOIR FOR AN ELECTROMAGNETIC ACCELERATOR, by C. R. Forbes and W. S. Partridge. Aug. 1956, 48p. incl. dtagrs. tables. (Technical rept. no. 6) (AFOSR-TN-56-386) (AF 18(600)1217) AD 96044 Unclassified

The power required to accelerate a pellet to very high velocities te enormous. It te not feasible, nor necessary, to deliver thte power from a continuous source. The extremely short time duration and small duty cycle allow the use of a system in whtch the energy te accumulated at a very slow rate and discharge at a very htgh rate. The feasibility of using the tnductance coil as an energy reservotr for such a system te discussed. Three systems are analyzed. The first system has the simplest circuit possible to transfer the energy from the ftetd of one coil to the field of another. The 2nd system te a modification of the first using the addition of a capacttor for tmproved performance. The

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3rd system employs a bank of capacitors as the energy reservoir, and serves as a standard for measuring the merit of the other 2 systems. The systems are evaluated from the standpoint of (1) energy storage and transfer, (2) power gain and supply, (3) timing, (4) switch requirements and (5) cost. It was concluded that it is not feasible to use the inductance coil as an energy reservoir for the systems considered. The problems created over-shadowed the mediocre performance obtained. The system using the capacitor bank as the energy reservotr is far supertor in both performance and simplicity. (Contractor's abstract)

UTA. 02:001

Utah U. Inst. for the Study of Rate Processes, Salt Lake City.

KINETICS CF OXIDATION OF CARBON, by M. C. Chen, H. Eyrtng, and C. J. Christensen. Mar. 1, 1952, 14p. incl. diagrs. tables. (Technical rept. no. 1) (AF 33(038)20839) AD 23509 Unclassified

The oxidation rate of carbon films on a cylindrical ceramic base was studied. The results are summarized in ne following two equations:

$$\Delta t = 8.9 \times 10^{5} r_0^{-1.00} \frac{L}{D} \left(\frac{W}{C} - 1\right)^{-5.0},$$

$$\frac{dr}{dt} = 1.12 \times 10^{-7} r_0 \frac{D}{L} \left(\frac{W}{C} - 1\right)^{5.0},$$

where Δt is the time required for the hot resistance of the cylindrical resistor of length L, diameter D, and initial resistance r_0 to increase 10% as a result of oxidation of the carbon. The power dissipation in the resistor is W, and C is the maximum power input possible before appreciable oxidation takes place. The second equation refers to the rate of resistance increase. Theoretical discussion is presented of the 2 equations, and a comparison is made with experimental results.

UTA. 02:002

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

THE THERMAL OXIDATION OF GASEOUS LOWER ALDEHYDES, by L. G. Tensmeyer and G. R. Hill. Apr. 15, 1952, 14p. table, refs. (Technical rept. no. 2) (AF 33(038)20839) AD 16308 Unclassified

A critical review is presented concerning the mechanism of the oxidation of formaldehyde. The work of the following investigators is considered briefly: Askey (1930); Fort and Hinshelwood (1930); Bone and Gardner (1936); Showden and Style (1939); Style and Summers (1946); Axford and Norrish (1948); and Harding and Norrish (1949). It is pointed out that an understanding of the oxidation of aldehydes is of great importance since aldehydes are apparently found as intermediates tn all hydrocarbon oxidations.

UTA. 02:003

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

THE SIGNIFICANCE OF ISOTOPIC REACTIONS IN RATE THEORY, by H. Eyring and F. W. Cagle, Jr. Mar. 15, 1952, 11p. tncl. diagrs. refs. (Technical rept. no. 3) (AF 33(038)20839) AD 23243 Unclasstfied

Also published in Jour. Phys. Chem., v. 56: 889-892, Sept. 1952.

The general theory of the tsotoptc effect on reaction rates is developed in terms of tlie absolute rate theory. The high temperature limtt of the separation factor $\left(m^{\ddagger}_{heavy}/m^{\ddagger}_{light}\right)^{1/2}$ is obtained and its significance and use discussed. The possibility of obtaining an α of less than unity is investigated and the rather physically unlikely condttions which would be necessary are stated. The electrolytic concentration of heavy water is considered since it provides a reaction with at least two mechanisms. An approximate separation factor is discussed for one mechanism and the unusual increase of separation factor with temperature, over a limited temperature range, is discussed. A very tentative activated complex is postulated for the hydrolysis of Al_4C_3 which explains the unusually high separation factor (ca 20) for the reaction with H_2O compared with D_2O. Four organic reactions involving isotopes for which separation factors have been observed tn light of a simplified model. Very good agreement between calculated and observed separation factors is obtained. (Contractor's abstract)

UTA. 02:004

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

THE MECHANISM OF THE MERCURY-SENSITIZED PHOTOCHEMICAL OXIDATION OF PROPANE, by N. V. Fok, B. B. Bereslavsky and others, tr. by G. N. Larsen. June 15, 1952, 3p. diagrs. (Trans. of [Doklady Akademii Nauk SSSR, v. 67: 499-501, 1949]) (AF 33(038)20839) AD 16170 Unclassified

In this study conducted at the Institute of Chemical Physics, Academy of Science USSR, condensation products of an equimolar mixture of propane and oxygen were analyzed polarographically and chemically. The analyses indicated the presence of aldehydes and organic peroxides. Yields of these compounds were noted in relation to time of exposure in the zone of illumination, over a temperature range from room temperature to 300° C, at a pressure of 50 mm Hg. The data, presented graphically, indicate that: (1) at room temperature only one organic peroxide is the product of reaction; (2) as temperatures increase to

100°[C] aldehydes begin to appear, though in lesser amounts than the peroxides; and (3) at 300°[C] the yield of peroxides drops abruptly while that of the aldehydes continues to increase. Results thus show that peroxides are the initial intermediate products, while the aldehydes are the secondary intermediate products in the reaction studied.

UTA. 02:005

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

EXPERIMENTAL DETERMINATION OF EQUILIBRIUM FREEZING TEMPERATURES, by D. Christensen, N. W. Ryan, and G. R. Hill. Oct. 15, 1952 [17]p. incl. diagrs. tables, refs. (Technical rept. no. 4) (AF 33-(038)20839) ATI-171900 Unclassified

In this study concerning the expansion of hot combustion gases through rocket nozzles, a method is being developed for determining the equilibrium "freezing" temperature by measurement. This measurement will eliminate the necessity of obtaining experimentally the rate constants, and will exclude the uncertainties associated with the assumptions and approximations made in the derivation of equations. Measurement of the "freezing" temperature requires that the composition and pressure be obtained as a function of temperature. These variables are determined at several points in the divergent section of the rocket nozzle, the "freezing" temperature being evaluated by interpolating between the points. It is pointed out that the equilibrium does not freeze at a particular temperature, but rather over a range of temperatures. A general description of the method to be applied and the equipment, e.g., nozzle, combustion chamber, feed system, thrust-measuring instrumentation, etc., is presented. In an appendix, an example of equilibrium "freezing" using 2NO and its dissociation products (N_2 and O_2) is given.

UTA. 02:006

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

THE KINETICS OF COMBUSTION OF METHYL ALCOHOL, by W. H. Wiser and G. R. Hill. Dec. 15, 1952, 71p. incl. illus. diagrs. tables, refs. (Technical rept. no. 5) (AF [33](038)20839) AD 17800 Unclassified

The combustion kinetics of MeOH were studied in an effort to determine the effect of the OH upon the velocity of combustion and to improve the energy output of fuels in internal combustion engines. With specially designed combustion apparatus, the combustion limits of MeOH-air mixtures were established as 7.9 ± 0.2 and 25.0 ± 0.6% on the lean and rich ends, respectively. The combustion tube was 57.0 cm long between 2 (1.7 and 8.0 mm) orifices; the od was 3 cm. The observed velocities (U_o) of the flame in the combustion tube were from 29.4 to 91.5 cm/sec. The flame front areas (A_f) were calculated by the method of Coward and Hartwell (Jour. Chem. Soc. 1932, 2676-2684) with values taken from the contact prints. These A_f values were from 10.3 to 19.2 sq cm. The velocity of the unburned gas ahead of the flame front (U_g) was small; at most, it equalled 1.3% of the U_o value. The fundamental flame velocity U_f was calculated from the equation $U_f = (U_o - U_g)\frac{A_t}{A_f}$, where A_t is the cross-sectional area of the flame tube. The U_f values ranged from 11.7 to 44.7 cm/sec. The presence of a bubble tube on the combustion tube did not alter the U_o values. Natural gas was employed to check the combustion velocity upon the concentration of MeOH and O, runs were with one of the variables constant and the other varied over a wide range. Maximal velocities were observed with 10.0% MeOH and 18.0 and 18.9% O; the latter 2 maxima were the highest. The results are tabulated and compared with previous results. The effects and causes are discussed as well as theoretical considerations. (ASTIA abstract)

UTA. 02:007

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

KINETICS OF OXIDATION OF CARBON [II], by M. C. Chen, C. J. Christensen, and H. Eyring. Dec. 15, 1952, 22p. incl. diagrs. tables. (Technical rept. no. 6) (AF [33](038)20839) AD 17873 Unclassified

The rate of C oxidation was evaluated in terms of the change in resistance of C films. The films were deposited from purified CH_4 gas at about 1000°C on a ceramic base. Flow rate of the oxidizing gas over the C resistor was measured by calibrated flowmeters. Values of resistance were determined as frequently as convenient for a period of 20 min. The resistance of the C films was determined from the equation $r_u = r_k \frac{P_u}{P_k}$. ($P_k$ is the voltage drop across the standard resistor, r_k, and P_u is the voltage drop across the C film resistor, r_u. The P_k employed to calculate r_u at a particular time is the average of P_u and P_k since both vary continuously.) When the reciprocal of the resistance of the C resistor was plotted against time, a straight line was obtained. The data may be expressed by the following equation $1/r_u = -mt + \text{constant}$. The slope of the straight line, m, was found graphically in each case. The resistance of the C resistor was measured from 350° to 500°C at 3 different O rates of flow. The effect of changing the % of O was determined when the temperature was kept constant. A determination was made with the O composition fixed at 1:1 ratio of O to N and varying temperatures. The slope and other related values are tabulated for the different rates of gas flow and temperatures; results are treated theoretically.

UTA. 02:008 - UTA. 02:011

UTA. 02:008

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

APPLICATION OF CONSISTENCY OF TYPE REACTIONS TO CHAIN DECOMPOSITIONS, by J. C. Giddings, F. W. Cagel, Jr. and others. July 15, 1953, 19p. incl. diagrs. tables, refs. (Technical rept. no. 8) (AF 33(038)20839) Unclassified

It is pointed out that there is no method available for studying and measuring directly the elementary processes that form the basis for all of the reactions found in fuels during combustion. Therefore, in this study, the concept of consistency of type reactions is introduced to reduce the over-all problem of solving the kinetic equations. An evaluation of the consistency of type reactions was made in terms of average deviation from the mean. Using 10 examples of direct bond rupture, it was found that the average deviation of ΔS, the activation entropy, is 1.7 EU. In 35 cases of H_2 abstraction reactions involving Me radicals, and a variety of other molecules, the average deviation was shown to be 1.4 EU. These small deviations justify application of the method. In applying the method, all reactions were written in terms of absolute reaction-rate theory, emphasizing the behavior of the potential energy surface. The results obtained show that: (1) κ (the transmission coefficient) = 0.1 for bond-rupture reactions in hydrocarbons; (2) the decomposition of acetaldehyde obeys Rice-Herzfeld kinetics very closely, showing that it is a chain reaction and has a true order of 3/2; (3) the activation entropies and transmission coefficients, respectively, found for various reactions are as follows:

$R' - R \rightarrow R' + R$	$\Delta S^{\ddagger} = -1.5$ EU	$\kappa = 0.1$
$R' + RH \rightarrow R'H + R$	$\Delta S^{\ddagger} -13.7$ EU	$\kappa = 1.0$
$RCH_2CH_2 \rightarrow R' + CH_2CH_2$	$\Delta S^{\ddagger} -1.5$ EU	$\kappa = 0.1$
$R' + R \rightarrow R' - R$	$\Delta S^{\ddagger} -1.0$ EU	$\kappa = 0.1$

It is pointed out that a system of equations has been formulated in which experimental work can be written easily in terms of the fundamental properties of the activated complex.

UTA. 02:009

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

EQUILIBRIUM THEORY OF UNIMOLECULAR REACTIONS, by J. C. Giddings and H. Eyring. Mar. 1954. 5 [p. incl. diagr. refs. (Technical rept. no. 9) (AF 33(038)20839) Unclassified

Published in Jour. Chem. Phys., v. 22: 538-542, Mar. 1954.

This paper develops an equilibrium theory of unimolecular reactions, and shows how this theory is related to other theories, such as the Rice-Ramsperger-Kassel treatment. Unimolecular decomposition reactions and isomerization reactions are described in terms of statistical mechanics and quantum mechanics (potential energy surfaces). The nature of the transmission coefficient is discussed in detail. (Contractor's abstract)

UTA. 02:010

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

A KINETIC COMPARISON OF THE COMBUSTION OF METHYL ALCOHOL AND METHANE, by W. H. Wiser and G. R. Hill. [1954] [6]p. incl. diagrs. tables, refs. (AF 33(038)20839) Unclassified

Published in Fifth Symposium (International) on Combustion, Pittsburgh U., Pa. (Aug. 30-Sept. 3, 1954), N. Y., Reinhold, 1955, p. 553-558.

Combustion tube determinations were made of the velocity of burning and combustion limits of methanol-air mixtures at a pressure of 65 cm Hg and an initial temperature of 24-27°C. Results show the combustion limits to be 7.9 ± 0.2% and 25.0 ± 0.6%. Calculations showed the fundamental flame velocity to vary from a minimum of 11.7 cm/sec at a methanol concentration of 20.0 mole % to a maximum of 44.7 cm/sec at 14.3 mole %, on the fuel-rich side of stoichiometric composition. Determinations under the same experimental conditions showed methane to have a maximum flame velocity of 36.3 cm/sec. Calculations of the relative heats of activation from experimental values showed that of methane to be 2163°K, and that of methanol 2023°K.

UTA. 02:011

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

SOME KINETIC PROPERTIES OF THE STEAM-CARBON REACTION AND COMPARISON OF THE CATALYTIC EFFECT ON COBALT, IRON, NICKEL AND VANADIUM OXIDES, by W. M. Tuddenham and G. R. Hill. Mar. 31, 1954 [23]p. incl. diagrs. tables, refs. (Technical rept. no. 10) (AF 33(038)-20839) Unclassified

Presented at 124th National meeting of the Amer. Chem. Soc., Div. of Gas and Fuel Chemistry, Chicago, Ill., Sept. 1953.

Also published in Indus. Engineering Chem., v. 47: 2129-2133, Oct. 1955.

A method employing the impingement of a high velocity jet of steam on heated carbon samples in a low pressure chamber has been used to study some of the kinetic properties of the steam-carbon reaction, and to compare the catalytic effects of cobalt, iron, nickel and vanadium oxides. Excess steam was frozen out and the gasification rate of the carbon was

found from the rats of pressure increass. (Contractor's abstract)

UTA. 02:012

Utah U. [Inst. for the Study of Raie Processes] Salt Lake City.

KINETICS OF THE OXIDATION OF PYROLYTIC CARBON, by M. C. Chen, C. J. Christensen, and H. Eyring. [1955] [16]p. incl. diagrs. iables, refs. [AFOSR-TN-55-182] (AF 33(038)20839) Unclassified

Published in Jour. Phys. Chem., v. 59: 1146-1148, Nov. 1955.

A method is elucidaied for determining the kinetics of C oxidation by measuring the raie of decrease in the electrical conductiviiy of the C in film form. This method is applied to films of pure pyrolytic C, and a raie equation is deiermined. An activation energy of 21 kcal and an activation entropy of -28 EU are found to apply to the oxidaiion of this particular C when oxidized at iemperatures up to 550°[C]. The oxidation rate is found to be firsi order with respect to O_2 pressure. (Contractor's abstract)

UTA. 02:013

Utah U. [Insi. for the Study of Raie Processes] Sali Lake City.

A KINETIC STUDY OF METHYL CHLORIDE COMBUSTION, by H. T. Henderson and G. R. Hill. Aug. 1955, 15p. incl. illus. diagrs. iables, refs. (Technical noie no. 14) ([AF]OSR-TN-55-310) (AF 33(038)20839) AD 72227 Unclassified

A study of the burning characieristics of methyl chloride has been made using the tube method of Gerstein, Levine, and Wong (Jour. Amer. Chem Soc., v. 73: 418, 1951). Burning velocity data have been taken in air and in oxygen. The burning velocity and limit data for methyl chloride are compared with methane and methyl alcohol and with some other chlorinated hydrocarbons. In addition, the influence of tube diameter for the G-L-W tube method has been studied, and is found to be much the same as for the Coward-Hartwell method (Jour. Amer. Chem. Soc., Pt. 2, 2676, 1932). A new generalized procedure for calculating flame front areas has been used. (Contractor's absiraci)

UTA. 02:014

Utah U. [Inst. for the Study of Rate Processes] Sali Lake Ciiy.

SECTION I. KINETICS OF THE STEAM-CARBON REACTION. SECTION II. A KINETIC THEORY FOR THE OXIDATION OF GRAPHITE, by J. S. Binford, Jr., G. D. Blyholder, and H. Eyring. Aug. 1955 [62]p. incl. diagrs. tables, refs. (Technical note no. 12) [AFOSR-TN-55-311] (AF 33(038)20839) Unclassified

Section I. A description is given of an apparatus for studying high-temperaiure (1500°C), low-pressure (1 to 100 μHg) heterogeneous processes in which one or more of the products is a gas. The H_2O-gas reaction has been studied in the 900°C to 1300°C iemperature range. This is the first kinetic study of this reaciion at high temperatures in which the oxidizing gases have been carefully preheated to the reaction temperature. A zero-order reaction with an activaiion energy of 60.3 kcal/mol is found in the 900°C to 1100°C range, changing to a first-order process by 1300°C, with a considerably lower value for the activation energy. Several possible mechanisms are discussed, including a surfaces rsarrangement of adsorption sites and predissociation of H_2O vapor. Section II. A considerable amount of data on the C-O_2 reaction has been collected from the literaiure, evaluaisd, and expressed in such a manner ihat comparison can be made. A theory is proposed which applies to the complete temperature range in which data have been obtained, 350° io 2000°C. In particular, the unusual maximum in the Arrhenius plot is explained on a theoretical basis, although the model proposed is not readily adapted to the known structural features of graphite. (Contractor's absiract, modified)

UTA. 02:015

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

REACTION KINETICS OF GRAPHITE OXIDATION AT LOW TEMPERATURES, by A. L. Ruoff and H. Eyring. Aug. 1955 [27]p. incl. diagrs. table, refs. (Technical noie no. 13) ([AF]OSR-TN-55-312) (AF 33(038)20839) AD 72229 Unclassified

Data were obtained on ths oxidation kinetics of graphiie by O to establish a definite reaction mechanism. Literature and experimental values are tabulated for the heat of activation, the temperature range of the reaction studied, the type of C oxidized, and the type of O supply (flow or stationary). Studies are being made of the effect of the CH_4 cracking temperature on consequent oxidation reactions with O. Results of a literature survey are discussed with respect to heats of activation, the reaction order of graphite oxidation, the primary reaction products, the catalytic effects on the gasification of C, and the role of surface oxides in C gasification. The various processes which might be rate determining are treated theoreiically, and calculations are made with the experimentally obiained value of the heat of activation ai 1 atm and 500°C. (ASTIA ahsiract)

UTA. 02:016

Utah U., [Insi. for the Study of Raie Processes] Salt Lake City.

FLAME PROPAGATION. THE RANDOM WALK OF CHEMICAL ENERGY, by H. Eyring, J. C. Giddings, and L. G. Tensmeyer. July 1955, 10p. incl. tables,

UTA. 02:017 - UTA. 02:019

refs. (Technical nots no. 15) ([AF]OSR-TN-55-363) (AF 33(038)20839) AD 74177 Unclassified

Also published in Jour. Chem. Phys., v. 24: 857-861, Apr. 1956.

A nsw approach to the theory of burning velocity is presented in which a flame front moves forward at a rate determined by the random walk of chemical (potential) ensrgy. The flame velocity is determined by the valus of n which is a collision rate divided by a rsaction rats, both determined at the point of maximum reaction velocity. The comparison between theoretical and experimental flame velocities is given for cases in which ths chemical kinetics ars quite well understood. Empirical activation energies for reaction are givsn for csrtain hydrocarbon flames. It is hoped that these may be useful in determining the important chsmical procssses in hydrocarbon flame-propagation. (Contractor's abstract)

UTA. 02:017

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

KINETICS OF THE STEAM-CARBON REACTION, by J. S. Binford, Jr. and H. Eyring. Jan. 1956 [25]p. incl. diagrs. tables, refs. (Technical note no. 17) (AFOSR-TN 56-60) (AF 33(038)20839) Unclassified

Also published in Jour. Phys. Chem., v. 60: 486-491, Apr. 1956.

A description is given of a more satisfactory type apparatus for the study of high-temperature (1500°C), low-pressure (1 to 100μ) heterogeneous processes in which one or more products is a gas. The water-gas reaction has been studied in the 900°C to 1300°C temperature range. This is the first kinetic study of this reaction at high temperatures in which the oxidizing gases have been carefully preheated to the reaction temperature. A zero-order reaction with an activation energy of 60.3 kcal/mol is found in the 900°C to 1100°C range, changing to a first-order process in the 1200°C to 1300°C range with a considerably lower value for the activation energy. Several possible mechanisms are discussed, including a surface rearrangement of adsorption sites and predissociation of water vapor. (Contractor s abstract)

UTA. 02:018

Utah U. [Inst. for the Study of Rate Processes] Salt Lake City.

THE MECHANISM OF INHIBITORS FOR CHAIN REACTIONS, by A. T. Ree and K. Yang. Jan. 1, 1956, 11p. incl. diagrs. tables. (Technical note no. 16) (AFOSR-TN-56-61) (AF 33(038)20839) Unclassified AD 81053 Unclassified

In this study, the Rice-Herzfeld mechanism for the pyrolysis of hydrocarbons is assumed:

(1) $R \cdot CH_3 \rightarrow CH_3 + R$, (1') $CH_3 + Hc \rightleftharpoons CH_3H_c$, (2) $CH_3' + RCH_3 \rightarrow CH_4 + R_0'$, (3) $R' \rightarrow P + CH_3$, (4) $CH_3' + CH_3' \rightarrow C_2H_6$, (5) $CH_3' + B + CH_3' \rightarrow C_2H_6 + B$, where P indicates olefines, and R and R' are alkyl radicals. CH_3' indicates $CH_3 + CH_3H_c$. Assuming ths following equilibrium, (6) $CH_3 + 2NO \rightleftharpoons CH_3(NO)_2$ for the inhibition mechanism, the rate equation for the inhibited pyrolysis is derived as,

$$r = r_o \frac{1}{1 + \frac{K_2}{1 + K_1 Hc} NO^2},$$

where r and r_o indicate an over-all rate of inhibited decomposition and that of an uninhibited one, and K_1 and K_2 are the equilibrium constants for the reaction 1' and 6, respectively. Using this result, the inhibition curves for butane, pentane, hexane, heptane, octane, nonane, and decane are reproduced with good agreement with experiments. (Contractor's abstract)

UTA. 02:019

Utah U. Inst. for the Study of Rate Processes, Salt Lake City.

THE KINETICS OF COMBUSTION OF METHYL CHLORIDE AND RELATED COMPOUNDS, by H. T. Henderson and G. R. Hill. June 30, 1955 [125]p. incl. illus. diagrs. tables, refs. (Technical rept. no. 11) (AFOSR-TN-56-62) (AF 33(038)20839) AD 81054 Unclassified

A study of the combustion of methyl chloride, using the tubs method of Gerstein, Levine, and Wong, (Jour. Amer. Chem. Soc., v. 73: 518, 1951), is described. The results are analyzed and compared with data for related compounds. Flams-temperature curves have been calculated for comparison with the burning-velocity curves obtained. Soms of the more significant results are summarized as follows: (1) A comparison of maximum burning rates has been made for methyl chloride, methyl alcohol, and methane in air mixtures, the ratios found being 1:4.14:3.31. (2) The maximum burning velocity of methyl chloride has been compared with that for other chlorinated hydrocarbons, and a simple correlation has been found between the population of chlorine atoms in the fuel molecule and the burning velocity. From this correlation, a value of U_f (burning velocity) = 18.7 cm/sec was predicted for a stoichiometric mixture of ethyl chloride/air. (3) Burning velocities have been obtained for the systems methyl chloride/oxygen and methyl chloride/air. The order of burning-rate dependence on oxygen, methyl chloride, and total combustibles was determined by the use of argon and nitrogen inerts. Some of these curves revealed a rather anomolous maximum and minimum, indicating a change in the mechanism of combustion. (4) Limits of combustion of methyl chloride in air and in oxygen/inert-gas mixtures were determined. These were

compared with values obtained from the litsrature for methyl chloride and other chlorinated compounds. The population of chlorine in the molecula was found to be relaied in a regular manner to the calorific value of ths lower limit mixtures. (5) Relative activation energies havs been calculated for methyl chloride, methyl alcohol, and methane in air. The method of obtaining these is discussed. Though a complete mechanism for methyl chloride burning, has not been attempted, some of the unique features concerning it have been considered and explained. Evidencs has been cited showing the inhibitory roll of chlorine and iis compounds. Msthyl chloride dissociation has been calculated using as a basis the reaction

$$CH_3Cl \longrightarrow CH_3 + Cl.$$

An improvemsnt has been suggested in the svaluation of areas of flames in tubes to give larger values of burning velocity, especially for slow-burning systems. A study of burning velocity has bsen made as a function of iube diametsr, tubes bslow 2.4-cm inside diamster having a distinct cooling and slowing effect, while in those above 2.8-cm inside diameter the burning rate is independeni of diameier. The onsei of turbulence vs tube diameier has also been observed, being earlier for the larger tube diameters. (Contractor's abstract, modified)

UTA. 02:020

Utah U. Inst. for the Study of Raie Processes, Sali Lake City.

MECHANISM OF INHIBITOR ACTION FOR CHAIN PROCESSES, by K. Yang, [A.] T. Ree, and H. Eyring. Mar. 10, 1956, 40p. incl. diagrs. tables, refs. (Technical note no. 18) (AFOSR-TN-56-I24) (AF 33-(038)20839) AD 82520 Unclassified

The Rice-Herzfeld mechanism for the pyrolysis of organic compounds is assumed: (I) $RCH_3 \rightarrow CH_3 + R$; (2) $CH_3 + R \cdot CH_3 \rightarrow CH_4 + R'$; (3) $R' \rightarrow CH_3$ + Produci (I); (4) $R \rightarrow CH_3$ + Product (2); (5) $CH_3 + CH_3 \rightarrow C_2H_6$; (6) $CH_3 + B + CH_3 \rightarrow C_2H_6 + B$. As the inhibition mechanism of an inhibitor for the chain process, the reactions, (i) $CH_3 + In \rightarrow CH_3In$; (j) $CH_3In \rightarrow$ Product (3); (2') $CH_3In + CH_3R \rightarrow CH_4 + R' + In$; (5') $CH_3 + CH_3In \rightarrow C_2H_6 + In$; (6') $CH_3 + B + CH_3In \rightarrow C_2H_6 + In + B$; (5") $CH_3In + CH_3In \rightarrow C_2H_6 + 2\,In$; (6") $CH_3In + CH_3In + B \rightarrow C_2H_6 + 2\,In + B$, are introduced. The symbols R' and R are alkyl or acyl radicals. The steady siaie treatment yields $[CH_3]_o = [CH_3] + b[CH_3In]$, and the overall rate of the inhibited reaciion, r, satisfies the following relationship:

$$\frac{r}{r_o} = \frac{I}{1 + \dfrac{{}_a b k_i}{k_j + k'_2 P_o}[In]},$$

where r_o ts the rate oi the uninhibited reaction, P_o the pressure of the decomposed organic compound, k the specific reaciion rates, and $[CH_3]_o$ and $[CH_3]$ the steady state concentrations of the CH_3 radicals for the uninhibited and inhibited reactions, rsspectively. The inhibition curvss for the thermal decompoeition of hydrocarbons, Et_2O, AcH, propaldehyde, and Me_2CO, are sxplained quantitatively and are in good agresment with experiment. The activation energies of reactions (j) and (2') are calculated from the proposed mechanism, and it is shown that inhibitors such as NO and propylene can suppress almost completely ths chain part of ths thermal decompositions of ths organic compounds studied. (Contractor's abstract)

UTA. 02:021

Utah U. Inst. for the Study of Rate Processes, Salt Lake City.

A STUDY OF THE THERMAL DECOMPOSITION OF METHANE, by F. W. Cagle, Jr. Mar. 31, 1956, 11p. refs. (Technical nots no. 19) (AFOSR-TN-56-177) (AF 33(038)20839) AD 86599 Unclassified

Also published in Jour. Chem. Phys., v. 25: 1300-1301, Dec. 1956.

A bibliography of ths literature on the homogeneous pyrolysis of CH_4 has been made. The known data are consistent with the following assumed mechanism:

	E
$CH_4 \xrightarrow{k_1} CH_3 + H$	101 kcal
$CH_3 + CH_4 \xrightarrow{k_2} C_2H_6 + H$	48
$H + CH_4 \xrightarrow{k_3} CH_3 + H_2$	7
$H + CH_3 + M \xrightarrow{k'_4} CH_4 + M$	0.

Th's mechanism assuming the usual steady state approximaiions gives:

$$-\frac{d[CH_4]}{di} = 2\left(\frac{k_1 k_2 k_3}{k'_4}\right)^{1/2} \cdot \frac{[CH_4]^{3/2}}{[M]^{1/2}}.$$

This leads to a calculated overall activaiion energy of 78 kcal in excsllent agreement with the measured value of 79 kcal. Further the expression agrees with the experimenially deiermined order of the reaction over the investigaied pressure range. A shori discussion of the nitric oxide inhibition data is included. (Coniracior's abstract)

UTA. 02:022

Utah U. Insi. for the Study of Paie Processes, Sali Lake Ciiy.

KINETICS OF GRAPHITE OXIDATION, by G. D. Blyholder and H. Eyring. Aug. 15, I956, 73p. incl. diagrs. tables, refs. (Technical noie no. 20) (AFOSR-TN-56-451) (AF 33(038)20839) AD 96796 Unclassified

UTA. 02:023 - UTA. 02:024

A description of an apparatus for studying heterogeneous gas-solid reactions in the one to 100 micron pressure and 600°C to 1300°C temperature range is presented. The data for the graphite-O_2 reaction in this range are presented. Below 800°C the surface reaction is zero order with an 80 kcal/mole activation energy. On samples thicker than 0.1 mm, the diffusion of O_2 into the pores in the graphite results in an observed half order reaction with a 42 kcal/mole activation energy. Above 1200°C the reaction is controlled by the frequency of O_2 collisions with the surface. Between 800°C and 1200°C a continuous transition region exists. An equation is derived which gives the reaction rate under conditions in which pore diffusion affects the observed reaction rate and the surface reaction varies with the pressure in a manner described by the Langmuir adsorption isotherm. A great deal of the literature on C oxidation deals with materials which have been carbonized but not graphitized. These materials are usually oxidized in first order reactions with an activation energy of 20 to 30 kcal/mole. A kinetic treatment is given which explains the maximum in the Arrhenian plot observed by many workers engaged in the oxidation of electrically heated, carbonized filaments. (Contractor's abstract)

UTA. 02:023

Utah U. Inst. for the Study of Rate Processes, Salt Lake City.

OXIDATION STUDIES IN TOLUENE AS A CARRIER-GAS, by L. G. Tensmeyer, H. Eyring, and G. R. Hill. Sept. 1, 1956, 67p. incl. illus. diagrs. tables, refs. (Technical rept. no. 21) (AFOSR-TN-56-503) (AF 33(038)20839) AD 110318 Unclassified

The attempt was made to study the initiation reactions of hydrocarbon oxidation by utilizing a toluene carrier-gas technique. A vacuum system for toluene purification was described. A more complex vacuum system adequate for study of the oxidation processes was also described, with suggestions for refinement of equipment for future work. An infrared technique utilizing solid KBr was adapted for the study of combustion products. Chemical titrations were also used for total acids and total peroxides. The results showed that the toluene carrier-gas technique will not yield unquestionable data in oxidation systems. This is due partly to further reactions of the benzyl radical. Applied to the formaldehyde-oxygen reaction some of the radicals produced, apparently CHO and CHO_3, do not react quickly and quantitatively with toluene. The method yielded data from which the rate of the initiation reaction $HCHO + O_2$ could be calculated for the first time. The value of this constant, $5 \times 10^4 T^{1/2} e^{-39,000/RT}$, must be received with caution, because of further reactions of the benzyl radical. Benzyl hydroperoxide, benzyl alcohol, benzaldehyde, and bibenzyl were also found as products. The determination of the hydroperoxide in particular gives support to the hydroperoxidation theory of hydrocarbon autoxidation. Predominance of benzaldehyde over benzyl alcohol and benzyl hydroperoxide as temperature increased, was shown to reflect the decreasing stability of the benzyl peroxy radical in the range 400-550 C. (Contractor's abstract)

UTA. 02:024

Utah U. Inst. for the Study of Rate Processes, Salt Lake City.

KINETICS AND THERMODYNAMICS OF COMBUSTION, by G. R. Hill, H. Eyring, and C. J. Christensen. Final rept. Sept. 30, 1956, 28p. incl. diagrs. table, refs. [AFOSR-TR-56-52] (AF 33(038)20839) AD 110336 Unclassified

The following research studies on homogeneous combustion and thermal decomposition mechanisms and on the determination of the mechanisms of heterogeneous combustion processes are summarized: (1) the experimental determination of free radical mechanisms in gas phase aldehyde oxidations; (2) the thermal decomposition of hydrocarbons and related compounds; (3) the kinetics of oxidation of carbon films; (4) kinetics of combustion of methylamine; (5) infra-red kinetic studies of diborane; and (6) the pyrolysis and polymerization mechanisms of large organic molecules.

Virginia Engineertng Experiment Station, Blacksburg.
see Virginia Polytechnic Inst. Engineering Experiment Station, Blacksburg.

VIS. 01:001

Virginia Inst. for Scientific Research, Richmond.

AN X-RAY AND METALLOGRAPHIC STUDY OF LARGE GRAIN TITANIUM (Abstract), by F. J. Denise. [1955] [1]p. [AF 18(600)1319] Unclassified

Presented at meeting of the Virginia Acad. of Science, Charlottesville, May 11-14, 1955.

Published in Virginia Jour. Science, v. 6: 253-254, Sept. 1955.

Large single crystals of high temperature beta phase titanium can be prepared by a modification of the strain-anneal method, but recrystallization occurs on cooling. Etching revealed the titanium rod to consist of a great many crystalline fragments which were oriented with respect to one another. This was confirmed by x-ray back reflection methods. The results indicate strongly the existence of an orientation relationship between a low temperature hexagonal phase and a high temperature cubic phase. (Contractor's abstract)

VIS. 01:002

Virginia Inst. for Scientific Research, Richmond.

PSEUDO-MONOCRYSTALS OF ALPHA-TITANIUM, by H. Leidheiser, Jr. and F. J. Denise. [Dec. 30, 1955] [5]p. incl. illus. [AFOSR-TN-56-3] (AF 18(600)1319) Unclassified

Also published in Jour. Chem. Phys., v. 24: 625-626, Mar. 1956.

In this study, the preparation of "pseudo-monocrystals" of α-Ti is described briefly, and the mechanism of their formation is considered.

VIS. 01:003

Virginia Inst. for Scientific Research, Richmond.

THE PREPARATION AND STRANGE BEHAVIOR OF PSEUDO-MONOCRYSTALS OF ALPHA-TITANIUM (Abstract), by F. J. Denise and H. Leidheiser, Jr. [1956] [2]p. [AF 18(600)1319] Unclassified

Presented at meeting of Virginia Acad. of Science, Richmond, May 9-12, 1956.

Published in Virginia Jour. Science, v. 7: 265-266, Sept. 1956.

Commercially pure titanium rods, 1/2" in diameter and 2" long, were wrapped in foil and sealed in evacuated Vycor tubes. When such rods were cycled between 850° and 1200°C or between room temperature and 1200°C, large crystals of the beta-phase were formed at the high temperature. On cooling through the transition temperature at 880°C the high-temperature crystal recrystallized to a very highly oriented assembly of small crystals of the low-temperature, alpha phase. Since the orientation was so high and continued to the boundaries of the original high-temperature crystal the term "pseudomonocrystal" is warranted. Heating a pseudocrystal in an evacuated Vycor tube at 850°C for several days resulted in a great change in shape of the cross section, which change in shape was discontinuous at the boundary of another pseudocrystal. One type of commercial titanium became severely distorted when cycled between 860° and 1200°C. Metallographic and x-ray studies were made of the pseudocrystals. (Contractor's abstract)

VPI. 01:001

Virginia Polytechnic Inst. Dept. of Chemistry, Blacksburg.

PREPARATION OF CONJUGATED ALKADIENES, by R. C. Krug, T. F. Yen, and G. R. Tichelaar. Final technical rept. Sept. 1, 1953-Aug. 31, 1955. Sept. 1955, 23p. ([AF]OSR-TR-55-25) (AF 18(600)-690) AD 71632 Unclassified

In this chemical study, the preparation of conjugated alkadienes by means of the alkylation of unsaturated cyclic sulfones was not successful; however, some new and highly reactive halogenated sulfolenes have been prepared. The pyrolysis of a monosulfolene gave 2-bromomethyl-1, 3-butadiene, which may serve as a starting point for the synthesis of other compounds. A description is given of a new Diels-Alder reaction involving the conversion of a bromosulfolene into new polynuclear compounds possessing the hydrogenated chrysene system. It is pointed out that the reactivity of the α-hydrogen atoms in the sulfones has been proved.

VPI. 01:002

Virginia Polytechnic Inst. [Dept. of Chemistry] Blacksburg.

HALOGENATED ISOPRENE CYCLIC SULFONES (Abstract), by R. C. Krug and T. F. Yen. [1955] [1]p. [AF 18(600)641] Unclassified

Presented at meeting of the Virginia Acad. of Science, Charlottesville, May 11-14, 1955.

Published in Virginia Jour. Science, v. 6: 259, Sept. 1955.

The nucleus and the side chain of isoprene cyclic sulfone may undergo halogenation, and thus a number of halogen derivatives of this sulfone could be prepared. The following reactions involved in the

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synthesis of certain of these compounds are discussed: the ionic and radical types of addition, the Wohl-Ziegler halogenation of the side chain, the allylic shift, dehydrohalogenation, and isomerization. (Contractor's abstract)

VPI. 01:003

Virginia Polytechnic Inst. [Dept. of Chemistry] Blacksburg.

SOME REACTIONS OF BUTADIENE CYCLIC SULFONE (Abstract), by R. C. Krug and G. R. Tichelaar. [1955] [1]p. [AF 18(600)690] Unclassified

Presented at meeting of the Virginia Acad. of Science, Charlottesville, May 11-14, 1955.

Published in Virginia Jour. Science, v. 6: 258, Sept. 1955.

Sulfur dioxide and 1,3-butadiene undergo a 1,4 Diels-Alder type addition to give butadiene cyclic sulfone, a compound of relatively low thermal stability. Due to its acidic alpha hydrogen atoms, this sulfone will react with Grignard reagents, sodium hydride, and other bases. The sulfone also undergoes many addition reactions at the carbon-carbon double bond. (Contractor's abstract)

VPI. 02:001

Virginia Polytechnic Inst. Engineering Experiment Station, Blacksburg.

PRESSURE DISTRIBUTION ABOUT TWO-DIMENSIONAL DIAMOND AIRFOILS AND A 180° WEDGE, by R. W. Truitt and F. W. Martin. June 1954, 25p. diagrs. (Rept. no AE641-1) ([AF]OSR-TN-54-149) (AF 18(600)641) AD 34600 Unclassified

The Schwarz-Christoffel mapping theorem was used to derive the pressure distribution about 2-dimensional diamond airfoils for the zero angle of attack condition. The theoretical (incompressible) pressures were compared with corresponding low-speed wind-tunnel tests, and the agreement was excellent except at the shoulder. The zero pressure coefficient was found to move toward the shoulder with increasing wedge angle. The effect of afterbody configuration is discussed in view of the experimental and theoretical results. A 180° wedge in a bounded or unbounded stream was found to be less sensitive to wall influence than small-angle wedges. Experimental low-speed results for the 180° wedge in an unbounded stream were found to be such that free-streamlines spring from the shoulder. The Sound-Space Theory was applied to the experimental results for the 180° wedge, and the local Mach number distribution was found to be symmetric about free stream Mach number one, but not constant. (Contractor's abstract)

VPI. 02:002

Virginia Polytechnic Inst. Engineering Experiment Station, Blacksburg.

INVESTIGATION OF WEDGES IN TRANSONIC FLOW, by R. W. Truitt. Feb. 1954, 157p. incl. diagrs. refs. ([AF]OSR-TR-54-5) (AF 18(600)641) AD 32070 Unclassified

The present work is devoted to the thesis that a continuous (approximate) analytical solution can be obtained by a fundamentally new approach to transonic inviscid flow over simple wedges at zero angle of attack. The theoretical treatment is based on a new theoretical approach to compressible flow by deriving a local time- and space-unit transformation which is defined on the local speed of sound. It is shown that the incompressible inviscid solution for simple wedges may be employed in a new expression for compressible pressure coefficient to obtain a continuous solution from low subsonic to slightly supersonic flow. A detailed discussion of the structure and behavior of the compressible flow field about simple wedges is presented. This detailed discussion leads to the formulation of the transonic problem. Specifically, the theory is shown to be in fundamental agreement with experiment in the subcritical compressible range. Proof of the validity of the theory in the transonic range is given, an analysis being made to show that the theory satisfies the transonic similarity laws. A general analytical solution is then constructed whereby the constant ($p_{L/}p^*$) distribution may be calculated. This then establishes the approximate free-stream Mach number range in which the local Mach number distribution is constant. Using the general analytical method so developed, the pressure distribution is calculated for several specific wedge angles for a series of free-stream Mach numbers from low subsonic values to Mach numbers of greater than unity. The corresponding pressure drag coefficients are also presented in plots using the transonic similarity parameters. The present theoretical results are then compared with existing experimental and theoretical findings. In appendix A the "Sound-Space Theory" for 2-dimensional subsonic compressible flow is presented. A brief outline of the derivation of the transonic similarity parameters is given in appendix B. In appendix C, a method is derived for locating detached shock waves ahead of 2-dimensional wedges. Finally, a new expression for the pressure coefficient for 2-dimensional supersonic flow is derived in appendix D.

VPI. 02:003

Virginia Polytechnic Inst. Engineering Experiment Station, Blacksburg.

EFFECTS OF AFTERBODY CONFIGURATION ON THE PRESSURE DISTRIBUTION OVER THE NOSE OF TWO-DIMENSIONAL WEDGES, by R. W. Truitt and F. W. Martin. Mar. 3, 1954, 2p. incl. illus. [AF 18(600)641] Unclassified

Published in Jour. Aeronaut. Sciences, v. 21: 567-568, Aug. 1954.

Ths cases of (1) the symmetric diamond wedge, and (2) the single wedge wtth straight afterbody are considered at 0° angle of attack. A plot is pressnted of the theoretical prssure distrtbutions for these 2 cases for a wedge semiangle, θ, of 5°. Experimental results, obtained at low speed ($M_0 \approx 0.1$) for both afterbodies, were plotted and found to be in good agreement with the theoretical results. From thess results, it is seen that increasing the change of flow direction at the shoulder causes the front-wedge pressure distribution to become increastngly more negative. For given free-stream boundary conditions, the incompressible flow over the front wedge ts differsnt for the 2 afterbody configurations. It seems apparent, therefore, that any change in afterbody configuration should result in changes in the tncompresstble front-wedge pressure distrtbution.

VPI. 02:004

Virginia Polytechnic Inst. [Engineering Experiment Statton] Blacksburg.

INVESTIGATION OF PRESSURE DISTRIBUTION OF A 180° WEDGE (Abstract), by R. W. Truitt and J. C. Wtlltams, III. [1954] [1]p. [AF 18(600)641] Unclassifted

Presented at meeting of the Virginia Acad. of Science, Charlottesvtlle, May 5-8, 1954.

Published in Vtrginia Jour. Sctence, v. 5: 287, Sept. 1954.

A 180° wedge ts analyzed for incompressible flow in both bounded and unbounded streams by the Schwarz-Christoffel transformation. It is found that theoretically the boundartes (wing tunnel walls) do not appreciably affect the pressure distributton on the front face of the 180° wedge for tunnel-wedge ratios above 7. An expertmentally determtned pressure distribution on the front face of a 180° wedge in an unbounded stream at a free stream Mach number of 0.1 was corrected for compressibility by the Sound-Space Theory. The local Mach number on the front face of the 180° wedge was not constant in the transonic range as ts normally assumed for small angle wedges. For every subsonic free-stream Mach number in the range of 0.6 to 1.0 there ts a correspondtng supersonic free stream Mach number at which the local Mach number distribution is identical. Thts local Mach number distribution was converted to p_L / p^* values and checked against experimental work by Griffith at Princeton. (Contractor's abstract)

VPI. 02:005

Virginia Polytechnic Inst. Engineering Expertment Station, Balcksburg.

INVESTIGATION OF WEDGES AT SMALL ANGLE OF ATTACK IN TRANSONIC FLOW, by R. W. Truitt. Final rept. May 1955 [74]p. incl. diagrs. refs. (Rept. no. AE641-2) ([AF]OSR-TR-55-14) (AF 18-(600)641) AD 63145 Unclassified

The throat station concept of Tsien and Fejer, combined with the principle of stationarity of local Mach number, ts used to find the pressure dtstributton on the front face of a 2-dimensional wedge in the transonic speed range. The pressure dtstrtbution is deiermined by the von Kármán-Tsien method in the entire subcrttical range. The pressure distribution correspondtng to the throat station crttical Mach number establishes the locatton of the throat station to be near the wedge shoulder. The local Mach number distribution, corresponding to the throat station critical Mach number, remains constant with any further increase in the subsonic free-stream Mach number. Then, by the prtnctple of stationartty, the local Mach number distribution remains stationary in the supersonic range if the detached shock is normal. The method is applied to the theoretical incompressible pressure distribution of a simple 2-dtmenstonal wedge up to the throat station crttical Mach number. The constant p_L / p^* distribution, correspondtng to this Mach number, ts used tn the Maccoll-Codd method to determine the pressure drag coefftcient tn the transonic range. Under the assumption of small angle of attack, the present method is used to find the slope of the lift curve, the pressure drag owing to angle of attack and the front-wedge center-of-pressure in the transonic range. The results of the present method are presented tn transonic similarity form, and compared wtth existing theoretical and experimental results. In general, ths agreemsnt of the present method with other ftndings is good. (Contractor's abstract)

VPI. 02:006

Vtrginia Polytechnic Inst. [Engineering Experiment Station] Blacksburg.

DETERMINATION OF THE TRANSONIC PRESSURE DRAG ON WEDGES BY THE THROAT STATION METHOD (Abstract), by R. W. Truitt [1955] [2]p. [AF 18(600)641] Unclassified

Presented at meeting of the Div. of Fluid Dynamics of ths Amsr. Phys. Soc., Old Point Comfort and Langley Aeronautical Lab., Va., Nov. 22-24, 1954.

Published tn Phys. Rev., v. 98: 1139-1140, May 15, 1955.

The throat station concept of Tsten and Fejsr, combined wtth the prtnctple of stationartty of the local Mach number, ts used to find the pressure drag on the front face of a two-dimensional wedge in the transonic speed range. The pressure dtstribu'ion ts dstermined by the von Kármán-Tsien method in the entire subcrttical range; the pressure dtstrtbution at the crttical Mach number establishes the location of the throat station at the wedge shoulder. The local Mach number

distribution, corresponding to the critical Mach number, remains constant with any further increase in the subsonic free-stream Mach number. Then, by the principle of stationarity, the local Mach number distribution remains stationary in the supersonic range if the detached shock is normal. The method is applied to the theoretical incompressible pressure distribution of a simple two-dimensional wedge up to the critical Mach number. The constant p_l/p distribution, corresponding to the critical Mach number, is used in the Maccoll-Codd method to determine the pressure drag coefficient in the transonic range ($-0.69 \leq \xi_0 \leq 1.1$). The results of the present method are presented in transonic similarity form and compared with existing theoretical and experimental results. The agreement of the present method with other findings is good.

VPI. 02:007

Virginia Polytechnic Inst. [Engineering Experiment Station] Blacksburg.

TRANSONIC LIFT OVER THE FRONT SURFACE OF A TWO-DIMENSIONAL DIAMOND AIRFOIL, by R. W. Truitt. Dec. 6, 1954 [2]p. incl. illus. [AF 18(600)-641] AD 73149 Unclassified

Also published in Jour. Aeronaut. Sciences, v. 22: 342-343, May 1955.

In this study, the throat station concept of Tsien and Fejer (A Method for Predicting the Transonic Flow over Airfoils and Similar Bodies from Data Obtained at Small Mach Numbers, GALCIT, Dec. 1944) combined with the Maccoll-Codd Method (Theoretical Investigations of the Flow Around Various Bodies in the Sonic Region of Velocities, Ministry of Supply, Armament Research Dept., Sept. 1945) are used to obtain the transonic chordwise lift distribution over the front surface of a symmetric diamond wedge at a small angle of attack. The present method is applied to the theoretical incompressible pressure distribution for the front surface of a symmetrical diamond ($\theta = 10°$) at 1° angle of attack. Results obtained indicate that: (1) The subsonic peak in the lift-curve slope arises primarily from the front wedge pressures. The subsonic reduced Mach number at the peak ($\xi = -0.983$) corresponds to the attainment of the Mach number freeze. (2) The curve of the lift-curve slope vs Mach number has a negative slope as long as the Mach number freeze persists. Excellent agreement with the theoretical value is obtained by the present calculated negative slope at $\xi_0 = 0$. (3) The change with Mach number of the pressure-drag coefficient owing to lift for a given angle of attack has the same type of variation as the curve of lift-slope vs Mach number. (4) By using the present method, the second or supersonic peak in the lift-slope curve can be anticipated for increasing Mach numbers above $Mo_{U.L.}$, the upper limit of the freeze for the wedge semiangle θ. Both the subsonic and supersonic peaks, therefore, result primarily from the flow over the front wedge.

VPI. 02:008

Virginia Polytechnic Inst. [Engineering Experiment Station] Blacksburg.

INVESTIGATION OF WEDGES AT ANGLE OF ATTACK (Abstract), by R. W. Truitt and R. D. Jones. [1955] [1]p. [AF 18(600)641] Unclassified

Presented at meeting of the Virginia Acad. of Science, Charlottesville, May 11-14, 1955.

Published in Virginia Jour. Science, v. 6: 278, Sept. 1955.

A series of wind tunnel tests was run on three symmetric diamond wedges (5°, 7½°, and 10°) to determine the pressure distributions. The pressure distributions were integrated to find the lift and pressure drag coefficients for a series of angles of attack. The results are compared with theory and other high speed experimental results. (Contractor's abstract)

VPI. 02:009

Virginia [Polytechnic Inst.] Engineering Experiment Station, Blacksburg.

TRANSONIC LIFT OVER THE FRONT SURFACE OF A SYMMETRIC DIAMOND WEDGE, by R. W. Truitt. [1956] 14p. incl. illus. (AF 18(600)641) Unclassified

Published in Proc. Fourth Midwestern Conference on Fluid Mechanics, Purdue U., Lafayette, Ind. (Sept. 8-9, 1955), Lafayette, Purdue U. Engineering Experiment Station (Research Series no. 128), [1956] p. 245-258.

The throat station concept, combined with the Maccoll-Codd method, is used to obtain the transonic chordwise lift distribution over the front surface of a symmetric diamond wedge at small angle of attack. The results given in transonic similarity form include the chordwise lift distribution, the variation of the lift-curve slope and the center-of-pressure position, in the reduced free-stream Mach number range ($-1.5 \leq \xi_0 \leq 0.983$). The present results are compared with existing experimental and theoretical findings. On the basis of the present results, it is found that the subsonic peak in the lift-slope curve is due primarily to the flow over the front-wedge. (Contractor's abstract)

VIT. 01:001

Vitro Corp. of America, West Orange, N. J.

ENERGY TRANSFER IN THE HIGH INTENSITY ARC. PART I. A STEADY STATE TREATMENT OF ENDOTHERMIC PROCESSES NEAR THE ANODE SURFACE, by M. A. Marquis, L. Mead and others.

VIT. 01:002

PART I. A STEADY STATE TREATMENT OF ENDOTHERMIC PROCESSES NEAR THE ANODE SURFACE, by M. A. Marquis, L. Mead and others. Apr. 16, 1956 [19]p. incl diagrs. tables. (AFOSR-TN-56-178) (AF 18(603)3) AD 87051 Unclassified

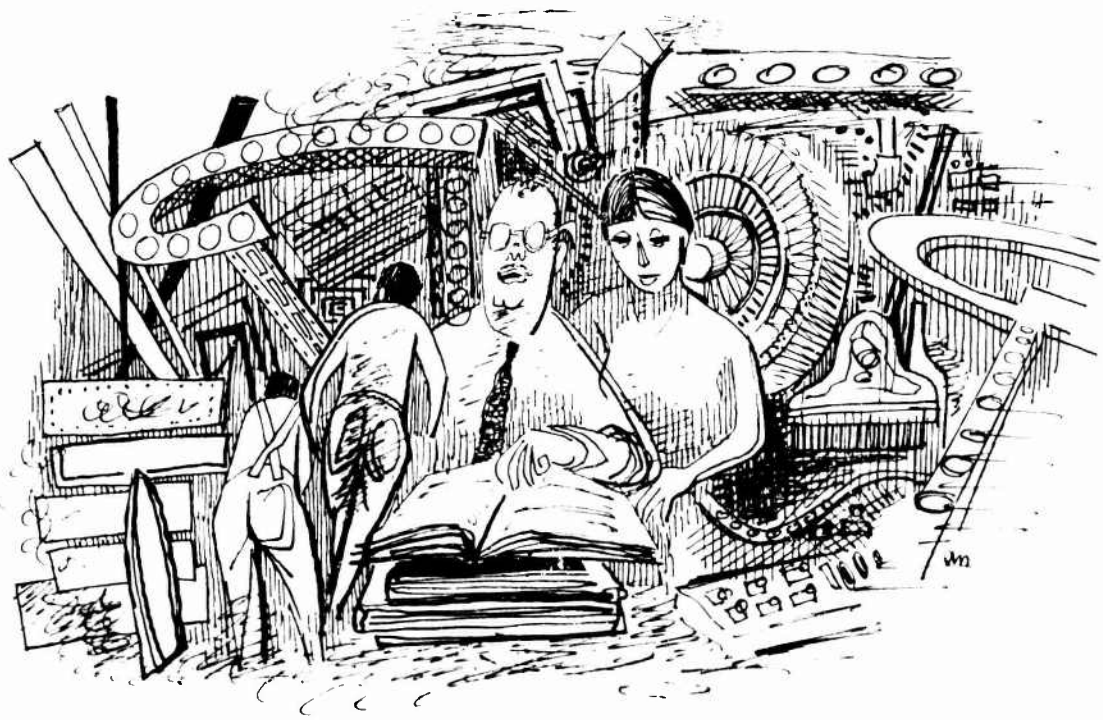
Conditions are defined for the steady-state or time-independent behavior of the high-intensity arc. The measured properties of the high-intensity arc agreed well with the requirements of steady-state behavior. The establishment and maintenance of an anode vapor phase independent of input power and time requires that a constant total amount of energy be expended per gram of anode material. The quantity of radiant energy originating from each gram of vaporized anode material should be independent of power input and time. Values of the 2 steady-state energy requirements are derived from the experimental data. A detailed energy distribution in terms of a single parameter is obtainable for a specified set of endothermic processes and a model anode. A series of values of the parameter fixes corresponding values of the percentage ionization of C atoms, the average excitation energy per neutral specie, and the average over-all temperature of the gas phase. Based on the calculated quantities, an energy distribution characterized by 15% ionization of C atoms appeared to be favored. (ASTIA abstract)

VIT. 01:003

Vitro Corp. of America, West Orange, N. J.

ENERGY TRANSFER IN THE HIGH INTENSITY ARC. PART II. QUALITATIVE THEORY OF THE ANODE SHEATH, by L. Mead, M. A. Marquis and others. [1956] [20]p. incl. diagrs. refs. (AFOSR-TN-56-179) (AF 19(603)3) AD 87052 Unclassified

A theory is described for the energy-transfer mechanism in a high-intensity arc. The phenomena of interest occur in a very thin region adjacent to the anode terminus of the discharge called the anode fall space (sheath). Modifications are proposed for Finkelnburg's theory (Jour. Appl. Phys., v. 20, no. 5, 1949) of the anode mechanism which involves a transfer of energy to the anode itself and to the vapor of the anode in the region of the fall space. A preliminary calculation is summarized of the potential distribution based on the modified theory. The modifications appeared adequate in explaining the superheating effect, the rise in anode potential, and the positive resistance characteristics in the high-intensity arc. A possible approach in overcoming the high-temperature barrier is the use of high-speed electronic measuring techniques. (ASTIA abstract)



WAL. 01:001

Walz, A. Emmendingen (Germany).

GENERAL APPROXIMATION THEORY FOR COMPRESSIBLE LAMINAR AND TURBULENT BOUNDARY-LAYERS WITH RESPECTATION OF FLOW-EFFECTS NORMAL TO THE WALL ACROSS THE BOUNDARY-LAYER (INVESTIGATIONS ON AN IMPROVEMENT OF KNOWN APPROXIMATION-METHODS OF BOUNDARY-LAYER CALCULATION), by A. Walz. Final rept. Aug. 1, 1954-Nov. 30, 1955 [122]p. incl. diagrs. tables, refs. [AFOSR-TR-56-13] (AF 61(514)738-C)
AD 86312 Unclassified

An approximate solution of the general equations of Navier and Stokes is given in which the partial differential equations are transformed into an infinite system of ordinary differential equations by partial integrations in the y direction. By limiting the investigation to 2 dimensions, only 4 of the infinite number of equations are physically meaningful: the momentum- and energy-law equations in the x and y directions, averaged over the boundary-layer thickness. The analysis is further restricted to a study of 3 boundary-layer parameters: the boundary-layer thickness, the form parameter of the velocity-profile, and the pressure difference between the edge of the boundary layer and the wall. Practical boundary-layer calculations are conducted by an iterative procedure, and when the correction terms are relatively small, the first approximation is given by the result of usual approximation theories based on the Prandtl boundary-layer theory. The example of a supersonic flow with following shock wave and measured pressure difference between the edge of the boundary layer and the wall shows satisfactory agreement between the theoretical result for this pressure difference and experiment. The theory permits the treatment of the problem of reciprocal effects between the boundary layer and the pressure distribution of a flow-body section in a manner such that the pressure distribution determined from the first approximation of the pressure difference is the base of a repeated boundary-layer calculation.

WAR. 01:001

Warner and Swasey Research Corp., New York.

INFRARED EMISSION AND ABSORPTION OF CARBON DIOXIDE AT HIGH TEMPERATURES, by R. H. Tourin. May 1954, iv. incl. illus. diagrs. tables, refs. (Technical rept. no. 258) [AFOSR-TR-54-22] (AF 18(600)-596) AD 37571 Unclassified

The infrared emission and absorption of heated carbon dioxide, enclosed in a special gas cell, have been measured at temperatures from 25° to 1000°C and at pressures up to 1000 mm Hg. Spectral absorptivities and absorption coefficients were calculated from spectrum tracings of the 4.3μ fundamental band and the 2.7μ combination bands, at concentrations up to 17 cm-atm. Saturation with respect to partial pressure, temperature, and total pressure was observed over most of the spectrum. A quantitative picture was obtained of the relation between temperature and the molecular spectral energy distribution. (Contractor's abstract)

WSC. 01:001

Washington State Coll. [Dept. of Physics] Pullman.

WORK FUNCTION OF CADMIUM, by P. A. Anderson. [1955] [2]p. incl. diagr. [AFOSR-TN-54-266] [AF 18(600)699] Unclassified

Published in Phys. Rev., v. 98: 1739-1740, June 15, 1955.

The contact difference of potential Cd-Ba is measured by the electron beam and Kelvin methods. These measurements agree within the limits of reproducibility of either method alone and yield a work function value of 4.08 ± 0.02 ev for the work function of cadmium films deposited on tantalum. The barium surfaces, formed by redistillation following fractional distillation, show their characteristic constancy and reproducibility to ± 0.01 ev. Cadmium retains some gas after exhaustive multiple distillation. Measurements taken immediately after deposition of a Cd film and during its aging show: (1) that freshly deposited Cd films are generally contaminated with gas which distills with the metal; (2) that the adsorbed gas is removed progressively by getter clean-up with an attendant rise in work function totaling 0.10 ev in extreme cases; and (3) that the work function thus established is constant and reproducible to 0.03 ev or better. Comparison of these measurements with our earlier work on zinc leads to the conclusion that a cadmium surface in equilibrium with the residual gas of a well-gettered tube contains so little adsorbed gas that its final work function can probably be accepted as characteristic of the clean metal. (Contractor's abstract)

WSC. 01:002

Washington State Coll. Dept. of Physics, Pullman.

THE ELECTRONIC WORK FUNCTIONS OF PURE AND COMPOSITE METAL SURFACES, by P. A. Anderson. Final rept. July 1953, 5p. ([AF]OSR-TR-55-79) (Sponsored jointly by Office of Naval Research under N6ori-167, Task 1 and [Air Force Office of Scientific Research under AF 18(600)699])
Unclassified

In this investigation of the electronic work functions of pure and composite metal surfaces, the following problems were studied and briefly discussed; (1) the work function of lithium; (2) the work function of copper; (3) the work function of germanium; (4) a direct comparison of the Kelvin and electron beam methods of contact potential measurement; (5) the work function of cadmium; (6) the work functions of polycrystalline

gold and of Au (100); (7) the effect of O_2 on the work function of barium; (8) determination of potential distributions and electron trajectories near patchy surfaces; and (9) the average work function of polycrystalline tungsten.

WSC. 01:003

Washington State Coll. [Dept. of Physics] Pullman.

WORK FUNCTION OF LEAD, by P. A. Anderson and A. L. Hunt. [1956] [2]p. incl. diagrs. [AF 18-(600)699] Unclassified

Published in Phys. Rev., v. 102: 367-368, Apr. 15, 1956.

The work functions of twelve lead surfaces have been determined by measurement of their contact differences of potential with respect to barium reference surfaces of known work function. The lead surfaces were prepared by subjecting Hilger's spectroscopic lead to intensive outgassing followed by fractional distillation, redistillation, and deposition on glass targets. The barium surfaces were prepared by a similar standardized technique which yields surfaces constant and reproducible to 0.01 ev. Measurement was by the electron beam method, and the time lapse between deposition and measurement of a fresh surface was five seconds. The contact difference of potential for Ba - Pb is found to be 1.48 ± 0.01 v. The work function of lead, referred to a Ba work function of 2.52 ev, is then 4.00 ± 0.02 ev. No drift of work function exceeding 0.01 ev was found on aging. Since the minimal time required for deposition of a monolayer of gas is large with respect to the metal deposition-measurement interval, it is concluded (1) that the film of gaseous contaminants adsorbed by a lead surface during equilibration is insufficiently dense to affect the work function, and (2) that the observed work function is probably characteristic of clean lead. (Contractor's abstract)

WAS. 01:001

Washington U. Dept. of Mathematics, St. Louis, Mo.

AUTOMORPHISMS GENERATED BY A CLASS OF SUBNORMAL SUBGROUPS, by F. Haimo. Mar. 1953, 10p. (AF 18(600)419) Unclassified

Also published in Duke Math. Jour., v. 21: 349-354, June 1954.

The author shows that the well-known result "that every normal subgroup of a group gives rise to an Abelian group of automorphisms of the group" is implied by the following: that to each of a large class of subnormal subgroups of a group G is associated an ascending chain of groups of automorphisms, the first of which is nilpotent, the rest solvable, and the number of groups in this chain depends upon how much of the ascending central series of G lies in the subnormal subgroup.

WAS. 01:002

Washington U. [Dept. of Mathematics] St. Louis, Mo.

INVESTIGATION OF ANALYTIC CONTINUED FRACTIONS AND GROUP THEORY, by F. Haimo, W. J. Thron, and R. A. Moore. Final rept. June 30, 1953, 6p. (AF 18(600)419) Unclassified

The investigators here summarize their accomplishments under the contract. W. J. Thron prepared a joint paper (with V. F. Cowling) on Zero Free Regions of Polynomials. Thron's investigations on the location of singular points of functions represented by continued fractions yielded partial results. R. A. Moore studied the oscillation and boundedness of solutions of a certain self-adjoint differential equation. Some results of Leighton and Hille were extended, and a number of equivalent systems of first-order equations were studied. F. Haimo obtained results on semi-direct group products, on group holomorphs, on fixed points of central automorphisms, on automorphisms generated by a class of subnormal subgroups, and on non-abelian complete groups.

WAS. 01:003

Washington U. [Dept. of Mathematics] St. Louis, Mo.

SOME NON-ABELIAN EXTENSIONS OF COMPLETELY DIVISIBLE GROUPS, by F. Haimo. Technical note. [1954] 6p. (AF 18(600)419) AD 46165 Unclassified

Also published in Proc. Amer. Math. Soc., v. 5: 25-28, Feb. 1954.

It has been shown by Baer that those Abelian groups G which are direct summands of every including Abelian group are precisely those Abelian groups G for which nG = G for every positive integer n. The latter class of groups consists of the so-called complete or infinitely divisible Abelian groups. Examination of the proof of the equivalence of these two classes discloses essential difficulties in the way of extension to the non-Abelian case. Once "complete" is defined suitably for these latter groups, the following can be proved: Let H be a complete group interpolated into the ascending central series of a group G. Let K be a subgroup, maximal with respect to the property of meeting H or that portion of the ascending series of G below H. Then if N(K) is the normalizer of K in G, N(K) = H + K. This result seems to be the natural extension of half of the Baer theorem to the non-Abelian case.

WAS. 01:004

Washington U. [Dept. of Mathematics] [St. Louis, Mo.].

ZERO-FREE REGIONS OF POLYNOMIALS, by V. F. Cowling and W. J. Thron. [1954] [6]p. (AF 18-(600)419; continued by AF 18(600)568) Unclassified

WAS. 02:001 - WAS. 02:003

Published in Amer. Math. Monthly, v. 61: 682-687, Dec. 1954.

The authors consider the polynomial

$$P(z) = a_0 + a_1 z^{\lambda 1} + \ldots + a_n z^{\lambda n},$$

where the $a_q \neq 0$ and $\lambda_1 < \lambda_2 < \ldots < \lambda_n$. The principal theorem is that all zeros of P (z) lie in the closed region

$$|z| \leq \max \left[\frac{1 + r_{k-1}}{r_k} \left| \frac{a_k - 1}{a_k} \right| \right]^{1/\alpha_k}$$

where $r_0 = 0$, $r_n = 1$, and the remaining r_m

$(m = 1, \ldots, n-1)$ are arbitrary positive numbers (their statement of this theorem contains an unfortunate typographical error; other typographical errors occur in the text). This theorem is a generalization of the known result obtained by setting the $r_m = 1$ (Math. Rev. abstract)

WAS. 02:001

Washington U. Dept. of Mathematics, St. Louis, Mo.

UNIVALENT FUNCTIONS AND LINEAR DIFFERENTIAL EQUATIONS, by Z. Nehari. Technical rept. June 1953, 18p. (AF 18(600)568) AD 28473 Unclassified

Also published in Lectures on Functions of a Complex Variable, by W. Kaplon, ed. Ann Arbor, Michigan U. Press, 1955, p. 49-60.

Consideration is given to a connection which exists between univalent functions and linear differential equations of the second order. The theory of univalent functions in a domain D is said to be equivalent to the theory of the equation

(1) $u''(z) + p(z)u(z) = 0$, where $p(z) = 1/2 \{f(z), z\}$, $f(z) = \frac{u(z)}{v(z)}$, and u(z) and v(z) are 2 analytic functions defined in D, whose coefficient p(z) is regular in D and whose solutions do not vanish in D more than once. This equivalence provides a new approach to the investigation of univalent functions since the methods available for the study of the zeros of the solutions of (1) are very different from those generally used in the theory of univalent functions. The results are said to be independent of any particular normalization of the schlicht function, since the Schwarzian derivative is invariant with respect to a general linear transformation. Consideration is given to the proposition: if $\sigma(z)$ is regular and not zero on a connected set T in the domain of regularity of u(z), then the function v(z) defined by $u(z) = \sigma(z) v(z)$ has on T the same zeros as u(z), and it satisfies the differential equation

$$(\sigma^2 v')' + (p\sigma^2 + \sigma\sigma'')v = 0.$$

Theorems attendant to the analysis are presented. (ASTIA abstract)

WAS. 02:002

Washington U. Dept. of Mathematics, St. Louis, Mo.

POWER-TYPE ENDOMORPHISMS OF SOME CLASS 2 GROUPS, by F. Haimo. Technical note. July 1953, 15p. (AF 18(600)568) AD 46168 Unclassified

Also published in Pacific Jour. Math., v. 5: 201-213, June 1955.

Abelian groups possess a class of endomorphisms of the form $x \rightarrow x^n$ for each integer n. In general, however, non-Abelian groups do not possess such power endomorphisms. In an earlier note, it was possible to show for a nilpotent group G with a uniform bound on the size of the classes of conjugates that there exists an integer $n \geq 2$ for which the mapping $x \rightarrow x^n$ is an endomorphism of G into its center. Endomorphisms of some groups of class 2 which induce power endomorphisms on the factor-commutator groups are considered. In particular, it will be shown, under suitable uniform torsion conditions for the group of inner automorphisms, that such power-type endomorphisms form a ring-like structure. Let G be a group of class 2 for which Q the commutator subgroup, has an exponent. Then the relation $(xy, u) = (x, u)(y, u)$ shows that $x \rightarrow (x, u)$ is an endomorphism of G into Q for fixed $u \in G$. Let n be any integer such that $n(n-1)/$ is a multiple of the exponent of Q. Then the mapping $x \rightarrow x^n(x, u)$ is a trivial example of a power-type endomorphism. If G/Q has an exponent m, it will be shown that the number of distinct endomorphisms of the form $x \rightarrow x^j$, where x^j is in the center Z of G, divides m. In particular, if G/Q is an elementary p-group (an Abelian group with a prime p as its exponent), then a non-Abelian group G of class 2 has 1 or p distinct central power endomorphisms. (Contractor's abstract)

WAS. 02:003

Washington U. Dept. of Mathematics, St. Louis, Mo.

NORMAL AUTOMORPHISMS AND THEIR FIXED POINTS, by F. Haimo. Technical note. Aug. 1953, 30p. (AF 18(600)568) AD 46164 Unclassified

Also published in Trans. Amer. Math. Soc., v. 78: 150-167, Jan. 1955.

The elements of the centralizer T of the group of inner automorphisms J of a group G (in the group A of automorphisms of G) are called the normal automorphisms of G. The center Z of G is the set of all elements of G which are fixed by each mapping from J. Likewise, let B be the set of fixed points held in common by the mappings from T. G/B is Abelian, and the elements of T which induce either the identity or

the involution on G/B form a subgroup W of T. An investigation of the ascendtng centrat sertes of W ts to be made. Just as the ascending centrat sertes $\{ Z_t \}$ is formed over $Z = Z_t$, so an ascending sertes is formed over B. Elements of G lying tn members of thts B-series turn out to be fixed points for high powers of normal automorphisms. For automorphisms which induce the identity on G/Z_n, it is shown that the common fixed points lie tn the centraltzer of Z_n tn G.

WAS. 02:004

Washington U. Dept. of Mathematics, St. Louis, Mo.

ON THE ZEROS OF SOLUTIONS OF SECOND-ORDER LINEAR DIFFERENTIAL EQUATIONS, by Z. Nehari. Technical note. Aug. 1953, 14p. (AF 18(600)568) AD 46033 Unclassified

Also published in Amer. Jour. Math., v. 76: 689-697, July 1954.

An analysis is made of the relation between the analytic function p(z) defined in a domain D of the complex plane and the location of the zeros of the solutions of the dtfferential equation $w''(z) + p(z)w(z) = 0$. Proofs are presented for the following theorems: (1) let p(z) be regular and let $|p(x + iy)| < x\epsilon(x)$ in the half strip $0 \leq x < \infty$, $-1 < y < 1$ $(z = x + ty)$, where $\epsilon(x) \to 0$ for $x \to \infty$; if, for sufficiently small positive η, $\int_0^\infty |xp[x \pm t(1-\eta)]\, dx < \infty$, then $w''(z) + p(z)w(z) = 0$ ts nonosctllatory tn any half strip $0 \leq x < \infty$, $-1 + \delta \leq y < 1 - \delta$, $(0 < \delta < 1)$; (2) if p(z) is regular tn the half strip $0 = x < \infty$, $-1 < y < 1$, and if $a'_1, a'_2, \ldots$ $(a_1 < a_2 < \ldots)$ are the abscissas of the zeros of any solution of $w''(z) + p(z)w(z) = 0$ in this half strtp, then the assumption $|p(x + iy)| < \frac{C}{x^\delta}$, $1 < \sigma < 2$, $0 \leq x < \infty$, $-1 < y < 1$ is incompatible with $a'_n = o(n^{2-\sigma})$; (3) tf p(z) ts regular tn $|z| < 1$ and $\int_0^{2\pi} |p(e^{i\theta})|\, d\theta < \infty$, then $w''(z) + p(z)w(z) = 0$ ts non-osctllatory in $|z| < 1$; and (4) if p(z) is regular in a domatn D bounded by an analyttc Jordan curve C, and $\int_C |p(z)dz| < \infty$, then $w''(z) + p(z)w(z) = 0$ ts nonos-cillatory tn D. (ASTIA abstract)

WAS. 02:005

Washington U. Dept. of Mathematics, St. Louis, Mo.

ENDOMORPHISMS FOR WHICH EVERY SUBGROUP IS ADMISSIBLE, by F. Haimo. Technical note. Oct. 1953, 5p. (AF 18(600)568) AD 46167 Unclassifted

A discussion ts gtven of groups G which are apertodtc and centerless, and a proof is presented that the image spaces of a finite set of normal members of R(G) cover G if, and only if, the correspondtng fixed point spaces form a cover; R(G) is the set of all admitting endomorphisms of G. (ASTIA abstract)

WAS. 02:006

Washington U. Dept. of Mathematics, St. Louis, Mo.

THE DECOMPOSITION OF FOURIER SERIES, by I. I. Hirschman, Jr. Technical note. Dec. 1953, 31p. incl. refs. (AF 18(600)568; AD 59692 Unclassified

If $f(\theta) \epsilon L^{\alpha,p}$ if $\| f \|_{\alpha,p}$ is finite where $\| f(\theta) \|_{\alpha,p} = \left(\int_\pi^\pi |f(\theta)|^p |\theta|^{\alpha p} d\theta\right)^{1/p}$, $(1 \leq p < \infty)$, $\| f(\theta) \|_{\alpha,\infty} = \text{essential sup}_{|\theta| \leq \pi} |f(\theta)\, \| \theta |^\alpha$ $(p = \infty)$, and we set $L^p = L^{0,p}$, $\| f \|_p = \| f \|_{0,p}$. Note that if $-\frac{1}{p} < \alpha < 1 - \frac{1}{p}$ then $L^\infty \subset L^{\alpha,p} \subset L^1$.

Let $f(\theta) \epsilon L^1$ and let $f(\theta) \sim \sum_{\nu=-\infty}^{\infty} a_\nu e^{i\nu\theta}$ where $a_\nu = (2\pi)^{-1} \int_{-\pi}^{\pi} f(\theta) e^{-i\nu\theta}\, d\theta$. Then define

$$\Delta_n(\theta) = \begin{cases} \sum_{2^n-1}^{2^n-1} a_\nu e^{i\nu\theta} & n = 1, 2, \ldots \\ a_0 & n = 0 \\ \sum_{-2^{-n}+1}^{-2^{-n}+1} a_\nu e^{i\nu\theta} & n = -1, -2, \ldots . \end{cases}$$

The $\Delta_n(\theta)$'s are blocks from the Fourier series of $f(\theta)$. It has been shown by Littlewood and Paley that if $1 < p < \infty$ then

$$A' \| f \|_p^p \leq \int_{-\pi}^{\pi} \left[\sum_{n=-\infty}^{\infty} |\Delta_n(\theta)|^2 \right]^{p/2} d\theta \leq A'' \| f \|_p^p$$

where A' and A'' are positive constants depending only on p. The work of Babenko suggests that if $1 < p < \infty$, $-\frac{1}{p} < \alpha < 1 - \frac{1}{p}$ then

$$A' \| f \|_{\alpha,p} \leq \int_{-\pi}^{\pi} \left[\sum_{n=-\infty}^{\infty} |\Delta_n(\theta)|^2 \right]^{p/2} |\theta|^{\alpha p} d\theta \leq$$

$A'' \| f \|_{\alpha,p}$ where A' and A'' now depend on p and α.

The present investigation is devoted to proving this inequality, which must occupy a central role in any theory of Fourier series of functions $f \epsilon L^{\alpha,p}$. The proof of this last equation makes use of the complex variable methods of Littlewood and Paley and Zygmund. Application of this equation is made to the theory of fractional integration in $L^{\alpha,p}$. (Extracted from rept.)

WAS. 02:007 - WAS. 02:011

WAS. 02:007

Washington U. Dep't. of Mathematics, St. Louts, Mo.

A MAXIMUM PROBLEM IN HARMONIC ANALYSIS II, by I. I. Hirschman, Jr. Technical note. Dec. 1953, 9p. (AF 18(600)568) AD 46169 Unclassifted

A proof ts presented of the followtng theorem: Let G be any locally compact Abeltan group, and let p be a number $1 < p < 2$. Then every function f tn $L_p(G)$ which ts maximal ts a translate of a subcharacter. The method of proof depends upon an examtnation of the case of equaltty in the Rtesz-Thortn convexity theorem.

WAS. 02:008

Washington U., St. Louis, Mo.

SOME CRITERIA OF UNIVALENCE, by Z. Nehart. Technical note. Dec. 1953, 7p. (AF 18(600)568) AD 46037 Unclasstfted

Also published in Proc. Amer. Math. Soc., v. 5: 700-704, Oct. 1954.

The main objective of thts study ts to estabtish the followtng more general crtterton of univalence: The function f(z) wtll be univalent tn $|z|<1$ tf $|\{f(z), z\}| = 2p(|z|)$, where p(x) ts a function wtth the followtng properties: (1) p(x) ts posttive and continuous for $-1 < x < 1$; (2) $p(-x) = p(x)$; (3) $(1-x^2)^2 p(x)$ ts non-tncreastng tf x vartes from 0 to 1; and (4) the differential equatton $y''(x) + p(x)y(x) = 0$ has a solution which does not vanish for $-1 < x < 1$. The constant 2 tn $|\{f(z), z\}| \leq 2p(|z|)$ cannot be replaced by a larger number. The notation $\{w, z\}$ refers to the Schwarztan dertvative of $w = f(z)$.

WAS. 02:009

Washington U. Dept. of Mathematics, St. Louts, Mo.

ON THE NUMBER OF SINGULAR POINTS LOCATED ON THE UNIT CIRCLE, OF CERTAIN FUNCTIONS REPRESENTED BY C-FRACTIONS, by V. Singh and W. J. Thron. Mar. 1954, 11p. ([AF]OSR-TN-54-76) (AF 18(600)568) Unclasstfted

Published in Pactftc Jour. Math., v. 6: 135-143, 1956.

Suppose the C-fractton $1 + K_1^{\infty}(d_n z^{a_n}/1)$ (d_n a complex number dtstinct from 0, a_n a posttive tnteger) satisfies the following conditions: (1) $\lim_{n\to\infty}(4|d_n|)^{1/a_n} = 1$, (2) there is an tncreastng sequence $\{n_k\}$ of posttive integers such that $\lim_{k\to\infty} a_{nk} = \infty$ and $\lim_{k\to\infty}[n_k/k] = 2$ and (3) $\liminf_{n\to\infty}[p_n/(h_n - p_n)] = t < 1$, where $h_n = \sum_1^{n+1} a_i$ and p_n is the maximum of the degrees of the nth numerator and denomtnator of $1 + K_1^{\infty}(|d_n| z^{a_n}/1)$. It ts shown that the C-fraction represents a function having a stngular point not a pole on each arc of the unit circle of length greater than 2θ, where $0 \leq \theta < \pi$, $\cos\theta = 1 - 2\{t + [t(1+2)]^{\frac{1}{2}}\}/(1+2t)$, tf $0 \leq t \leq \frac{1}{2}$, and $\cos\theta = -t$, if $\frac{1}{2} < t < 1$. (Math Rev. abstract)

WAS. 02:010

Washington U. Dept. of Mathematics, St. Louis, Mo.

ON THE COEFFICIENTS OF R-UNIVALENT FUNCTIONS, by Z. Nehari. May 1954 [5]p. [AFOSR-TN-54-128] (AF 18(600)568) Unclasstfted

Published in Duke Math. Jour., v. 22: 223-228, June 1955.

It ts proven that tn the class of analytical functions f(z) designated by S_R and which maps $|z| > 1$ tn a domatn embedded tn a closed Riemann surface R and which function ts expanded

$$f(z) = z + a_1 z^{-1} + a_2 z^{-2} + \ldots$$

near $z = \infty$, the regton of vartabtlity of the coefftctent a_1 tn thts class ts contained tn a ctrcle of which the radtus equals 1.

WAS. 02:011

Washington U. Dept. of Mathematics, St. Louis, Mo.

VIBRATION AND STABILITY PROBLEMS OF BEAMS TREATED BY MATRICES, by K. F. Marguerre. Technical note. July 1954, 27p. refs. (Rept. no. 11) ([AF]OSR-TN-54-331) (AF 18(600)568) AD 54873 Unclasstfied

Also published in Jour. Math. and Phys., v. 35: 28-43, Apr. 1956.

A short survey ts given of the matrtx method of solution for the dtfferential equation of a vtbrating beam and for the related problem of the column. The equation for the etgenvalue appears as the condtion that a second-order subdetermtnant of the governing matrtx must vanish, but systematic dtfftculties artse tn the cases of tntermedtate rtgtd supports or tdeal pin connections. Even tf the supports or the htnges are elastic, whtch can be taken tnto account by a transttion matrtx, the coefftctents of the equation for the etgenvalues may appear as dtfferences of large numbers. These dtfftculties are overcome by the notion of a kind of assoctated matrtx called the Δ-matrtx, and simple rules of calculation are given for such matrtces. A ltstlng of all Δ-matrices eventually of tnterest for etgenvalue calculations ts tncluded. (ASTIA abstract)

WAS. 02:012

Washington U. Dept. of Mathematics, St. Louis, Mo.

AN INTEGRAL EQUATION ASSOCIATED WITH A FUNCTION-THEORETIC EXTREMAL PROBLEM, by Z. Nehari. June 1954 [30]p. [Repl. no. 10] [AFOSR-TN-54-332] (AF 18(600)568)
Unclassified

Presented at the International Congress of Mathematicians, Amsterdam (Holland), Sept. 1954.

Published in Jour. Analyse Math. (Jerusalem), v. 4: 29-48, 1954/55.

Let $L^2(D)$ be the family of functions, single-valued and regular in a finite domain D and square-integrable over the boundary C which consists of a finite number of rectifiable Jordan curves. The starting problem is to minimize $\int_C |f(z)|^2 ds$, $ds = |dz|$, for $f(z) \in L^2(D)$ under the condition that $\int_{C_1} |f(z)|^2 ds = 1$, where C_1 is an assigned subset of D consisting of a finite number of rectifiable Jordan arcs or curves. It is shown that $\int_C |g(z)|^2 ds \geq \lambda_1$ for any admissible g(z), where $\lambda_1 (> 0)$ is the lowest eigenvalue of the integral equation

$$f(\zeta) = \lambda \int_{C_1} K(z, \zeta) f(z) ds,$$

$K(z, \zeta)$ being the Szegö kernel function of $L^2(D)$; the equality can appear only if g(z) is a solution of the integral equation associated with $\lambda = \lambda_1$. On the other hand, the author proves the following result: Let ζ_ν ($\nu = 1, \ldots, n$) be any points in a subdomain D_1 bounded by C_1 of D; then

$$\lambda_1 \sum_{\nu,\mu=1}^{n} a_\nu \bar{a}_\mu K(\zeta_\mu, \zeta_\nu) \leq \sum_{\nu,\mu=1}^{n} a_\nu \bar{a}_\mu K_1(\zeta_\mu, \zeta_\nu)$$

($n = 1, 2, \ldots$), where $K_1(z, \zeta)$ is the kernel associated with D_1 and the a's are indeterminate variables; every inequality is sharp. Analogous problems for the Bergman kernel function are discussed. (Math. Rev. abstract)

WAS. 02:013

Washington U. Dept. of Mathematics, St. Louis, Mo.

A MAXIMUM PROBLEM IN HARMONIC ANALYSIS, by E. Hewitt and I. [I.] Hirschman, Jr. [1954] [13] p. refs. [AF 18(600)568] Unclassified

Published in Amer. Jour. Math., v. 76: 839-852, Oct. 1954.

Let G be a locally compact Abelian group, G^* its character group. Denote by f^* the Fourier transform of the (suitably restricted) function f on G. This paper deals with the cases of equality in the familiar majorisation $\|f^*\|_q \leq \|f\|_p$, where $1 < p < 2$, $1/p + 1/q = 1$, $f \in L_p(G)$ and the norms are the usual ones on the appropriate Lebesgue spaces constructed relative to Haar measures. An $f \in L_p(G)$ for which equality holds is termed maximal in $L_p(G)$. The case in which G is the compact circle group was discussed by Hardy and Littlewood (Math. Ann., v. 97: 159-209, 1926), who showed that, for any p satisfying $1 < p < 2$, the maximal functions in $L_p(G)$ are precisely the scalar multiples of the characters of G. The authors extend this result to arbitrary G, for which it is necessary to introduce the so-called sub-characters: these are the scalar multiples of functions on G, of the form $x \to (x, y)\varphi_A(x)$, where (x, y) is the value at x of the character $y \in G^*$, A is a compact and open subgroup of G, and φ_A is the characteristic function of A. Main theorem: For any p, $1 < p < 2$, the maximal functions in $L_p(G)$ are precisely the scalar multiples of sub-characters and the translates thereof. A preliminary step in the proof is the determination of cases of equality in Hölder's inequality, whilst the main stage invokes complex function theory and the maximum modulus principle in a manner reminiscent of recent proofs of the Riesz Convexity Theorem. Various examples are given: G compact; $G = R^n$; G the additive group of p-adic numbers; and G the direct product of denumerably many copies of the multiplicative group $\{-1, +1\}$. (Math. Rev. abstract)

WAS. 02:014

Washington U. Dept. of Mathematics, St. Louis, Mo.

[THE BASIC EQUATIONS OF ELASTICITY AND METHODS OF ATTACK] Ansätze zur Lösung der Elastischen Grundgleichungen, by K. F. Marguerre. Nov. 1954, 33p. incl. refs. (AF 18(600)568)
Unclassified

In recent days many special problems of 3-dimensional theory of elasticity have been solved (chiefly in the U. S. A.). The methods of attack, apparently varying greatly from author to author, can be shown to be closely related to one another; basically all the different solutions turn out to be built up by a set of potentials. In this study, the procedures of about 50 papers, together with an interesting new one, are discussed in such a way that their interrelations become clear. Elasticity-problems of 2 dimensions (plane and axial symmetry), and 3 dimensions as well as problems of the torsion type, are considered. An appendix gives the necessary rules of vector and tensor calculus. (Contractor's abstract)

WAS. 02:015

Washington U. Dept. of Mathematics, St. Louis, Mo.

THE BEHAVIOR OF SOLUTIONS OF A LINEAR

WAS. 02:016 - WAS. 02:019

DIFFERENTIAL EQUATION OF SECOND-ORDER, by R. A. Moore. Technical note. Dec. 1954, 30p. incl. refs. (AF 18(600)568) AD 59691 Unclassified

Also published in Pacific Jour. Math., v. 5: 125-145, Mar. 1955.

A study is made of the oscillation and boundedness of solutions of the self-adjoint differential equation $(r(x)\,y')' + p(x)y = 0$ on the infinite half-axis I, $a \leq x < \infty$. It is assumed throughout that r(x) and p(x) are real continuous functions, and that r(x) is positive on I. A nonnull solution of the above equation is said to be oscillatory if it has an infinity of zeros on I. Brief reviews of a number of results and techniques which underlie the results of this mathematical investigation are presented.

WAS. 02:016

Washington U. Dept. of Mathematics, St. Louis, Mo.

SEMI-DIRECT PRODUCTS WITH AMPLE HOMOMORPHISMS, by F. Haimo. Jan. 1955 [25]p. [AFOSR-TN-55-71] [AF 18(600)568] Unclassified

Published in Trans. Amer. Math. Soc., v. 84: 401-425, Mar. 1957.

If G = HK, where H is a normal subgroup of the group G and where K is a subgroup of G with the trivial intersection with H, then G is said to be a semidirect product of H and K or a splitting extension of H by K. Special types of semidirect products are the hotomorphs and the dthedrat groups. In this mathematical study some properties of semidirect products are found, and their relationship with the results reported in the literature are given.

WAS. 02:017

Washington U. Dept. of Mathematics, St. Louis, Mo.

A FAMILY OF BEST TWIN CONVERGENCE REGIONS FOR CONTINUED FRACTIONS, by V. Singh and W. J. Thron. June 1954, 11p. (Rept. no. 12) [AFOSR-TN-55-72] (AF 18(600)568) Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 277-282, Apr. 1956.

Combining methods of the theory of linear fractional transformations and their iteration with an application of Strettjes-Vitali theorem, it has been proved that the continued fraction $1 + K(c_n^2/1)$ converges if for all $n \geq 1$, $|c_{2n-1}| \leq p$ and $|c_{2n} + 1| \leq p$, where $0 < p < 1$. This result gives a set of best twin convergence regions and is an improvement of an earlier theorem by one of the authors (Duke Math. Jour. v. 10: 677-685, 1943) (Contractor's abstract)

WAS. 02:018

Washington U. Dept. of Mathematics, St. Louis, Mo.

WEIGHTED QUADRATIC NORMS AND LEGENDRE POLYNOMIALS, by I. I. Hirschman, Jr. Nov. 1954 [32]p. (Rept. no. 13) [AFOSR-TN-55-73] (AF 18-(600)568) Unclassified

Also published in Canad. Jour. Math., v. 7: 462-482, 1955.

Let $w_n(x) = (n + \frac{1}{2})^{\frac{1}{2}} P_n(x)$ be the normalized Legendre polynomials. If $f(x) \in L^1(-1, 1)$ and if $a_n = \int_{-1}^{1} w_n(x) f(x)\,dx$, then we write $f(x) \sim \sum_0^\infty a_n w_n(x)$. Let T be the linear transformation which carries f(x) into Tf(x) defined (formally by $Tf(x) \sim \sum_0^\infty a_n t_n w_n(x)$, and let $N_{\alpha,\beta}[f] = [\int_{-1}^{1} (1 + x)^\alpha (1 - x)^\beta [f(x)]^2 dx]^{\frac{1}{2}}$, where $-1 < \alpha, \beta < 1$. $N_{\alpha,\beta}$ will also be used to denote the space of functions f(x) for which $N_{\alpha,\beta}[f]$ is finite. The present paper gives a rather general sufficient condition for T to be a bounded linear transformation of $N_{\alpha,\beta}$ into itself if $-\frac{1}{2} < \alpha, \beta < \frac{1}{2}$. Specifically it is proved that if

$$(a.) \quad |t_n| \leq C \qquad n = 0, 1, \ldots,$$

$$(b.) \quad \sum_{2^n}^{2^{n+1}} |t_k - t_{k-1}| \leq C \qquad n = 0, 1, \ldots,$$

then

$$N_{\alpha,\beta}[Tf] \leq D(\alpha,\beta)\, C N_{\alpha,\beta}[f] \quad (-\tfrac{1}{2} < \alpha, \beta < \tfrac{1}{2}),$$

where $D(\alpha,\beta)$ depends only upon α and β. (Contractor's abstract)

WAS. 02:019

Washington U. Dept. of Mathematics, St. Louis, Mo.

A REGULAR SINGULAR FUNCTIONAL, by A. D. Martin. [May 1955] [16]p. [AFOSR-TN-55-84] (In cooperation with Institute for Advanced Study, Princeton, N. J.) [AF 18(600)568 and AF 18(600)1109] Unclassified

Published in Canad. Jour. Math., v. 8: 53-68, 1956.

Extremals exist for quadratic functionals of the type $\int_a^b [r(x)y'^2 + p(x)y^2]\,dx$, with $0 < a < b$, in which $x = 0$ is a singular point of the functional otherwise regular on a closed interval [0, b], if the functions r and p are continuous and positive. The Riccati equation $z' - \frac{z^2}{r(x)} + p(x) = 0$ then has continuous solutions, at least locally; it and its solutions are presumed to be

annihilated if r vanishes, although the functional is much less affected. In order to generalize the Riccati equation $z' - \frac{(z + q(x))^2}{r(x)} + p(x) = 0$, a consideration is made of the functional $J(y)\Big|_a^b = \int_a^b [r(x)y'^2 + 2q(x)yy' + p(x)y^2]\,dx$, a Lebesque integral. The functions r, p, and q are measurable functions defined on $(-\infty, \infty)$, with r and q bounded on bounded subinterval of $(-\infty, \infty)$ and p integrable Lebesgue on each bounded subinterval. A function y is held F_t-admissible on [a, b] if y is absolutely continuous on [a, b] and y'^2 is integrable Lebesgue thereon, and if y (a) = t. F_t [a, b] denotes the class of all functions y which are F_t-admissible on [a, b]. Principal attention is given to cases in which t = 0 or 1. Conjugate points are defined and the necessary conditions and sufficient conditions are established for existence of a minimum limit of $J(y)\Big|_a^b$ among functions F_t-admissible.

WAS. 02:020

Washington U. Dept. of Mathematics, St. Louis, Mo.

THE DECOMPOSITION OF WALSH AND FOURIER SERIES, by I. I. Hirschman, Jr. [1955] 65p. refs. (AF 18(600)568) Unclassified

Published in Mem. Amer. Math. Soc., No. 15, 1955, 65p.

Inequalities are generalized for Fourier series and Walsh expansions of Paley, Littlewood, Riesz, Marcinkiewicz, Babenko and others by introduction of a weighting factor in certain means. The Walsh functions $\psi(k, t)$ $(k = 0, 1 \cdots; 0 \leqq t \leqq 1)$ are defined by $\psi(k, t) = \varphi(n_1, t)\varphi(n_2, t) \cdots \varphi(n_r, t)$, where

$$\varphi(n, t) = \text{sign sin } (2^{n+1}\pi t)$$

and $k = 2^{n_1} + 2^{n_2} + \cdots + 2^{n_r}$ is the dyadic representation of n. If $f(t) \in L(0, 1)$, $c(o) = \int_0^1 f(t)dt = 0$, we have

$$f(t) \sim \sum_0^\infty c(k)\psi(k, t),\quad c(k) = \int_0^1 f(t)\psi(k, t)dt,$$

with the formal decompositions

$$f(t) = \sum_{n=0}^{\infty} fn(t),\quad fn(t) = \sum_{2^n}^{2^{n+1}-1} c(k)\psi(k, t),\quad c(k) = \sum_{n=1}^{\infty} c_n(k),\quad c_n(k) = \int_{2^{-n}}^{2^{-n+1}} f(t)\psi(k, t)dt.$$

Then if $w(\psi) = w_{\alpha, p}(\psi) = \left\{\int_0^1 t^{p\alpha} |\psi(t)|^p dt\right\}^{1/p}$ and $w(a) = w_{\alpha p}(a) = \left\{\sum_{k=0}^{\infty} (k+1)^{p\alpha} |a(k)|^p\right\}^{1/p}$ for functions $\psi(t)$ in (0, 1) or sequences a(k), respectively, it is shown that

(1) $A' \leqq w(F)/w(f) \leqq A''$, $A' \leqq w(C)/w(c) \leqq A''$

when $F(t)^2 = \sum_n |f_n(t)|^2$, $C(k)^2 = \sum_n |c_n(k)|^2$ and $1 < p < \infty$, $-1/p < \alpha < 1 - 1/p$. Further, if $S_m = S_m(t) = \sum_{k=0}^{m} c(k)\psi(k, t)$, $S_\mu = S_\mu(k) = \int_\mu^1 f(t)\psi(k, t)dt$, then $w(S_m) \leqq Aw(f)$ and $w(S_\mu) \leqq Aw(c)$. The case $\alpha = 1$ of the first inequality (1) is due to Paley (Proc. London Math. Soc., v. 34: 241-264, 1932). The results for Fourier series follow a similar pattern. If

$$f(\theta) \sim \sum_{-\infty}^{\infty} a_\nu e^{i\nu\theta}\quad (-\pi \leqq \theta < \pi),$$

we have the decomposition

$$f(\theta) \sim \sum_n \Delta_n(\theta),\quad \Delta_n(\theta) = \sum_{2^{n-1}}^{2^n - 1} a_\nu e^{i\nu\theta} \text{ or } \sum_{-2^{-n+1}}^{-2^{-n}+1} a_\nu e^{i\nu\theta}$$

according as $n > 0$ or $n < 0$. Instead of $w_{\alpha p}$ there is the analogous mean $||\psi(\theta)|| = ||\psi(\theta)||_{\alpha, p} = \left\{\int_0^{2\pi} |\psi(\theta)|^p |\theta|^{\alpha p} d\theta\right\}^{1/p}$, and the analogue of (1) is

(2) $A' \leqq ||F||/||f|| \leqq A''$

when $F(\theta)^2 = \sum_n |\Delta_n(\theta)|^2$. The case $\alpha = 0$ here is due to Littlewood and Paley [ibid., v. 42: 52-89, 1936]. This result is equivalent to (3) $\|T_\epsilon f\| \leqq A\|f\|$, where the transformation $T_\epsilon f$ is defined by $T_\epsilon f \sim \sum \epsilon_n \Delta_n(\theta)$, and ϵ_n is a sequence with values ± 1. The particular case $\epsilon_n = 1$ for $n > 0$, $\epsilon_n = -1$ for $n < 0$ gives $\|\tilde{f}\| \leqq A\|f\|$, where $\tilde{f}$ is the conjugate function of f. This result is due to Babenko (Dokl. Akad. Nauk SSSR, (NS), v. 62:157-160, 1948) and reduces to the theorem of M. Riesz (Math. Z., v. 27: 218-244, 1927) when $\alpha = 0$. The proof of (2) depends on the inequality

$$\int_{-\pi}^{\pi}\left[\int_0^1 |g'(re^{i\theta})|^2 |1 - re^{i\theta}|^{2\alpha}(1 - r)dr\right]^{p/2} d\theta \leqq A\|g(e^{i\theta})\|^p$$

for functions g(z) analytic in $|z| < 1$, a result which generalizes the case $\alpha = 0$ of Paley and Littlewood. This proof does not simplify when $p = 2$, and a special elementary proof is given for this. The inequality (3) is extended to transformation Λf defined by $\Lambda f(\theta) \sim \sum a_\nu \lambda_\nu e^{i\nu\theta}$ in which the sequence

WAS. 02:021 - WAS. 02:023

λ_ν is bounded and of bounded variation in ranges $(\pm 2^k, \pm 2^{k+1})$, the case $\alpha = 0$ being due to Marcinkiewicz (Studia Math., v. 8: 78-91, 1939). (Math. Rev. abstract)

WAS. 02:021

[Washington U. Dept. of Mathematics, St. Louis, Mo.]

QUADRATIC FUNCTIONALS WITH A SINGULAR END POINT, by W. Leighton and A. D. Martin. [1955] [30]p. [AF 18(600)568] Unclassified

Published in Trans. Amer. Math. Soc., v. 78: 98-128, Jan. 1955.

The authors consider the functional

$$J(y)\Big|_e^b = \int_e^b (ry'^2 - py^2)dx,$$

where $0 < e < b < d$, where $r(x)$ and $p(x)$ are continuous functions of x in $0 < x < d$, and the integral is an L-integral, in a further development of a previous paper by M. Morse and W. Leighton (Trans. Amer. Math. Soc., v. 40: 252-286, 1936) in which $p(x)$ was assumed to have a constant sign in a neighborhood of $x = 0$. This hypothesis is removed. A function $y(x)$ is said to be F-admissible in $[0, b]$ if 1) $y(x)$ is continuous in $(0, b]$ and $y(b) = 0$; 2) $y(x)$ is AC and y'^2 is L-integrable on each closed subinterval of $(0, b]$. In addition, if $y(x)$ is also bounded in $[0, b)$, or continuous in $[0, b]$ with $y(0) = 0$, then $y(x)$ is said to be F'-, or A-admissible, respectively. The authors seek necessary and sufficient conditions in order that $\liminf J(y)\Big|_x^b \geq 0$ as $x \to 0+$, for all $y(x)$ which are F-, or F'-, or A-admissible in $[0, b]$. Then $J(y)$ is said to possess a F-, or F'-, or A-minimum limit in $[0, b)$. The point $x = 0$ is, in general, a singular point. Here are some main results: I. If $[0, b)$ contains no focal point of the y-axis, then $J(y)$ possesses an F-minimum limit (variable end-point problem). II. If $[0, b)$ contains no conjugate point of $x = 0$ and $\int_x^b p(x)dx = 0(1)$ as $x \to 0+$, then $J(y)$ possesses an A-minimum limit (fixed end-point problem). (Math. Rev. abstract)

WAS. 02:022

Washington U. Dept. of Mathematics, St. Louis, Mo.

TWO PARAMETER MOMENT PROBLEMS, by A. Devinatz. Aug. 16, 1956 [18]p. refs. [AFOSR-TN-56-240] (AF 18(600)568) AD 88360 Unclassified

Also published in Duke Math. Jour., v. 24: 481-498, Dec. 1957.

According to Stieltjes, a necessary and sufficient condition that a sequence of constants $\{\mu(n), N = 0, 1 \ldots\}$ may be written as the integral $\mu(n) = \int_0^\infty x^n \, d\alpha(x)$, where the measure $d\alpha(x)$ is non-negative and bounded. Hamburger stated that a necessary and sufficient condition that there exists a non-negative bounded measure $d\alpha(x)$, such that $\mu(n) = \int_{-\infty}^\infty x^n \, d\alpha(x)$. It is shown that under an additional restriction the 2 parameter analogues of conditions for any finite set $\{\zeta_i\}$ of real numbers ((1) $\sum_{i=0}^n \sum_{j=0}^n \zeta_i \zeta_j \mu(i+j) \geq 0$ and $\sum_{i=0}^n \sum_{j=0}^n \zeta_i \zeta_j \mu(i+j+1) \geq 0$ and (2) $\sum_{i=0}^n \sum_{j=0}^n \zeta_i \zeta_j \mu(i \pm j) \geq 0$) are sufficient to give the 2 parameter analogues of the 2 integral equations, respectively. The additional restriction is put on amounts to demanding uniqueness for the measures which appear in these representations.

WAS. 02:023

Washington U. Dept. of Mathematics, St. Louis, Mo.

NONOSCILLATION AND DISCONJUGACY IN THE COMPLEX DOMAIN, by P. R. Beesack. [1956] [32]p. incl. refs. [AF 18(600)568] Unclassified

Published in Trans. Amer. Math. Soc., v. 81: 211-242, Jan. 1956.

The equation $w''(z) + p(z)w(z) = 0$, with $p(z)$ analytic in domain D, is called disconjugate on D if no solution $w \neq 0$ vanishes more than once in D, non-oscillatory on D if no solution vanishes infinitely often in D. Criteria for disconjugacy or non-oscillation are given: mostly they involve properties of $M(r) = \sup_{|z|=r} |p(z)|$, D being a disk $|z| < R$. Typical results: (A) Disconjugacy holds in $|z| < b \leq 1$ if $(1 - r^2)^2 M(r)$ is nonincreasing for $0 \leq r < b$ and if $y'' + M(r)y = 0$ has a solution which does not vanish for $-b < r < b$. (B) If $(1 - r^2)M(r) \leq n(n+1)$, where n is an odd positive integer, and if b is the least positive zero of $P_n'(r)$, then there is disconjugacy in $|z| < b$. (C) If $y'' + M(t)Y = 0$ has a solution with $y(0) = 0$ and $y(t) \neq 0$ for $0 < t < R$, then there is disconjugacy in $|z| < \frac{1}{2}R$. (E) If D lies in the half-strip $x \geq 0$, $|y| \geq 1$, and includes the real axis $x > 0$, if $|p(x+iy)| \leq \delta(x)$ where $\delta(x) > 0$ as $x \to +\infty$ and $\int_0^\infty x|p(x)|\,dx < \infty$, then there is non-oscillation in D. (A) includes as special cases several

results proved by Z. Nehari (Bull. Amer. Math. Soc., v. 55: 545-551, 1949) or announced by V. V. Pokornyi (Dokl. Akad. Nauk SSSR (N. S.), v. 79: 743-746, 1951). (C) and (D) were also announced by Pokornyi (E) and its method of proof are closely related to work of Z. Nehari (Amer. Jour. Math., v. 76: 689-697, 1954). Many other results are proved, some of them being extensions or refinements of known results. (Math Rev. abstract)

WAS. 02:024

Washington U. Dept. of Mathematics, St. Louis, Mo.

A NOTE ON ENTROPY, by I. I. Hirschman, Jr. [1956] [5]p. [AF 18(600)568] Unclassified

Published in Amer. Jour. Math., v. 79: 152-156, Jan. 1957.

For $f(x) \in L^2(-\infty, \infty)$ and $g(y) \sim \int_{-\infty}^{\infty} f(x)e^{-2\pi ixy}dx$ and $f(x) \sim \int_{-\infty}^{\infty} g(y)e^{2\pi ixy}dy$, where "$\sim$" refers to convergence in the mean of L^2, the author proves: If $\| f\| = \| g\| = 1$, then $E[|f(x)|^2] + E[|g(y)|^2] \geqq 0$, whenever the left side has meaning, where $E[\varphi(x)] = \int_{-\infty}^{\infty} \varphi(x)dx$. He conjectures that $E[|f(x)|^2] + E[|g(y)^2] \leqq \log 2 - 1$ may hold under the same conditions. (Math. Rev. abstract)

WAS. 02:025

Washington U. Dept. of Mathematics, St. Louis, Mo.

HARMONIC ANALYSIS AND ULTRASPHERICAL POLYNOMIALS, by I. I, Hirschman, Jr. July 1956, 24p. incl. refs. (Bound in Cornell U. Dept. of Math., Ithaca, N. Y. Final tech. rept. on the Symposium on Harmonic Analysis and Related Integral Transforms, Volume I; AF 18(603)12) [AF 18(600)568] Unclassified

The considerable analogy that exists between Fourier series and expansion in terms of the classical polynomials is shown to be applicable to the case of ultraspherical polynomials. The extent of this relationship is demonstrated by a consideration of the douhle convolution structure of the ultraspherical polynomials.

WAS. 03:001

Washington U. Dept. of Physics, St. Louis, Mo.

ANGULAR DISTRIBUTIONS OF PROTONS FROM $Na^{23}(d, p)Na^{24}$ and $Ti^{47, 48}(d, p)Ti^{48, 49}$, by M. M. Bretscher, J. O. Alderman and others. June 21, 1954 [7]p. incl. diagrs. table, refs. (Technical rept. no. 1) ([AF]OSR-TN-54-350) [Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)777 and Office of Naval Research under N6ori-11701] AD 57108 Unclassified

Also published in Phys. Rev., v. 96: 103-109, Oct. 1, 1954.

Sodium and titanium targets were bombarded with 10-mev deuterons, and angular distributions of protons from the stripping reaction were observed with arrays of nuclear emulsions. Absorbing foils in front of each emulsion were arranged so that the integrated flux of protons in a limited energy range could be determined. Distributions were found for each of the four most energetic proton groups from sodium, corresponding to Q values of 4.731 (ground state), 4.259, 4.167, and 3.390 mev. The data were compared with the Butler theory, and l_n values of 2, 2, 0, and 0, respectively, were necessary to fit theory to data. With Ti^{47} targets, l_n values of 3, 1 (and 3?), 1, and 1, respectively, were determined for proton groups corresponding to Q values of 8.14, 6.81, 5.83, and 4.83 mev. With Ti^{48} targets l_n values of 3, 1, 1, and either 1 or 2 were determined for proton groups corresponding to Q values of 5.81 (ground state), 4.46, 4.11, and 3.40 mev, respectively, From these data, parity and possible spin values for the various states of Na^{24}, Ti^{48}, and Ti^{49} are deduced. (Contractor's abstract)

WAS. 03:002

Washington U. [Dept. of Physics] St. Louis, Mo.

ANGULAR DISTRIBUTIONS IN (d, p) REACTIONS WITH Ti^{47} AND Ti^{48} (Abstract), by F. B. Shull and M. M. Bretscher. [1954] [1]p. incl. table. [AF 18(600)777] Unclassified

Presented at meeting of the Amer. Phys. Soc., Minneapolis, Minn., June 28-30, 1954.

Published in Bull. Amer. Phys. Soc., v. 29: 15, June 28, 1954.

Thin targets of TiO_2 (one with Ti^{47} enriched to 82 percent, another with Ti^{48} enriched to 99 percent) were bombarded with 10.2-mev deuterons. Proton angular distributions were determined by a photographic method. Aluminum foils in front of nuclear emulsion plates served as energy selectors, so that proton groups from various excited states could be studied separately. Comparison with Butler's theoretical curves establishes the angular momentum $l_n\hbar$ for the captured neutron, from which spin and parity of the final nuclear level may be determined. The results are tabulated:

WAS. 03:003 - WAS. 03:005

Reaction	Q value (mev)[a]	l_n	Final spin	Ftnal parity
$Ti^{47}(d, p)Ti^{48}$	8.14	3	0	even
	6.81	1, (3?)	1, 2, 3, 4	even
	5.83	1	1, 2, 3, 4	even
	4.83	1	1, 2, 3, 4	even
$Ti^{48}(d, p)Ti^{49}$	5.81	3	5/2, 7/2	odd
	4.46	1	1/2, 3/2	odd
	4.11	1	1/2, 3/2	odd

(Contractor's abstract)

WAS. 03:003

Washington U. [Dept. of Physics] St. Louis, Mo.

THE STRIPPING REACTIONS $Fe^{56}(d, p)Fe^{57}(d, p)$ Fe^{58} (Abstract), by C. E. McFarland, F. B. Shull and others. [1955] [1]p. [AF 18(600)777] Unclassifted

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Bull. Amer. Phys. Soc., v. 30: 55, Apr. 28, 1955.

Published in Phys. Rev., v. 99: 655, July 15, 1955.

Targets of concentrated Fe^{57} (74.6 percent) and natural Fe^{56}, both tn the form of Fe_2O_3, were bombarded wtth 10-mev deuterons. Energy spectra of the protons emttted were observed at tntervals of 5° tn the forward hemtsphere with the aid of a proportional counter telescope and an absorber stack of vartable thtckness. Q-values measured for the $Fe^{56}(d, p)Fe^{57}$ reaction are 5.53 (ground state) and 4.24 mev. Those for the $Fe^{57}(d, p)Fe^{58}$ reactton are 7.09 (ground state), 6.26, 5.t5, and 3.72 mev. By compartson wtth curves calculated from Butler's theory of strtpptng reacttons, the angular dtstrtbutton of each of these groups was found to correspond to the capture of neutrons havtng one untt of orbttal angular momentum. The sptn of each of the two observed states of Fe^{57} ts hence etther t/2 or 3/2 and the partty of both states ts odd. The sptn of each of the observed states of Fe^{58} ts 0, t, 2, or 3, and thetr parittes are all even. (Contractor's abstract)

WAS. 03:004

Washington U. [Dept. of Physics] St. Louis, Mo.

ANGULAR DISTRIBUTIONS OF PROTONS FROM $Cr^{52, 53}(d, p)$-$Cr^{53, 54}$ (Abstract), by A. J. Elwyn and F. B. Shull. [1956] [t]p. [AF t8(600)777] Unclasstfted

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 281, June 21, 1956.

Thin targets of Cr_2O_3, one enriched with 90% Cr^{53} another enriched with 99% Cr^{52}, were bombarded by 10-mev deuterons. Protons corresponding to the formation of the final nucteus tn its ground and various of its excited states were detected by a double proportional counter telescope. Proton energi[illegible]ere selected by means of aluminum foils placed i[illegible]ont of the counter system. Q values were measured and angular distributions of the proton groups were obtatned. Compartson with Butler's theoretical curves establishes the angular momentum $l_n\hbar$ for the captured neutron from which the spin and parity of the ftnal nuclear state may be determtned. The tentative results are given in the following table:

	Q value	$l_n\hbar$	Final spin	Final parity
$Cr^{52}(d, p)Cr^{53}$	5.74	1	3/2	Odd
	5.17	1	1/2, 3/2	Odd
	4.77	3	5/2, 7/2	Odd
	3.43	1	1/2, 3/2	Odd
	7.55	1	0	Even
	6.69	1	0, 1, 2, 3	Even
	6.24	1	0, 1, 2, 3	Even
	4.88	1	0, 1, 2, 3	Even
	4.36	1	0, 1, 2, 3	Even
	3.76	1	0, 1, 2, 3	Even

(Contractor's abstract)

WAS. 03:005

Washtngton U. Dept. of Physics, St. Louis, Mo.

DtSPERSION CONTRIBUTION TO HIGH-ENERGY ELECTRON-DEUTERON SCATTERING, by H. S. Valk and B. J. Malenka. [1956] [5]p. incl. table. (Sponsored jotntly by Offtce of Naval Research, Atomtc Energy Commtsston, and Air Force Offtce of Sctentiftc Research under [AF 18(600)777]) Unclassifted

Published in Phys. Rev., v. t04: 800-804, Nov. 1, t956.

An attempt ts made to estimate the contrtbution of the tntermedtate nuclear vtrtual states to the htgh energy electron elastic scatterttng cross sectton tn the spectal case of the deuteron. A method ts developed by whtch the nuclear exctted states can be approximated by suttably modtfied free-nucleon wave functtons tn the sum over tntermedtate states. Expresstons for the contrtbutton to the cross section artstng from the cross terms between the ftrst- (tn e^2) and second-order terms

of the scattertng amplitude are obtained and some numertcal results are presented. Some dtsagreement with previous assumptions as to the magnitude of the "true" dispersion correction ts indtcated. (Contractor's abstract)

WAS. 04:001

Washington U. Dept. of [Physics], St. Louis, Mo.

ELECTRON TRANSFER BETWEEN NAPHTHALENE NEGATIVE ION AND NAPHTHALENE, by R. L. Ward and S. I. Weissman. [1954] [1]p. [AF 18(600)1133] Unclassifted

Published in Jour. Amer. Chem. Soc., v. 76: 3612, July 5, 1954.

The electron-transfer reaction between naphthalene negative ton and naphthalene dissolved tn tetrahydrofuran was examined spectroscopically. When naphthalene was added to a dtlute solution of naphthalene negattve ton, the paramagnetic resonance spectrum of the latter was altered. Addition of a small amount of naphthalene broadened the tndividual hyperftne components. As larger amounts of naphthalene were added to hyperftne components merged into a stngle peak with broad latls exiendtng beyond the region encompassed by the origtnal hyperfine pattern. The ltne-broadening in the presence of naphthalene was ascrtbed to the transfer of electrons from naphthalene negative tons to naphthalene molecules. The method dtd not depend on some method of dtstingutshing reactants from products. The observations revealed directly the quantity of tnterest, the mean ltme during which a particular configuration perststs undisturbed. (C. A., 1955: 8706a)

WAS. 04:002

Washington U. Dept. of Physics, St. Louis, Mo.

PARAMAGNETIC RESONANCE ABSORPTION IN GLASS, by R. H. Sands. Mar. 2, 1955 [5]p. incl. diagrs. lable. (Technical repl. no. 1) ([AF]OSR-TN-55-61) (AF 18(600)1133) AD 99521(a) Unclassified

Also published in Phys. Rev., v. 99: 1222-1226, Aug. 15, 1955.

Paramagnetic resonance absorptions occurring with spectroscopic splitting factors of 4 and 6 were noted in all glass samples studied. These were apparently anisotropic g-values for a specific impurity, and the peaks recorded are interpreted as being the result of a distribution of Stark fields over all directions in the glass. Resonances were also recorded having g-values near 2. Nearly all of these showed hyperfine structures characteristic of the known paramagnetic additions in the glasses. The absorption line observed for cupric ions in lattice-modifying positions in a soda-lime-silica base glass has been quantitatively explained, and the parameters compared favorably with those resulting for copper tn the Tutton salts. (Contractor's abstract)

WAS. 04:003

Washington U. Dept. of [Physics], St. Louis, Mo.

REACTIONS OF SODIUM METAL WITH AROMATIC HYDROCARBONS, by D. E. Paul, D. Lipkin, and S. I. Weissman. May 9, 1955 [5]p. incl. diagrs. tables, refs. (Technical rept. no. 3) ([AF]OSR-TN-55-118) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1133, Atomic Energy Commission, and Office of Naval Research). AD 99521(c) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 116-120, Jan. 5, 1956.

The stoichiometry, optical absorption spectra, and electrical conductivity of the products of the reaction of metallic sodium with aromatic hydrocarbons tn tetrahydrofuran solution were studied. The results indicate that products contatning 1 mole of sodium/mole of hydrocarbon are formed, tn agreement with the conclustons arrived at by paramagnetic resonance absorption measurements. A relationship was found between the absorpiton spectra of reaction products and thetr parent hydrocarbons. The absorption spectra also were used as an analytical tool for the study of equilibria involving pairs of aromatic hydrocarbons and their corresponding negative tons. The results of these measurements give the following order of increasing electron affinities: benzene ≪ phenanthrene < naphthalene < anthracene, naphthacene. A mechanism is proposed for the reaction of a negative ion hydrocarbon free radical with various reactants, i. e., carbon dioxide, water. (Contractor's abstract)

WAS. 04:004

Washington U. [Dept. of Physics] St. Louis, Mo.

OPTICAL AND PARAMAGNETIC RESONANCE SPECTRA OF SOME COORDINATION COMPOUNDS, by S. I. Weissman. [1956] [4]p. [Technical repl. no. 7] [AFOSR-TN-55-193] [AF 18(600)1133] Unclassified

Published in Recueil Trav. Chim. Pays-Bas, v. 75: 853-856, June 1956.

A brief description is given of some of the applications of optical and paramagnetic resonance spectroscopy to the study of coordination compounds. The study presented here concerns the chelate compounds of beryllium with dibenzoyl methane, benzoylacetone, and acetylacetone. In some respects, these compounds resemble aromatic hydrocarbons. As in the case of aromatic hydrocarbons, beryllium dibenzoylmethide and beryllium benzoyl acetonate are reduced by metallic sodium in tetrahydrofuran solutions, yielding negative

WAS. 04:005 - WAS. 04:008

ions. The acetylacetonate, however, is not reduced. Paramagnetic resonance measurements indicate that the first-formed compounds are paramagnetic, while those finally produced in the presence of excess sodium are diamagnetic. The optical spectra of the reduction products correspond quite well to a picture in which the singly-charged negative ion contains one electron in the lowest vacant orbital of the chelate, while the doubly-charged negative ion contains 2 electrons in this orbital. The paramagnetic resonance spectra of the singly-charged negative ions of the dibenzoyl methide and benzoyl acetonate are different from each other. The former exhibits a single absorption peak with some signs of a close hyperfine structure (probably from the protons in the molecule), while the latter possesses a spectrum of 4 peaks. These undoubtedly result from interaction with the beryllium nucleus. The separation between peaks corresponds to admixture of a few % of beryllium 2s atomic function in the molecular orbital of the unpaired electron. Apparently in the negative ion of the large dibenzoyl methide complex, the electron resides in the rings. In the smaller benzoyl acetonate, it may be found, infrequently, in the beryllium atom.

WAS. 04:005

Washington U. [Dept. of Physics] St. Louis, Mo.

PARAMAGNETIC RESONANCE OF FREE RADICALS, by G. E. Pake, S. I. Weissmann, and J. Townsend. Jan. 24, 1955 [12]p. incl. diagrs. refs. (Technical rept. no. 4) ([AF]OSR-TN-55-194) (AF 18(600)1133) AD 86308 Unclassified

Also published in Faraday Soc. Discussions, No. 19: 147-158, 1955.

Paramagnetic resonance spectra of free radicals are discussed, with emphasis being placed upon observed hyperfine patterns. A brief description is given of a paramagnetic resonance spectrometer, and examples of applications to problems of physical, chemical, and biological interest are presented. (Contractor's abstract)

WAS. 04:006

Washington U. Dept. of Physics, St. Louis, Mo.

DOUBLE-FREQUENCY MAGNETIC RESONANCE IN A FREE RADICAL, by J. H. Burgess and R. E. Norberg. July 11, 1955 [1]p. incl. diagrs. (Technical rept. no. 2) ([AF]OSR-TN-55-267) (Sponsored jointly by [Air Force] Office of Scientific Research under 18(600)1133 and Office of Naval Research) AD 99521(b) Unclassified

Also published in Phys. Rev., v. 100: 752-753, Oct. 15, 1955.

In the course of double resonance experiments on hyperfine components resolvable in aqueous solutions of the free radical ion peroxylamine disulfonate, $ON(SO_3)_2^-$, an unusual distortion of the absorption line shape has been observed. This "bump" occurs at a position dependent both on the intensity of the saturating field and on the 2 applied frequencies. Experiment shows that the effective gyromagnetic ratio of the combined transition determines the direction of the position shift of the bump. Increasing the amplitude of the saturating field, increases both the magnitude of the shift of the bump and the enhancement of the detected transition. An analysis, based on the density matrix equation, leads to an expression for $\chi''(\omega_d)$, the imagtnary component of the susceptibility at the detecting frequency.

WAS. 04:007

Washington U. [Dept. of Physics] St. Louis, Mo.

MEASUREMENT OF THE RATE OF AN ELECTRON EXCHANGE REACTION BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY, by C. R. Bruce, R. E. Norberg, and S. I. Weissman. Nov. 28, 1955 [2]p. incl. diagrs. (Technical rept. no. 5) ([AF]OSR-TN-55-472) (Sponsored jointly by Air Force Office of Scientific Research under AF 18(600)1133, Office of Naval Research, and Atomic Energy Commission) AD 86308(a) Unclassified

Also published in Jour. Chem. Phys., v. 24: 473-475, Feb. 1956.

The electron-exchange reaction between N, N, N', N'-tetramethyl-p-phenylenediamine and Wurster's blue was studied. The method is applicable to reactions in which $k > 3 \times 10^3$ l/mol/sec. This limitation occurs because 1 member of a pair of molecules between which 1 electron-exchange occurs must be paramagnetic. For $k = 3 \times 10^3$ l/mol/sec, contributions of thermal paramagnetic relaxation to the line breadth may become comparable with the exchange contribution.

WAS. 04:008

Washington U. [Dept. of Physics], St. Louis, Mo.

ISOTROPIC HYPERFINE INTERACTIONS IN AROMATIC FREE RADICALS, by S. I. Weissman. Dec. 19, 1955 [2]p. (Technical rept. no. 11) ([AF]OSR-TN-55-473) (AF 18(600)1133) AD 123638 Unclassified

Also published in Jour. Chem. Phys., v. 25: 890-891, Nov. 1956.

It is shown by a procedure similar to one used by Abragam, Horowitz, and Pryce in their studies of hyperfine structure in paramagnetic ions and atoms that configurational admixture of the type $(\sigma_B)^2(\pi) + \lambda(\sigma_B)(\sigma_A)(\pi)$, the hyperfine interaction is $32\pi/3\sqrt{6}\,\mu_n\mu_e\,\sigma_B(r_n)\sigma_A(r_n)$ where μ_e and μ_n are

magnetic moments of the electron and the nucleus η, and $\sigma(r_\eta)$ is the magnitude of the orbital σ at the position of the nucleus. Since the hyperfine coupling is linear in λ only small admixtures of excited configurations are required to account for the proton hyperfine splittings observed in aromatic free radicals. (Contractor's abstract)

WAS. 04:009

Washington U. [Dept. of Physics] St. Louis, Mo.

HYPERFINE STRUCTURE IN THE PARAMAGNETIC RESONANCE OF VANADIUM IONS IN SOLUTION (Abstract), by G. E. Pake and R. H. Sands. [1955] [1]p. [AF 18(600)1133] Unclassified

Presented at meeting of the Amer. Phys. Soc., California U., Berkeley, Dec. 28-30, 1954.

Published in Phys. Rev., v. 98: 266, Apr. 1, 1955.

Paramagnetic resonances of vanadium ions in aqueous, acetone, and ether solutions have been observed. Although attempts were made at preparing valence states V^{3+}, V^{4+}, and V^{5+} in accordance with the procedures of Freed, solutions corresponding in color to V^{3+} and to V^{4+} both gave the same hyperfine pattern of eight (21 + 1) lines of different individual widths. The hyperfine coupling constant corresponds to about 120 oersteds, with line spacings being progressively larger toward higher fields as expected in second order for a spectrum centered at 3200 oersteds. The coupling is slightly larger for aqueous than ether solutions, which is not unlikely for solvents forming different complexes with the vanadium ions if the electron promotion hypothesis of Abragam and Pryce for the unexpectedly large hyperfine couplings in such ions is valid. Asymmetric component line shapes for certain solvents and temperatures are interpreted as viscosity effects leading to incomplete averaging of an anisotropic spectroscopic splitting factor of the complexed ion.

WAS. 04:010

Washington U. [Dept. of Physics] St. Louis, Mo.

NUCLEAR MAGNETIC RELAXATION TIMES IN POLYETHYLENE (Abstract), by I. J. Lowe, L. O. Bowen, and R. E. Norberg. [1955] [1]p. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18(600)1133]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Chicago U., Ill., Nov. 25-26, 1955.

Published in Phys. Rev., v. 100: 1243, Nov. 15, 1955.

Direct measurements of T_1 and T_2 for the proton magnetic resonance in polyethylene have been made from observations of Bloch decays and spin echoes produced by microsecond pulses of 30 mc/sec radio-frequency power. Observations were made at temperatures between 240°K and 392°K using the same commercial stock material as Wilson and Pake. The results are in substantial agreement with the relaxation times postulated by Wilson and Pake and show the coexistence of several very distinct T_2's between 260°K and 295°K. The T_2 values measured ranged from 4 microseconds near 240°K to 0.1 second in a molten sample at 392°K. Over much of this temperature range T_1 was measured to be of the order of 0.1 second with T_2 becoming nearly equal to T_1 at 392°K. The short T_2 component visible on the Bloch decays grows progressively weaker as the temperature is raised, becoming nearly undetectable by 340°K. Near 280°K there is a weak "slow-beat" structure on the Bloch decays.

WAS. 04:011

Washington U. [Dept. of Physics] St. Louis, Mo.

PARAMAGNETIC RESONANCE OF OCTACYANOTUNGSTATE (V), by S. I. Weissman and C. S. Garner. Feb. 6, 1956 [1]p. (Technical rept. no. 6) ([AF]OSR-TN-56-149) [In cooperation with California U., Los Angeles] (Sponsored jointly by Air Force Office of Scientific Research under AF 18-(600)1133 and Atomic Energy Commission under AT(11-1)34) AD 86308(b) Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1072, Mar. 5, 1956.

The paramagnetic resonance of $K_3W(CN)_8 \cdot 0.55\ H_2O$ and the aqueous solutions are described. At room temperature a polycrystalline sample yields a single, almost symmetrical, resonance. The g value at peak center is 1.98; peak breadth between points of extreme slope is 30 oersteds. An approximately 0.01 M $W(CN)_8^{---}$ aqueous solution yields a symmetrical resonance of three lines, with the central intense peak at g = 1.972 and breadth between points of extreme slope of 9.3 oersteds; the two satellites are 7 ± 3% of central peak intensity and are separated by 52 oersteds. The central peak probably results from ions containing W^{184} which has zero spin and is 86% abundant, while the satellites are the hyperfine components associated with W^{183} which has a spin 1/2 and is 14% abundant. The sharp spectrum of the aqueous solution is briefly discussed, and an attempted measurement of the rate of electron exchange between $W(CN)_8^{---}$ and $W(CN)_8^{----}$ by observation of the spectrum of the former in the presence of the latter is described.

WAS. 04:012

Washington U. [Dept. of Physics] St. Louis, Mo.

SPIN DENSITY IN NAPHTHALENE NEGATIVE ION,

WAS. 04:013 - WAS. 04:016

by T. R. Tuttle, Jr., R. L. Ward, and S. I. Weissman. July 1956 [1]p. incl. diagr. (Technical rept. no. 8) ([AF]OSR-TN-56-226) (AF 18(600)1133) AD 88035 Unclassified

Also published in Jour. Chem. Phys., v. 25: 189, July 1956.

The paramagnetic resonance absorption of naphthalene negative ion in dilute liquid solution consists of a complex pattern of hyperfine components. The salts of Li and K in solution in tetrahydrofuran, and of Na, K, and Rb in dimethoxyethane yielded almost identical spectra of 17 lines. The 17 hyperfine components resulted from the isotropic part of the interaction between the electronic magnetic moment and the moments of the 8 protons in naphthalene negative ion. Two spectra of both α-deutero- and β-deuteronaphthalene yielded a 15- and 16-line spectra, respectively. When the value at the nucleus in a H atom in its normal state is taken as the unit of spin, the spin densities of α- and β-H were 0.010 and 0.0035, respectively. The sum of the spin densities at the positions of all the H nuclei was 0.054.

WAS. 04:013

Washington U. [Dept. of Physics] St. Louis, Mo.

C^{13} HYPERFINE SPLITTING IN NAPHTHALENE NEGATIVE ION, by T. R. Tuttle, Jr. and S. I. Weissman. July 1956 [1]p. (Technical rept. no. 9) ([AF]OSR-TN-56-227) (AF 18(600)1133) AD 88036 Unclassified

Also published in Jour. Chem. Phys., v. 25: 189-190, July 1956.

The isotropic hyperfine splitting of naphthalene negative ion containing C^{13} in the α position was measured. The sample contained 53 atom-% of C^{13} in this position. The C^{13} splitting was 7.1 oersteds; this corresponds to a spin density at the C nucleus of 0.056. The spin density at the nucleus for a C atom in the $2s(2p)^3$ configuration was estimated as 4.25. If in the 2σ orbitals involved the respective coefficients of carbon 2s and hydrogen 1s functions were c_1, h_1, and c_2, h_2, the observed C^{13} splitting resulted in $c_1c_2/h_1h_2 = 1.31$.

WAS. 04:014

Washington U. [Dept. of Physics] St. Louis, Mo.

HYPERFINE STRUCTURE AND ELECTRON DENSITIES IN AROMATIC FREE RADICALS, by E. de Boer. July 1956 [1]p. incl. diagrs. (Technical rept. no. 10) ([AF]OSR-TN-56-228) (AF 18(600)1133) AD 88037 Unclassified

Presented at Symposium on Molecular Structure and Spectroscopy, Ohio State U., Columbus, June 11-15, 1956.

Abstract published in Symposium on Molecular Structure and Spectroscopy. Abstracts, 1956, p. 3.

Also published in Jour. Chem. Phys., v. 25: 190, July 1956.

With the aid of Hückel's molecular orbital approximation, the distribution of π electrons in the univalent anions of naphthalene, anthracene, and biphenyl was calculated. The predicted paramagnetic absorption spectra for naphthalene, anthracene, and biphenyl radicals containing 17, 21 and 9 peaks, respectively, agreed with experimental results. The measurements were carried out in 1, 2-dimethoxyethane with K as the reducing agent. The length of the paramagnetic absorption spectrum measured between centers of extreme peaks of naphthalene negative ion was 27.2 ± 0.3 oersteds; the hyperfine interaction for anthracene univalent ion was over a range of 26.4 ± 0.2 oersteds, while that for the biphenyl free radical was 21.0 ± 0.2 oersteds.

WAS. 04:015

Washington U. Dept. of Physics, St. Louis, Mo.

RADIATION DAMPING AND RESONANCE SHAPES IN HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE, by C. R. Bruce, R. E. Norberg, and G. E. Pake. June 11, 1956 [2]p. [Technical rept. no. 12] [AFOSR-TN-56-250] (Sponsored jointly by Air Force Office of Scientific Research under [AF 18-(600)1133] and Office of Naval Research) AD 88370 Unclassified

Also published in Phys. Rev., v. 104: 419-420, Oct. 15, 1956.

An analysis of a nuclear spin-resonant circuit system shows that the electric circuit parameters rather than the nuclear spin relaxation times may determine resonance widths, maximum signal, and integrated intensities in high-resolution continuous-wave nuclear magnetic resonance. (Contractor's abstract)

WAS. 04:016

Washington U. [Dept. of Physics] St. Louis, Mo.

ELECTRON SPIN RESONANCE AND THE STRUCTURE OF FREE RADICALS, by S. I. Weissman, T. R. Tuttle, Jr., and E. de Boer. Aug. 1956 [4]p. incl. diagrs. refs. (Technical rept. no. 13) ([AF]OSR TN-56-443) (AF 18(600)1133) AD 96786 Unclassified

Also published in Jour. Phys. Chem., v. 61: 28-31, Jan. 1957.

In this study, it is pointed out that the hyperfine structure of the electron spin resonance of a polyatomic free radical yields information concerning the electronic

siructure of the radical. The hyperfine inieraction is conveniently separaied inio an isoiropic and a non-isoiropic pari. Only the former is observed in fluid solutions. From ii ihe value of the eleciron spin density ai ihe position of each magnetic nucleus in the molecule may be deduced. The spin density ai $\vec{r}_0$ is ihe expeciation value of $\sum_k \sigma_{zk}\,\delta(\vec{r}_k - \vec{r}_0)$, where σ_{zk} is the Pauli operaior for z componeni of spin of the k^{th} eleciron and r_k iis position. The nonisoiropic part is observable in deiail in diluie single crysiais and in ceriain average properties in rigid glassy solutions. It yields expeciaiion values of $\sum_k \frac{\sigma_{zk}(3\cos^2\theta_k - 1)}{|\vec{r}_k - \vec{r}_0|^3}$ θ_k is the angle beiween $r_k - r_0$ and the exiernal magnetic field. if the elecironic wave function of a free radicai is represenied by a single configuraiion consisting of filled orbitals and one singly occupied orbital, the spin densiiy ai each poini is proportional io the square of the ampliiude of the singly occupied orbiial ai thai poini. in planar aromatic free radicals the unpaired eleciron is usually placed in a π orbiial which yields zero spin density in ihe plane of ihe molecule; neverineless, experimenis reveal nonvanishing spin densities in the molecular plane for many aromatic free radicals. These are inierpreied ihrough admixiure of configuraiions coniaining unfilled σ orbiials. The coniribuiion of such an admixiure io spin density is linear in the ampliiude of ihe admixiure. The above consideraiions apply to ihe proion and C^{13} hyperfine spliiiings in negaiive ion hydrocarbons, iriarylmeihyls, and oiher free radicals. Several examples are discussed. (Coniractor's absiraci)

WAS. 04:017

Washingion U. Depi. of Physics, Si. Louis, Mo.

ON THE INTERPRETATION OF THE ELECTRON SPIN RESONANCE SPECTRA OF SOLUTIONS OF HYDROCARBONS IN SULFURIC ACID, by S. i. Weissman, E. de Boer, and J. J. Conradi. Nov. 1956 [2]p. incl. diagrs. (Technical repi. no. 14) ([AF]OSR-TN-56-567) (AF 18(600)1133) AD 110388 Unclassified

Also published in Jour. Chem. Phys., v. 26: 963-964, Apr. 1957.

Several hydrocarbons (antharacene, perylene and tetracene) are examined in conceniraied sulfurtc acid for electron spin resonance absorpiion. A description for each subsiance is made of the specira which consisi of characteristic, well resolved, hyperfine patterns. it is postulated that singly charged positive ions are responsible for part of the observed paramagnetism.

WAS. 04:018

Washington U. Dept. of [Physics] St. Louis, Mo.

PARAMAGNETIC RESONANCE SPECTRA OF SOME ISOTOPICALLY SUBSTITUTED NAPHTHALENE NEGATIVE IONS (Absiract), by T. R. Tuiile, Jr. [1956] [1]p. [AF 18(600)1133] Unclassified

Presenied at Symposium on Molecular Siructure and Specitroscopy, Ohio Siaie U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Siructure and Spectroscopy. Absiracis, 1956, p. 30.

The paramagnetic resonance specira of three isotopically subsiituied naphthalene negative ions have been siudied under moderate resolution io deiermine the α- and β-proion, and α-C^{13} hyperfine spliiting facions. The specirum of the α-deuiero compound has 15 peaks and thai of the β-deuiero 14 peaks. These facis, aiong with the relative inensities of lines, iead to values of ihe proion spliiting on the α-position of 5.1 gauss and on the β-position of 1.7 gauss. Naphthalene negative ion with 53 aiom perceni C^{13} in the α-position gives a specirum of 21 lines. An assignmeni of 5.4 gauss for the α-C^{13} spliiting gives good agreemeni with ihe observed specirum. The observed spliitings are compared with those calcula'ed using S. i. Weissman's method involving configuraiional inieracion. (Coniractor's absiraci)

WAS. 04:019

Washingion U. Depi. of [Physics] St. Louis, Mo.

SPECTROSCOPIC DETERMINATION OF ELECTRON EXCHANGE BETWEEN NAPHTHALENE NEGATIVE ION AND NAPHTHALENE (Absiraci), by R. L. Ward. [1956] [1]p. (Sponsored joinily by Air Force Office of Scieniific Research under [AF 18(600)1133], Office of Naval Research, and Aiomic Energy Commission) Unclassified

Presenied ai Symposium on Molecular Siruciure and Specitroscopy, Ohio Siaie U., Columbus, June 11-15, 1956.

Published in Symposium on Molecular Siruciure and Specitroscopy. Absiracts, 1956, p. 3.

The rate consianis for the eleciron exchange beiween sodium naphthalenide and naphthalene and beiween poiassium naphihalenide and naphihalene in ieira-hydrofuran and 1,2-dimeihoxyethane have been de-iermined by paramagneiic resonance techniques. Addition of small amounis of naphthalene leads to broadening of ihe individual hyperfine components. Larger amounts of naphthalene cause the hyperfine componenis io merge tnto a single peak with broad tatls. In ihe case of $K^+C_{10}H_8^-$ in 1,2-dimethoxyeihane it has been possible io add quantities of naphihalene such that exchange narrowing begins to take place. The rate constanis, for ihe bimolecular exchange, vary beiween 6.2×10^6 liters/mol/sec and 1.2×10^8 liters/mol/sec. (Contractor's abstract)

WAS. 05:001 - WAU.01:001

WAS. 05:001

Washington U. Depi. of Physics, Si. Louis, Mo.

IONIZATION OF INERT GASES BY POSITIVE POTASSIUM IONS, by D. E. Moe. Nov. 1956 [6]p. incl. diagrs. refs. (Technical rept. no. 1) ([AF]OSR-TN-56-166) (Sponsored joinily by Air Force Office of Scientific Research under AF 18(600)1317, Office of Naval Research, and Research Corp., New York) AD 86587 Unclassified

Also published in Phys. Rev., v. 104: 694-699, Nov. 1, 1956.

ionizaiion of the ineri gases by relaiively low-energy K^+ ions has been investigaied. The use of relaiively iniense ion beams and phase-sensitive deiection of ionization signals yields a large increase in sensiiivity over ihai obiained in former investigations. The enhanced sensitivity permits detection of ionization ai iower ion energies ihan heretofore reporied. Evidence is presenied for a real ionization threshold potential for K^+ ions in Kr. Both the absoiuie ionization cross section and iis dertvative with respeci io ion energy are reporied. The laiter shows a fine siruciure which is characieristic of ihe bombarded gas. The eleciron energy disiribution of ihe ionization elecirons is determined from sioppting potential curves, and is found to be characteristic of the bombarded gas. In general, the energy disiribution of ihe ionizaiion elecirons is independent of the incideni ion energy. The results of ihis investigation support the qualiiative iheory of tonization by tons proposed by Weizel. (Coniracior's abstraci)

WAS. 05:002

Washington U. Dept. of Physics, Si. Louis, Mo.

TEMPERATURE DEPENDENCE OF THE MOBILITY OF POSITIVE IONS IN ARGON AND KRYPTON, by E. C. Beaty. Oci. 1956 [4]p. incl. diagrs. refs. (Technical rept. no. 2) (AFOSR-TN-56-198) (Sponsored jointly by Air Force Offtce of Sctentific Research under AF 18-(600)1317, Office of Naval Research and Research Corp., New York) AD 87511 Unclasstfied

Also published in Phys. Rev., v. 104: 17-20, Oct. 1, 1956.

The mobilities of A^+ and Kr^+ tn ihe parent gases have been measured at room temperature and at one lower temperature, 77.4°K in A and 90°K tn Kr. in each case, the atomtc ions were found to have a higher mobtlity at the lower temperature. For A^+ tn A, the mobtlity (extrapolated to zero field at 77.4°K) was 1.36 ttmes the value at 300°K. Extrapo'ation could not be carrted out accurately tn Kr, but evtdence ts found that the ratto of the mobtlity at 90°K to the value at 300°K is somewhat larger than 1.2. The change tn temperature had no effect on the mobtlttes of the molecular tons. Agreement of the room temperature resulis with those of other investigaiors is good except for a large disagreemeni with Biondi and Chanin on ihe molecular ions. The disagreement is particularly large ai A_2^+ at low E/p_0 and suggesis a difference in ihe ions measured in the 2 experiments. (Coniracior's absiraci)

WAS. 06:001

Washington U. Depi. of Physics, Si. Louis, Mo.

LIGHT-INDUCED PARAMAGNETISM IN CHLOROPLASTS, by B. Commoner, J. J. Heise, and J. Townsend. Dec. 1956 [9]p. incl. diagrs. refs. (Technical repi. no. 1) ([AF]OSR-TN-56-410) (AF 18(600)1592) AD 96219 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 42: 710-718, Oct. 1956.

Ii was observed thai ihe paramagnetic resonance absorption of suspensions of chloroplasis from iobacco (Nicotiana tabacum (variety Whiie Burley)) ai 35°C increased 3 io 6 times when the suspensions were illuminated. This response was rapid, readily reversible, and recurrent. A maximum was obiained about 20 sec afier onsei of illumination, and decay time in the dark was 50-60 sec with half-times being 8 and 32 sec, respectively. Ii was concluded thai unpaired elecirons associated with either or both an excited siaie of chlorophyll and oxidation-reduction inlermediaies, e.g., diphosphopyridine nucleotide, are ihe cause of the paramagnetic resonance absorption tn tlluminated chloroplasis. Experiments are underway which are designed io idenlify the substances in question, and io describe ihetr relaiionship to the process of photosynthesis.

WAU. 01:001

Washington U. [Depi. of Chemistry] Seattle.

THE EXCITED ELECTRONIC STATE OF THE 2600 Å TRANSITION IN BENZENE, by A. C. Albrecht and W. T. Simpson. [1953] [1]p. (AF 18(600)375) Unclassified

Published in Jour. Chem. Phys., v. 21: 940, May 1953.

Both molecular-orbttal and valence-bond approximations foi C_6H_6 indicate that ihe ftrst singlet exctted electronic siate is of the symmeiry spectes B_{2u}. Experiments were performed wtth para-disubstituted benzene derivattves, tncluding p-dimethoxybenzene. The results obtatned from the crystal spectrum confirmed the presence of the exctted electronic state tn the spectes B_{2u}. The presence of both "x" and "y" absorption tn the 2280 Å band was demonstrated.

WAU. 01:002

Washington U. Dept. of Chemistry, Seattle.

SPECTRA OF SIMPLE AMIDES IN THE VACUUM ULTRAVIOLET, by H. D. Hunt and W. T. Simpson. [1953] [4]p. incl. diagrs. tables, refs. [AF 18-(600)375] Unclassified

Published in Jour. Amer. Chem. Soc., v. 75: 4540-4543, Sept. 20, 1953.

Absorption spectra from 2340 to 1500 Å for dimethylformamide and from 2000 to 1220 Å for formamide each show two broad absorption bands. The absorption maxima for the former are at 1974 and 1621 Å, for the latter at 1717 and 1345 Å. Approximate extinction coefficients for the maxima, Einstein absorption coefficients, etc., are given for the two bands of dimethylformamide. A Rydberg series leading to an ionization potential of 10.2 ev is found for formamide. An orbital energy diagram is presented which accounts for the observations. The longer wave length and shorter wave length bands are assigned as NV_1 and NV_2, respectively, the assignments are discussed, and the effect of hyperconjugation is considered. An improvement in the use of the Lyman source is described, involving the use of a Teflon capillary. (Contractor's abstract)

WAU. 01:003

Washington U. Dept. of Chemistry, Seattle.

STRUCTURES AND Π-ELECTRON SPECTRA. II. THE TRANSFORMATION MATRIX, by C. W. Looney and W. T. Simpson. [1954] [8]p. incl. refs. [AF 18-(600)375] Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 6285-6292, Dec. 20, 1954.

A definite procedure is presented for the construction of a transformation matrix which relates π-electron spectra to structures. Arbitrariness in the transformation matrix which may exist even after the incorporation of symmetry is discussed. A method of removing the arbitrariness is shown, as applied to crystal violet and p-methoxy malachite green. (Contractor's abstract)

WAU. 01:004

Washington U. Dept. of Chemistry, Seattle

STRUCTURES AND Π-ELECTRON SPECTRA. III. TRIPHENYLMETHANE DYES, by C. W. Looney and W. T. Simpson. [1954] [8]p. incl. diagr. tables, refs. (AF 18(600)375) Unclassified

Published in Jour. Amer. Chem. Soc., v. 76: 6293-6300, Dec. 20, 1954.

The results of a spectroscopic investigation of crystal violet, p-methoxy malachite green, malachite green, p-nitro malachite green, and Michler's hydrol blue are presented. The positions, intensities and symmetry classifications of the visible and near ultraviolet bands are given. The observed transition energies and polarizations for crystal violet and methoxy malachite green were used in paper II as input data for a theoretical treatment using the methods of the structure representation. The observed intensities for crystal violet are here used similarly. Using only these input data the transition energies for malachite green, and the intensities for methoxy malachite green and malachite green are here calculated theoretically and compared with experiment. Electric moments of the structures are obtained. The transition energies and intensities of p-nitro malachite green and Michler's hydrol blue are also treated theoretically. Finally a set of relative basicities is deduced from the spectral data, spectroscopic resonance energies are obtained, and heats of carbinol formation predicted. (Contractor's abstract)

WAU. 01:005

Washington U. Dept. of Chemistry, Seattle.

OVERLAPS OF TRIAL FUNCTIONS FOR THE HYDROGEN MOLECULE. I. GROUND-STATE CHARACTER OF THE 1s A.O. APPROXIMATIONS, by J. Braunstein and W. T. Simpson. [1955] [2]p. incl. table. [AF 18(600)375] Unclassified

Published in Jour. Chem. Phys., v. 23: 174-175, Jan. 1955.

The contributions of the ground state wave function in some of the trial functions for the hydrogen molecule have been evaluated as the overlap integrals of the trial functions with the thirteen term function of James and Coolidge. The rms errors and mean excited state energies are presented and the results of a binding energy calculation reported. (Contractor's abstract)

WAU. 01:006

Washington U. Dept. of Chemistry, Seattle.

OVERLAPS OF TRIAL FUNCTIONS FOR THE HYDROGEN MOLECULE. II. COVALENT AND IONIC CHARACTER OF H_2, by J. Braunstein and W. T. Simpson. [1955] [3]p. incl. diagrs. table. [AF 18-(600)375] Unclassified

Published in Jour. Chem. Phys., v. 23: 176-178, Jan. 1955.

The mutual overlaps of some of the trial functions for the hydrogen molecule are presented and their relation to the covalent and ionic character of the bond are discussed. Difficulties involved in the definition of covalent and ionic as orthogonal components of wave

WAU. 01:007 - WAU. 01:010

functions are pointed out and contour maps indicating the shapes of some of the functions discussed are given. (Contractor's abstract)

WAU. 01:007

Washington U. Dept. of Chemtstry, Seattle.

THE UNIT-CELL DIMENSIONS AND SPACE GROUP OF 1, 1'-DIETHYL-2, 2'-PYRIDOCYANINA IODINE, by J. D. Turner. [1955] [1]p. (AF 18(300)375) Unclassified

Published in Acta Crystallographica, v. 8: 119, Feb. 1955.

The crystals used in thts study were obtained from a sample prepared by the method of Brooker and Keyes (Jour. Amer. Chem. Soc., v. 57: 2488, 1935). Although most of the crystals were multiple twinned or poorly formed, a few suitable for single-crystal x-ray photographs were found. These were small needles, bounded on the stdes by prominent 110 and $1\bar{1}0$ and small 100 faces, and on the ends by 001 faces. The crystals are deep orange in color and under the polartzing nicroscope show distinct pleochroism, the color varytng from yellow to deep red, with the direction of maximum absorption in the 010 plane approximately -35° from the c axis. Oscillation, rotation, equt-inclination Weissenberg and precession photographs were taken, ustng Cu $K\alpha$ radiation. The cell dimensions were determined from the rotation and zero-level Weissenberg photographs, the camera radius of 57.074 mm having been determined by calibration with sodium chloride. The dimensions of the monoclinic unit cell were found to be: $a_o = 11.94 \pm 0.01$, $b_o = 10.66 \pm 0.02$, $c_o = 12.97 \pm 0.02$ Å, $\beta = 114.6 \pm 0.1°$. Systematic extinctions were found for hkl reflections with h + k odd and for h0l reflections with l odd. The space group must then be either Cc-C_s^4 or C2/c-C_{2h}^6.

The observed density of 1.557 g cm^{-3} agrees well with the density of 1.567 g cm^{-3} calculated on the basis of four formula units per unit cell.

WAU. 01:008

Washington U. Dept. of Chemistry, Seattle.

LOW RESOLUTION ELECTRONIC SPECTRUM OF HEXAMETHYLBENZENE WITH APPLICATION TO BENZENE, by R. C. Nelson and W. T. Simpson. June 1955 [6]p. incl. diagrs. refs. (AF 18(600)375) Unclassified

Published in Jour. Chem. Phys., v. 23. 1146-1151, June 1955.

The crystal spectrum of hexamethylbenzene has been obtained using polarized light in the region 1725-2800 Å and the results including extinctions for out-of-plane absorption are tnterpreted. The vapor spectrum has been determined in the region 1300-2800 Å and the solution spectrum shows a new band at 2350 Å. A suggestion is made for determining quantum numbers in the Rydberg sertes formula. (Contractor's abstract)

WAU. 01:009

Washington U. Dept. of Chemistry, Seattle.

POLARIZATION OF THE 1850 Å BAND OF AMIDES, by D. L. Peterson and W. T. Simpson. [1955] [2]p. tncl. diagr. (AF 18(600)375) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 3929-3930, July 20, 1955.

A measurement of the transitional moment-vector dtrection for the ftrst N, V transition tn amtdes was obtatned on sublimated flakes of myristamide, in the region beiween 2300 and 1600 Å with ltght polarized along a and b crystallographic axes which are the prtncipal dtrections. X-ray precesston photographs were utilized in the orienlatton of samples. The optical denstty ratios observed along the principal dtrections over the long-wave-length (1/3 of the main band) were constant at $D_a/D_b = 14.62$; the resulting value for the ortentatton of the electric moment ts $\theta = \pm \arctan 0.262$, where θ is measured from the a axis. From the known crystal structure of myrtsta-mtde, the computed ortentations, tndicative of the amtde group ttself, were 9.1° and 26.7° from the line joining the N and O. These values do not agree with the recent data reported by Ward (Chem. Abstracts, v. 49: 7381a, 1955) whtch inferred that absorptton must be nearly along the C-N ltne of the amide group.

WAU. 01:010

Washington U. Dept. of Chemistry, Seattle.

LOW RESOLUTION ELECTRONIC SPECTRUM OF CRYSTALLINE PARA-DIMETHOXYBENZENE WITH APPLICATION TO BENZENE, by A. C. Albrecht and W. T. Simpson. Aug. 1955 [6]p. incl. diagrs. table, refs. (AF 18(600)375) Unclassified

Published in Jour. Chem. Phys., v. 23: 1480-1495, Aug. 1955.

The spectrum of a thin (0.37 μ) crystal of para-dimethoxybenzene for light incident on the 001 plane and polarized along the a and b crystallographic axes is given. From this, approximate spectra are deter-mined for the two in-plane directions of the molecule. Absorptton at 2900 Å is polarized predominantly in a direction perpendicular to the line joining the substituents while absorption at 2350 Å is parallel to this line. The 2600 and 2000 Å absorptions tn benzene are related respectively to the 2900 and 2350 Å bands in

dimethoxybenzene and consequently the benzene bands are found to arise from transition to upper states of species B_{2u} and B_{1u} respectively. The relation to conventional orbital theory is briefly discussed. (Contractor's abstract)

WAU. 01:011

Washington U. Dept. of Chemistry, Seattle.

SPECTROSCOPIC STUDY OF WURSTER'S BLUE AND TETRAMETHYL-p-PHENYLENE-DIAMINE WITH ASSIGNMENTS OF ELECTRONIC TRANSITIONS, by A. C. Albrecht and W. T. Simpson. [1955] [8]p. incl. diagrs. table, refs. (AF 18(600)375) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 4454-4461, Sept. 5, 1955.

The visible and near ultraviolet bands of Wurster's Blue, and the ultraviolet bands of N, N, N', N'-tetramethyl-p-phenylenediamine are studied experimentally and given qualitative theoretical interpretation. Relative symmetry classification of the electronic wave functions is achieved by the method of polarized photooxidation. This information together with one absolute symmetry classification based on the pleochroism of crystals of Wurster's Blue perchlorate leads to assignment of the 2600 Å band of benzene as $A_{1g} \rightarrow B_{2u}$, and the 2000 Å band of benzene as $A_{1g} \rightarrow B_{1u}$. Orientation effects in polarized photooxidation experiments are given quantitative consideration. (Contractor's abstract)

WAU. 01:012

Washington U. Dept. of Chemistry, Seattle.

RESONANCE FORCE THEORY OF CAROTENOID PIGMENTS, by W. T. Simpson. [1955] [5]p. incl. diagrs. refs. (AF 18(600)375) Unclassified

Published in Jour. Amer. Chem. Soc., v. 77: 6164-6168, Dec. 5, 1955.

A theory of the electronic spectra of carotenoid pigments is presented in which the double bonds are treated as quasi independent weakly interacting systems. The excited states are described as derived from an n-fold degenerate manifold, where n is the number of double bonds. The states split under a perturbation patterned after simple electrostatic resonance interaction. A number of experimentally observed phenomena are considered including the positions of energy levels, the ground state steric configuration, isomerization processes, intensities and intensity changes. (Contractor's abstract)

WAU. 01:013

Washington U. Dept. of Chemistry, Seattle.

MODIFICATION OF THE VECTOR MODEL TO INCLUDE A FIRST ORDER NON-ORTHOGONALITY CORRECTION, by W. T. Simpson. [Mar. 1956] 10p. refs. (AFOSR-TN-56-78) (AF 18(600)375) AD 81530 Unclassified

Also published in Jour. Chem. Phys., v. 25: 1124-1127, Dec. 1956.

When the vector model is used to describe chemical bonding, it appears that the orbitals participating in bond formation are required to be orthogonal. The success of the model on an empirical basis is puzzling because chemical binding will not occur without overlap. In this study the many-electron functions, consisting of products of appropriately overlapping ordinary atomic orbitals, are orthogonalized. The characteristic simple form of the model is then retained provided that the exchange integral is replaced by a corrected exchange integral called a bond integral. The success of the model becomes less puzzling because this integral is usually evaluated empirically. The nature of the bond integral is examined in the framework of the Heitler-London treatment of the H_2 molecule. (Contractor's abstract)

WAU. 01:014

Washington U. Dept. of Chemistry, Seattle.

COUPLING STRENGTH FOR RESONANCE FORCE TRANSFER OF ELECTRONIC ENERGY IN VAN DER WAALS SOLIDS, by W. T. Simpson and D. L. Peterson. [1956] [19]p. incl. diagrs. refs. (AFOSR-TN-56-195) (AF 18(600)375) AD 87068 Unclassified

Also published in Jour. Chem. Phys., v. 26: 588-593, Mar. 1957.

The interpretation of the absorption spectrum of a molecular crystal requires a knowledge of the strength of resonance force electrostatic interaction between molecules in the crystal as compared to an energy parameter characterizing the molecular vibrational level pattern. Depending on the relative magnitudes of these energy terms the spectrum reflects absorption by the crystal as a whole or by independent, though oriented molecules. These 2 familiar cases are examined from both stationary state and time-dependent points of view with the object of defining the energy parameters. The resonance force interaction term is a theoretically derived quantity, the crystal electronic band width; the comparable vibrational energy term is shown to be the width of the total electronic band comprising all the vibronic transitions for an isolated molecule. Particular attention is given to the case in which these terms are nearly equal. (Contractor's abstract)

WAU. 01:015 - WAU. 02:002

WAU. 01:015

Washington U. Dept. of Chemistry, Seattle.

THEORETICAL ELECTRONIC SPECTRUM OF THE ALLYL SYSTEM, by H. D. Hunt, D. L. Peterson, and W. T. Simpson. [June 1956] [17]p. incl. diagrs. tables, refs. (AFOSR-TN-56-285) (AF 18-(600)375) AD 89495 Unclassified

Also published in Jour. Chem. Phys., v. 27: 20-23, July 1957.

Properties of π-electrons in allyl anion, cation, and radical are calculated by including interaction between anti-symmetrized products of molecular-orbital functions. Detailed results in the form of energies and orbital composition of π-electron state function for the anion as well as transition intensities and energies for all 3 molecules, including and excluding configurational interaction, are presented. The extent to which a valence-bond-type wave function resembles an obtained state function is investigated by the computation of overlaps between the 2 functions. The overlaps and energies of various valence-bond-type functions are presented, and suggest a relatively greater applicability of the valence-bond approach in the case of the neutral radical compared to that of the ions. (Contractor's abstract)

WAU. 01:016

Washington U. Dept. of Chemistry, Seattle.

CLASSIFICATION OF π-ELECTRON STATES, by W. T. Simpson. [1956] [6]p. incl. diagrs. refs. (AF 18-(600,375) Unclassified

Published in Jour. Amer. Chem. Soc., v. 78: 3585-3590, Aug. 5, 1956.

A classification of π-electron states is proposed in which two types are distinguished. The first type is described as involving resonance among normal structures. Empirical justification may be found in the spectra of dyes, radicals and aromatic hydrocarbons. The second is described as involving resonance among excited structures. States of this type are reached in transitions in the carotenoid pigments. The spectra of benzene, azulene and naphthalene are examined and the various states classified as belonging to one or the other of the two types under consideration (Contractor's abstract)

WAU. 01:017

Washington U. Dept. of Chemistry, Seattle.

CALCULATION OF BOND EIGENFUNCTION MATRIX ELEMENTS WITH THE VECTOR MODEL, by W. T. Simpson. Dec. 1956 [2]p. (AF 18(600)375) Unclassified

Published in Jour. of Chem. Phys., v. 25: 1297-1298, Dec. 1956.

The vector model is generally considered not too well suited for abbreviated valence bond calculations in which not all of a set of interacting linearly independent canonical structures are used. But the model can be adapted to give matrix elements connecting bond eigenfunctions. This is demonstrated with a simple case in which the exchange degeneracy problem is considered for the π electrons in benzene whereby the Kekulé structures are used, but the Dewar structures are omitted.

WAU. 02:001

Washington U. Dept. of Chemistry, Seattle.

HYDROGEN SORPTION AND THE PARAHYDROGEN CONVERSION ON EVAPORATED NICKEL FILMS, by J. H. Singleton. Mar. 18, 1957 [6]p. incl. diagrs. tables, refs. [Technical note no. 1] (AFOSR-TN-56-211) (AF 18(600)987) AD 87525 Unclassified

Also published in Jour. Phys. Chem., v. 60: 1606-1611, Dec. 1956.

The changes in electrical resistance of an evaporated Ni film, due to the adsorption and absorption of H, have been studied at -78°. Three processes have been distinguished. Initially, H is irreversibly adsorbed causing a drop in resistance. This is followed by reversible adsorption over a pressure range from 10^{-5} to at least 600 mm, causing an increase in resistance; this adsorbed H is responsible for the parahydrogen conversion. A third type of sorption occurs rapidly at room temperature and to an appreciable extent at -78°, decreasing the resistance of the film and poisoning the catalyst with respect to the parahydrogen conversion. The limitations involved in obtaining evaporated metal films of reproducible properties are discussed. (Contractor's abstract)

WAU. 02:002

Washington U. Dept. of Chemistry, Seattle.

ARGON-XENON LAYER FORMATION ON SMITH'S BLACK FORM 65° TO 80°K, by C. F. Prenzlow and G. D. Halsey, Jr. [Aug. 1956] [22]p. incl. diagrs. table, refs. (AFOSR-TN-56-396) (AF 19(604)247 and AF 18(600)987) AD 96054 Unclassified

Also published in Jour. Phys. Chem., v. 61: 1158-1165, Sept. 1957.

Argon (A) isotherms have been determined over the range 70°-80°K, in order to calculate the energies and entropies of adsorption of A on bare P-33(2700) C black, the same black covered with 1 layer of preadsorbed Xe and with 6 layers of Xe. Since the isotherms show a progressive sharpening of their stepwise character with reduction in temperature, measurements of the the isotherms of A, O_2, and N_2 were made at 65°K on the bare surface and on 1 layer of Xe. The results were compared with other data to provide 20 estimates of v_m and the area. A study of the riser in the second layer of Xe from 65° to 70°K failed to disclose a vertical discontinuity. It is concluded that the 2-dimensional Ising model is not applicable to this system. (Contractor's abstract)

WAU. 03:001

Washington U. Dept. of Physics, Seattle.

STUDIES OF TRANSITIONS BETWEEN PURE QUADRUPOLE ENERGY STATES UNDER PULSED EXCITATION, by O. J. Judd and W. G. Proctor. Sept. 1954 [34]p. incl. diagrs. ([AF]OSR-TN-54-256) (AF 18-(600)653) AD 59812 Unclassified

The transients following one and two pulses of radio-frequency excitation forcing transitions between the almost pure quadrupole energy levels have been examined for Cl^{35} in $NaClO_3$. The observed patterns are compared to calculations for a number of crystal orientations. Both nuclear absorption and induction techniques were used, and general formulas are provided for examination of signals for both techniques, with the restriction that the electric field gradient is axially symmetric.

WAU. 03:002

Washington U. [Dept. of Physics, Seattle].

NUCLEAR ELECTRIC QUADRUPOLE INTERACTIONS OF B^{11} IN KERNITE (Abstract), by H. L. Blood and W. G. Proctor. [1954] [1]p. [AF 18(600)653] Unclassified

Presented at Meeting of the Amer. Phys. Soc., Seattle, Wash., July 7-10, 1954.

Published in Phys. Rev., v. 96: 861, Nov. 1, 1954.

Kernite, a monoclinic crystal of space group $P2/c$, has four molecules $Na_2B_4O_7 \cdot 4H_2O$ in a unit cell. Rotation of the crystal about the symmetry axis when perpendicular to a strong magnetic field H_0 reveals a pattern of 11 lines for the transitions between the magnetic energy levels of B^{11} ($I = 3/2$), strongly perturbed by the nuclear electric quadrupole interaction. Rotation about an axis perpendicular to the symmetry axis reveals a pattern of 21 lines, which, when related to the above, establish four non-equivalent sites for the boron nuclei in the unit cell. One rotation is sufficient to specify the electric field gradient tensor (except for signs) at a nuclear site if, as is the case for two of the sites, the transitions are such that second perturbation methods may be used in the analysis. In this way we have obtained a tentative value for the quadrupole coupling constant at one site to be 1250 kc. Rotation about a third axis is now in progress.

WAU. 03:003

Washington U. Dept. of Physics, Seattle.

A NOTE ON THE STRUCTURE OF KERNITE, by H. L. Blood and W. G. Proctor. Mar. 1955, 4p. incl. tables. ([AF]OSR-TN-55-35) (AF 18(600)653) AD 58380 Unclassified

A study was made of the nuclear electric quadrupole interactions of B^{11} and Na^{23} in a single crystal of kernite, $Na_2B_4O_7 \cdot 4H_2O$, the low hydrate of the sodium biborates, using nuclear magnetic resonance techniques. Analysis of the frequency dependence of the various transitions involved upon crystal orientation in the magnetic field was carried out according to the theory of Volkoff (Canad. Jour. Phys., v. 31: 820, 1953). The analysis shows that there are 4 nonequivalent sites for B in the tetramolecular unit cell. Two of these sites have strong quadrupole interactions, and 2 have relatively weak interactions as shown by the magnitudes of the quadrupole coupling constants. Furthermore, there are 4 B atoms associated with each site, the positions of 2 being obtained from each other by inversion through the center of symmetry, and the positions of the remaining 2 being obtained from these by rotation about the 2-fold symmetry axis. Tabular data present for each site the absolute values of the largest quadrupole coupling constant and the eigenvalue of the electric field gradient tensor, the asymmetry parameter, and the orientation of the principle electric axis. It is pointed out that the present data conflict seriously with the kernite model proposed by Pertoles.

WAU. 03:004

Washington U. [Dept. of Physics] Seattle.

SATURATION OF NUCLEAR QUADRUPOLE ENERGY LEVELS BY ULTRASONIC MEANS (Abstract), by W. H. Tantilla and W. G. Proctor. [1955] [1]p. ([AF]OSR-TN-55-127) (AF 18(600)653) Unclassified

Published in Phys. Rev., v. 98: 1854, June 15, 1955.

The pure quadrupole energy levels of Cl^{35} in $NaClO_3$ have been partially saturated by subjecting a $NaClO_3$

WAU. 03:005 - WAU. 03:008

crystal to ultrasonic waves at the transition frequency (30 mc). The experiment was performed at liquid nitrogen temperature at which the thermal relaxation time is about 0.9 sec; the acoustic energy was introduced into the crystal for a period of 0.3 sec. The population difference of the two energy levels was determined shortly after the cessation of the ultrasonic pulse by the amplitude of a pulsed nuclear induction signal. It was observed that the population difference was reduced at least by a factor of five. The experiment was performed in order to study the relaxation mechanisms of the Cl nuclei in the crystal. (Contractor's abstract)

WAU. 03:005

Washington U. [Dept. of Physics] Seattle.

NUCLEAR ELECTRIC QUADRUPOLE INTERACTIONS OF Rb^{87} IN A RUBIDIUM TUTTON SALT (Abstract), by R. F. Kiddle and W. G. Proctor. [1955] [1]p. ([AF]OSR-TN-55-128) [AF 18(600)653] Unclassified

The splitting of the normal nuclear Zeeman spectrum of Rb^{87} by the interaction of the electric quadrupole moment with the electric field gradients in a single crystal of the monoclinic Tutton salt $Rb_2Mg(SO_4)_2 \cdot 6H_2O$ has been observed with a nuclear induction spectrometer. We find that there are two distinguishable sites in the bimolecular unit cell, as would be expected from the crystal symmetry (P2, a). Analysis with perturbation theory gives a quadrupole coupling constant of 3109 ± 50 kc/sec with an asymmetry parameter η equal to .48 ± .05 for both sites, although the orientations of the principal axes of the field gradient tensor are not identical. From the known value of the Rb^{87} quadruple moment (Q_{zz}) is calculated to be 4.3×10^4 statvolts/cm^2, indicating that the crystal bonding is primarily ionic in character. (Contractor's abstract)

WAU. 03:006

Washington U. [Dept. of Physics] Seattle.

NUCLEAR QUADRUPOLE THERMAL RELAXATION IN SODIUM CHLORATE, by C. H. Chang. Aug. 1955 [31]p. incl. diagr. table, refs. ([AF OSR-TN-55-401]) (In cooperation with Smith Coll., Northampton, Mass.) (AF 18(600)653) AD 79857 Unclassified

The theory of nuclear quadrupole thermal relaxation in solids is applied to the Cl nucleus in the $NaClO_3$ crystal to determine: (1) theoretical values of the thermal relaxation time as a function of temperature; and (2) the possibility of externally exciting electric quadrupole transitions by the application of ultrasonic waves of appropriate frequency. The calculation of relaxation time is based on a simplified model in which the field-gradient tensor is assumed to have axial symmetry and to be correctly expressed by 2 terms in a Taylor expansion of the distance between the Cl nucleus and a single nucleus that is responsible for the electric field. A semiphenomenological theoretical calculation is made of the temperature dependence of the nuclear electric quadrupole thermal relaxation time. The energy density required in an ultrasonic wave for influencing the thermal relaxation time is of the order of 2×10^{-4} ergs/cu cm/kc over the natural bandwidth for the case of longitudinal waves at liquid-air temperature. At room temperature, the energy required would have to be about 20 times larger; another factor of 20 would be required at each temperature if the excitation is to be transverse rather than longitudinal waves. (ASTIA abstract)

WAU. 03:007

Washington U. Dept. of Physics, Seattle.

ULTRASONIC SATURATION OF NUCLEAR MAGNETIC ENERGY LEVELS, by W. G. Proctor and W. A. Robinson. Mar. 1, 1956 [3]p. (AFOSR-TN-56-101) (AF 18(600)653) AD 82014 Unclassified

Also published in Phys. Rev., v. 102: 1183-1184, May 15, 1956.

A change in the population of the nuclear magnetic energy levels of Na^{23} in a single crystal of NaCl was observed as a result of ultrasonic excitation. Tests were performed in a steady magnetic field of 4220 oersteds, and the nuclear magnetic resonance occurred at a frequency of 4.75 mc/sec. Thermal relaxation time was 8 sec at room temperature. A decrease in the $m = +3/2$, $m = -3/2$ population difference for a small range of ultrasonic frequencies centered exactly at twice the nuclear frequency. The difference of frequency values was 4 kc/sec for the population decrease, which was 1/2 of the maximum decrease.

WAU. 03:008

Washington U. [Dept. of Physics] Seattle.

ULTRASONIC EXCITATION OF NUCLEAR MAGNETIC ENERGY LEVELS OF Na^{23} IN NaCl, by W. G. Proctor and W. A. Robinson. [1956] iv. incl. diagrs. tables, refs. [AFOSR-TN-56-465] [AF 18(600)653] AD 97093 Unclassified

Also published in Phys. Rev., v. 104: 1344-1352, Dec. 1, 1956.

The nuclear magnetic levels of Na^{23} in a single crystal of NaCl placed in a strong magnetic field have been saturated by the pure quadrupole transition $\Delta m = 2$, caused by ultrasonic excitation. The observed transition rate has been compared with theoretical expressions to find that the electric field gradient generated at the nuclear site by the lattice distortion is very close to that expected from a simple classical model. Hence the

large covalent and anti-shielding factor required to explain the spin-lattice relaxation time on the basis of the theory of Van Kranendonk (Physica, v. 20: 781, 1954) is not found. Possible reasons for this discrepancy are discussed. (Contractor's abstract)

WAU. 03:009

Washington U. [Dept. of Physics] Seattle.

INFLUENCE OF ULTRASONIC ENERGY ON THE RELAXATION OF CHLORINE NUCLEI IN SODIUM CHLORATE, by W. G. Proctor and W. H. Tantilla. [1956] [7]p. incl. diagrs. tables, refs. [AF 18-(600)653] Unclassified

Published in Phys. Rev., v. 101: 1757-1763, Mar. 15, 1956.

An investigation of the direct and indirect thermal relaxation processes of Cl^{35} in a single crystal of $NaClO_3$ has been made by using pulsed techniques. The temperature dependence of the indirect process has been measured at four temperatures ranging between room temperature and liquid nitrogen temperature. The experimental results are in good agreement with the theoretical results of Chang. The direct process has been studied by introducing into the crystal ultrasonic energy at a frequency equal to the transition frequency between the two quadrupolar energy levels of the Cl^{35} nucleus. The agreement between the theoretical dependence of the direct-process relaxation time as a function of the energy density of the transition-frequency lattice vibration is poor. The experiment, as done, has the basic weakness that the calculated energy density of the introduced lattice vibrations is a function of the phonon relaxation time, T_p, a quantity only poorly known in the most favorable cases. A different method for making the same type of study independent of the phonon relaxation time is discussed. (Contractor's abstract)

WAU. 03:010

Washington U. [Dept. of Physics] Seattle.

ULTRASONIC EXCITATION IN $NaNO_3$ (Abstract), by R. T. Schumacher and W. A. Robinson. [1956] [1 .p. AF 18(600)653] Unclassified

Presented at meeting of the Amer. Phys. Soc., Eugene, Ore., June 21-23, 1956.

Published in Bull. Amer. Phys. Soc., Series II, v. 1: 254, June 21, 1956.

We have observed the effects of ultrasonic excitation of pure quadrupole transitions of Na^{23} nuclei in a single crystal of $NaNO_3$. Pound has shown that the m = 3/2 to m = 1/2 and m = -1/2 to m = -3/2 transitions are split from the center line by static electric field gradients split from the center line by static electric field gradients. It was observed in the experiment that the magnetic resonance absorption curve of the center line at ν_0 by cw techniques inducing $\Delta m = \pm 2$ transitions between m = 1/2 and m = -3/2 levels by means of an x-cut quartz transducer tuned to $2\nu_0 + \delta$, where δ is the splitting of the satellites from the center line. The strength of the center line absorption signal was observed to vary as a function of power to the transducer in a manner essentially in agreement with the theoretical predictions of m = 1/2, m = -1/2 population difference as a function of m = 1/2 ↔ m = -3/2 transition probability. The experiment also yields information about the phonon relaxation time in $NaNO_3$. Orientation dependence of the center line absorption signal at a single ultrasonic power level will be discussed.

WAU. 05:011

Washington U. [Dept. of Physics] Seattle.

NUCLEAR QUADRUPOLE INTERACTIONS IN TWO TUTTON SALTS, by R. F. Kiddle and W. G. Proctor. [1956] [5]p. incl. diagrs. table, refs. [AF 18(600)653] Unclassified

Published in Phys. Rev., v. 104: 932-936, Nov. 15, 1956.

This paper reports results of nuclear induction experiments on two isomorphic single crystals of Tutton' s salts, $Rb_2Mg(SO_4)_2 \cdot 6H_2O$ and $Cs_2Mg(SO_4)_2 \cdot 6H_2O$, belonging to crystal class $P2_1/a$. The splittings, due to nuclear electri. quadrupole interactions of the nuclear magnetic resonance spectra of Rb^{87} and Cs^{133} observed in these experiments are analyzed by using perturbation theory. Analysis of the data yields a quadrupole coupling constant for Rb^{87} of $|eQq/h| = 3141 \pm 35$ kc/sec, and the asymmetry of the field gradient at the nuclear site is $\eta = (\phi_{xx} - \phi_{yy})/\phi_{zz} = 0.47 \pm 0.01$. The principal axis of the field gradient is directed toward the nearest sulfate ion but no correlation of asymmetry and near neighbor locations is observed. Comparison of the magnitudes of the field gradient at the nuclear sites of Rb and Cs were obtained by comparing the observed line patterns for the symmetry axis rotations, using the known moments of Cs and Rb. The complexity of the Cs spectra precluded a more complete comparison of the electric field symmetry. (Contractor's abstract)

WAY. 01:001

Wayne [State] U. Dept. of Chemistry, Detroit, Mich.

ON CUPROUS OXIDE PHOTOVOLTAIC CELLS I. BAND STRUCTURE OF CUPROUS OXIDE AND THE EFFECT OF SULFIDING, by H. J. Bowden and G. M. McManus. Nov. 1954, 28p. diagrs. refs. (Technical

WAY. 01:002 - WAY. 02:003

note no. 1) ([AF]OSR-TN-54-329) (AF 18(600)481) AD 53878 Unclassified

This work stems from the original discovery by Fink and Adler that the photocurrent from cuprous oxide photovoltaic cells is increased if the cells have been subjected to a sulfiding treatment so that the top layer of the oxide is converted to cuprous sulfide. A review of information available to date on cuprous oxide is presented, with an analysis and conclusions concerning the band structure of this material. Data from Hall effect and conductivity measurements are combined to yield a value of 2.0 ev for the width of the forbidden region, with acceptor levels at 0.3 ev above the top of the filled band. Sensitivity to method of preparation is discussed. In the expertmental portion, the methods of preparing and sulfiding the cuprous oxide cells are described. The experiments to study the effect of the sulfiding on the response of the cells are described and discussed. It is found that for over-all sulfiding, short sulfiding times yielding thin films of the sulfide give the greater improvement while thicker films may even cause a decrease in output. In further experiments using open mesh top contacts, it is found that the greatest improvement is obtained when there is sulfide only under the contact. It is concluded that the effect of the sulfiding treatment is to create a low resistance ohmic contact. This view is supported by experiments with a moving light probe. Further, various cells were made from isolated films of cuprous oxide by applying silver paint contacts, and studies on these indicate that the ordinary unsulfided contacts are rectifying while the sulfided contacts are nonrectifying. (Contractor's abstract)

WAY. 01:002

Wayne [State] U. [Dept. of Chemistry] Detroit, Mich.

THE MAXIMUM EFFICIENCY OF SOLAR ENERGY CONVERSION BY QUANTUM PROCESSES, by D. Trivich and P. A. Flinn. [1954] 8p. [AF 18(600)481] Unclassified

A method is presented for the calculation of the maximum conversion efficiency of photovoltaic cells considered as converting solar energy into electrical by quantum processes. Mathematical expressions are developed for computing the total useful solar radiation absorbed by such a cell above a threshold frequency ν_0 and for the maximum efficiency for any given value of ν_0. The optimum threshold wavelength of solar radiation received at the earth's surface is found to be about 11,600A°; the efficiency for this choice of threshold is 40% or more. Possible increase in efficiency by use of multiple converters or by minimizing back diffusion is cited, and the calculation of the optimum threshold and efficiency is appended.

WAY. 01:003

Wayne [State] U. [Dept. of Chemistry] Detroit, Mich.

PHOTOVOLTAIC CELLS IN SOLAR ENERGY CONVERSION, by D. Trivich, P. A. Flinn, and H. J. Bowlden. [1954] 11p. incl. diagrs. table. [AF 18(600)481] Unclassified

The function and mechanism of n-p type photovoltaic cells are illustrated and described. Various factors affecting the power efficiency for conversion of solar into electrical energy are briefly analyzed and discussed. Measured values for commercial selenium cells of 1.5 cm^2 area at various qualities and intensities of light are tabulated with regard to short circuit current, open circuit potential maximum power, quantum yield, voltage and power efficiency.

WAY. 02:001

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

ON A PROBLEM OF MINIMAL SURFACE AND OF COMPRESSIBLE FLOW EQUATION WITH POLYGONAL BOUNDARY (I), by Y. W. Chen. Jan. 1954, 45p. ([AF]OSR-TN-54-10) (AF 18(600)437) AD 25396 Unclassified

Presented at meeting of the Amer. Math. Soc., New York, Apr. 23-24, 1954.

Abstract published in Bull. Amer. Math. Soc., v. 60: 338, July 1954.

The problem of a minimal surface in the compressible flow of a gas obeying Chaplygin's approximate adiabatic law is discussed as part of an investigation of a uniform stream disturbed by the presence of a polygonal profile. Solutions with convex polygonal profiles are obtained in the physical plane by a method of conformal mapping which generalizes the classical Schwarz-Christoffel formula.

WAY. 02:002

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

ON A MIXED BOUNDARY VALUE PROBLEM OF HARMONIC FUNCTIONS, by N. Pernavs and Y. W. Chen. Nov. 1954, 6p. ([AF]OSR-TN-54-310) (AF 18(600)437) AD 51760 Unclassified

Also published in Proc. Amer. Math. Soc., v. 7: 127-130, Feb. 1956.

A simple proof is given by the use of subharmonic functions of the existence and uniqueness of the mixed boundary value problem. The proof involves the use of conformal mapping, and is the only step of the proof which cannot be used to treat the problem for more than 2 independent variables.

WAY. 02:003

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

DEGENERATE SOLUTIONS OF PARTIAL

DIFFERENTIAL EQUATIONS, by Y. W. Chen. June 30, 1954 [7]p. (AF 18(600)437) Unclassified

Published in Proc. Amer. Math. Soc., v. 6: 855-861, Dec. 1955.

The equation of motion of compressible fluids is of the form

$$(*)\quad L(u) = \sum_{i,j=1}^{n} a_{ij}(p_1, p_2, \cdots, p_n)\partial^2 u/\partial x_i \partial x_j = 0$$

$$\left(p_i = \frac{\partial u}{\partial x_i}\right).$$

A solution of (*), whose first partial derivatives satisfy n - s functional relations

$$p_\alpha = F^\alpha(p_1, \cdots, p_s) \quad (\alpha = s+1, s+2, \cdots, n)$$

among themselves is called a "s-tuple wave" (degenerate compressible flow). A necessary and sufficient condition for the existence of a degenerate solution u, of the type of an s-tuple wave, with nonvanishing determinant $|\partial^2 u/\partial x_k \partial x_l|$ is the following: the n - s + 1 functions F^α and G satisfy a system of C(n - 1, s - 1) differential equations of second order and degree s - 1, in the variables p_k,

$$(**)\quad (a_{lk} + 2a_{l\beta}\partial F^\beta/\partial p_k + a_{\alpha\beta}\partial F^\alpha/\partial p_l \partial F^\beta/\partial p_k) P_{lk}^{(m)} = 0$$

with

$$|x_\alpha \partial^2 F^\alpha/\partial p_l \partial p_k + \partial^2 G/\partial p_l \partial p_k| \neq 0.$$

The author introduces new independent variables $x_1', \cdots, x_n'$ and dependent variable $u'(x_1', \cdots, x_n')$ by the elementary contact transformation:

$$x_k' = p_k,\ x_\alpha' = x_\alpha,\ u' = u - p_k x_k,\ p_k' = -x_k,\ p_\alpha' = p_\alpha.$$

Hence one obtains:

$$G(x_1', x_2', \cdots, x_s') = u' - x_\alpha' F^\alpha(x_1', \cdots, x_r').$$

Each $P_{lk}^{(m)}$ is a homogeneous polynomial of degree s - 1 in the second derivatives of F^α and G with integer coefficients. In the case of double waves (s = 2) there are n - 1 equations and the same number of unknown functions $F^\alpha(p_1, p_2)$ and $G(p_1, p_2)$. Centered waves are those with G = 0. An interesting example is given by $L(u) = \Delta^2 u(x_1, x_2, x_3)$. The corresponding equation (**) is the differential equation of minimal surfaces. The solution of the initial-value problem for the functions $F^\alpha(p_1, p_2)$ (s = 2, problem I), which exists uniquely in a neighborhood of the initial curve Γ in the (p_1, p_2)-plane:

$$\Gamma: p_1 = s_1(\tau),\ p_2 = s_2(\tau)$$

gives a solution of the initial-value problem for the unknown function u(x) (in the neighborhood of an initial manifold M_{n-1} in the x-space, problem II). Conversely, one can find by simple means of differentiation and elimination from an unique solution u = U(x) of problem II the solution of problem I. The author discusses especially the case of constant coefficients a_{ij}, L(u) is totally and the initial manifold is "space like". (Math. Rev. abstract)

WAY. 02:004

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

ON A BOUNDARY VALUE PROBLEM OF MINIMAL SURFACES (II), by Y. W. Chen. Jan. 1955, 28p. ([AF]OSR-TN-55-31) (AF 18(600)437) AD 53871 Unclassifted

Presented at meeting of the Amer. Math. Soc., Pittsburgh, Pa., Dec. 27-29, 1954.

A proof is presented of an existence theorem under very general assumptions on the boundary curves. The theorem is proved for any convex polygon, and the theorem is extended to boundary curves which consist of convex arcs with a finite number of protruding corners. The general case makes essential use of level lines of the harmonic function $-qx(w) + py(w) \pm z^*(w)$; $p+tq = e^{t\alpha}$, where α is arbitrary and $z^*(w)$ is the harmonic conjugate of z(w). Uniqueness is obtained for symmetrical profiles. The behavior of the discontinuity around the corners is studied. A different version of the results is formulated in terms of the conjugate minimal surfaces, and an elementary proof of the existence for a convex symmetrical profile is sketched. (ASTIA abstract)

WAY 02:005

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

DISCONTINUITY AND REPRESENTATIONS OF MINIMAL SURFACE SOLUTIONS, by Y. W. Chen. [1955] [24]p. refs. [AF 18(600)437] Unclassified

Published in Proc. Conference on Differential Equations, Maryland U., College Park (Mar. 17-19, 1955), 1956, p. 115-138.

Proof is given of the existence of a solution z(x, y) of the minimal surface equation

$$\left(\frac{z_x}{\sqrt{(1 + z_x^2 + z_y^2)}}\right)_x + \left(\frac{z_y}{\sqrt{(1 + z_x^2 + z_y^2)}}\right)_y = 0,$$

which is defined exterior to a closed convex curve C, such that (i) ∇z tends to a prescribed finite limit at infinity, and (ii) $\partial z/\partial n = 0$ on C in a generalized sense. The curve C is assumed to possess at most a finite number of protruding corners. A motivation for the problem can be found in the fact that solutions of the above equation can be viewed as local approximations

WAY. 02:006 - WES. 01:001

to "subsonic" solutions of the equations

$(\rho z_x)_x + (\rho z_y)_y = 0$,

$$\rho = [1 - \frac{\gamma - 1}{4}(z_x^2 + z_y^2)]^{1/(\gamma-1)} (\gamma > 1),$$

which describes the flow of an ideal compressible fluid. The problem is first solved in terms of uniformizing parametric coordinates (u, v) by means of an established variational procedure. The chief new difficulty is to show that the Jacobian $\partial(x, y)/\partial(u, v)$ does not vanish for this solution. This is done by a careful study of the behavior of the "Tchaplygin function"

$$\zeta = \frac{z_x - iz_y}{1 + \sqrt{(1 + z_x^2 + z_y^2)}}$$

which is an analytic function of u + iv for any solution, and is obviously bounded in magnitude. In the case that C is a convex polygon, the author shows that $\partial z/\partial n$ exists and vanishes at all points of C except at the vertices, where the solution surface necessarily contains a vertical segment. As a corollary of his method, the author shows that the corresponding problem, in which (ii) is replaced by (ii') $z = 0$ on C, admits no solution for any polygonal contour C. (Math. Rev. abstract, modified)

WAY. 02:006

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

REFLECTION LAWS OF LINEAR DIFFERENTIAL EQUATIONS OF MIXED TYPE, by Y. W. Chen. Aug. 1956, 30p. (AFOSR-TN-56-399) (In cooperation with Calif. U., Berkeley) (AF 18(600)437) AD 96057
Unclassified

A study is made of a simple class of equations of the form $x^s u_{yy} + u_{xx} = 0$, with $s \neq 0$ and of the analytical extension of the solutions. The following theorem is proved: Let $u(x, y)$ be a given solution of class C_2 in a domain $0 < x < 1$, $a < y < b$ with continuous first and mixed 2nd derivatives on $x = 0$, and let $u(0, y) = T_0(y)$, $u_x(0, y) = T_1(y)$. Then (1) $T_0(y)$ and $T_1(y)$ uniquely determine the solution, and (2) when one of the $T_1(y)$ is zero, the other is necessarily an analytic function of y. In the latter case $u(x, y)$ can be extended to become an analytic function of 2 complex variables. The classical reflection principle for harmonic functions ($s = 0$) is generalized.

WAY. 02:007

Wayne [State] U. [Dept. of Mathematics] Detroit, Mich.

DISCONTINUITY OF SOLUTIONS OF QUASI-LINEAR DIFFERENTIAL EQUATIONS IN TWO VARIABLES, by Y. W. Chen. [Aug. 1956] [9] p. refs. [AF 18-(600)437]
Unclassified

Published in Commun. Pure and Appl. Math., v. 9: 373-381, Aug. 1956.

Published in Trans. Symposium on Partial Differential Equations, California U., Berkeley (June 20-July 1, 1955), N. Y., Interscience Publishers Inc., 1955, p. 75-83.

This paper consists of two parts. The first part is concerned with hyperbolic differential equations of the following form: $A(p_x, p_y)\, p_{xx} + B(p_x, p_y)\, p_{xy} + C(p_x, p_y)\, p_{yy} + k(p_x, p_y) y^{-1} p_y = 0$. A discontinuity of a second derivative of p propagates along the backward characteristics to a point P on the axis $y = 0$, and the question is how this continuity will be reflected from the axis into the interior of the domain along the forward characteristic issued from P. This paper demonstrates in a very simple manner both the quantitative and qualitative features of the non-linear behavior of the solution, without going into the details of the convergence procedure which is indicated. In the second part of this paper statement is made of an existence theorem for the equation of minimal surfaces, and an outline of the proof is given. The problem is to find a solution $z(x, y)$ of:

$$(1 + z_y^2) z_{xx} - 2z_x z_y z_{xy} + (1 + z_x^2) z_{yy} = 0$$

in the exterior of a convex curve C with a finite number of protruding corners, such that it has a preassigned normal direction at infinity and $\partial z/\partial n = 0$ on C. (Contractor's abstract, modified)

WES. 01:001

Wesleyan U. Dept. of Chemistry, Middletown, Conn.

THE APPARENT ABSORPTION SPECTRUM OF PHOTOLYTIC COLLOIDAL SILVER, by E. V. Rosenberg, R. M. Rosenberg, and J. Gomez-Ibanez. Aug. 27, 1956 [7] p. incl. diagrs. table. (AFOSR-TN-56-421) (AF 18(600)343) AD 96502
Unclassified

In this study AgBr sols were added to mixtures of NH_3-$Na_2S_2O_3$. The resulting solutions were colorless if the sols had not been exposed to light, but exhibited a yellow-brown color if they had been exposed to a 100-w bulb light source. The absorption spectra of the exposed solutions (photolytic Ag sols), determined with Bechman DU or Model B spectrophotometers, showed a broad peak near 410 mμ which changes shape and decreased in absorbancy over a 24-hr period. Test results indicated that the apparent absorption spectrum is produced by colloidal Ag, thus supporting the latent-image hypothesis. The hypothesis is further strengthened by the results of Van Kreveld and Jurriens (Physica, v. 4: 285, 1937) who measured the decrease in transmittance of a photographic emulsion on exposure.

WHE. 01:001

Westinghouse Electric Corp. Westinghouse Research Labs., East Pittsburgh, Pa.

INVESTIGATION OF PROPOSED HIGH-VOLTAGE BREAKDOWN MECHANISM, by A. I. Bennett, Jr. June 23, 1954, 6p. incl. diagrs. refs. (Repl. no. 71F159-R1) (AF 18(600)793) Unclassified

It is known that if a sufficiently high potential difference is impressed in a pair of electrodes immersed in a high vacuum (i.e., at a pressure < 10^{-6} mm Hg), a catastrophic reaction occurs, culminating in a high-current, low-voltage arc limited primarily by the power supply. Inasmuch as this phenomenon is usually a limiting factor in high-voltage devices employing vacuum tubes, attempts have been made to determine the nature of the mechanism involved in this breakdown. A mechanism of breakdown proposed some time ago by J. G. Trump and R. J. Van de Graaf (Jour. Appl. Phys., v. 18: 327, 1947) is reviewed in the light of recent data which indicate that the process may actually be adequate to explain this phenomenon. The Trump-Van de Graaf explanation envisions an electron, produced perhaps by field emission, leaving the cathode and striking the anode, where there is a finite probability that a positive ion or photon will be ejected. All of the positive ions, and a geometrically-determined fraction of the photons, will in turn impinge on the cathode, releasing some electrons by photoemission or by ion secondary emission. If the average number of such secondary electrons produced/primary electron is > 1, a cumulative process will occur, resulting in breakdown. A proposed experiment is described, by means of which it should be possible to obtain quantitative information about this mechanism. One of the major advantages of the experiment is that data are taken without actually causing breakdown, which if allowed to occur, would probably change the nature of the electrodes, making the results of subsequent experiments different. A disadvantage of the proposed experiment is that the photoelectron production is not measured under conditions of high-cathode gradient such as usually exists in actual high-voltage vacuum installations.

WHE. 01:002

Westinghouse Electric Corp. Westinghouse Research Labs., East Pittsburgh, Pa.

[INVESTIGATION OF PROPOSED HIGH-VOLTAGE BREAKDOWN MECHANISMS], by A. I. Bennett, Jr. Final rept. Dec. 1, 1954, 7p. incl. refs. (Rept. no. 71F159-R2) (AF 18(600)793) AD 51753 Unclassified

This study is concerned with high-voltage breakdown in a vacuum. In this brief review, the following are presented: (1) a description of the basic problem involved; (2) the experimental apparatus used; (3) the experimental and theoretical work performed, and (4) the present and proposed experimental program. It is concluded that the necessary apparatus is available for a series of experiments designed to throw light on the nature of the fundamental processes of high-voltage breakdown. It does not seem likely that an experimental program involving the actual production of successive breakdowns can yield much exact information on the initiation mechanism, since the discharge itself radically alters the properties of the surfaces involved. The absence of actual breakdown is an advantage offered by the present experimental program. It is pointed out that any research on breakdown initiation must include procedures for obtaining and preserving the cleanest possible surfaces. A bibliography of 41 references compiled from published literature, ranging in time from 1922 to 1954, is included.

Whitemarsh Research Labs., Wyndmoor, Pa. see Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs., Wyndmoor.

WIS. 01:001

Wisconsin U., Madison.

CHARACTERIZATIONS OF FOURIER-STIELTJES TRANSFORMS, by W. F. Eberlein. Sept. 1, 1954, 5p. (Technical note no. 2) ([AF]OSR-TN-54-242) (AF 18(600)679) AD 44481 Unclassified

Also published in Duke Math. Jour., v. 22: 465-468, Sept. 1955.

A complex-valued function $\phi(x)$ on a locally compact Abelian group G with character group Γ is said to satisfy condition (B) if for some constant M

$$\left| \sum a_n \phi(x_n) \right| \leq M \sup_{\gamma \in \Gamma} \left| \sum a_n (x_n, \gamma) \right|$$

for all finite sets of complex numbers (a_n) and points (x_n) in G. The function ϕ is called a Fourier-Stieltjes transform (F-S) if there exists a bounded Radon measure μ on Γ such that

$$\phi(x) = \int_{\Gamma} (x, \gamma) d\mu(\gamma).$$

The main result is the following theorem: If ϕ is measurable and satisfies (B), there exists a unique Radon measure μ on Γ such that (F-S) holds nearly everywhere in x and $\| \mu \| \leq M_0$, where M_0 is the smallest value of M satisfying B. If ϕ is continuous, then (F-S) holds everywhere and $\| \mu \| = M_0$.

WIS. 01:002

Wisconsin U., Madison.

ON NUMERICAL INTEGRATION I, by W. F. Eberlein.

WIS. 01:003 - WIS. 02:002

Nov. 2, 1954, 8p. incl. table. (Technical note no. 3) ([AF]OSR-TN-54-243) (AF 18(600)679) AD 52633 Unclassified

In this report, it is shown that the choice of optimal quadrature formula leads to the problem of minimizing the expression

$$E(s) = (s+1)^{-1} - \sum_{m=1}^{n} A_m X_m^s \quad (0 \leq s \leq \infty)$$

under a suitable norm. A two-point formula is calculated which is better than the two-point Gauss formula in a number of standard cases. (Contractor's abstract)

WIS. 01:003

Wisconsin U., Madison.

THE POINT SPECTRUM OF WEAKLY ALMOST PERIODIC FUNCTIONS, by W. F. Eberlein. Sept. 3, 1954, 4p. (Technical note no. 4) ([AF]OSR-TN-54-244) (AF 18(600)679) AD 44949 Unclassified

Also published in Mich. Math. Jour., v. 3: 137-139, 1955-56.

A proof is presented for the following theorem: every function x in the family W of weakly almost periodic functions on a locally compact Abelian group G admits the unique decomposition $x = x_1 + x_2$, where x_1 is in the algebra u of almost periodic functions on G, and $M(|x_2|^2) = 0$; x_2 has no point spectrum.

WIS. 01:004

Wisconsin U., Madison.

A NOTE ON FOURIER-STIELTJES TRANSFORMS, by W. F. Eberlein. June 1, 1954, 3p. (Technical note no. 1) (AF 18(600)679) AD 40281 Unclassified

Also published in Proc. Amer. Math. Soc., v. 6: 310-312, Apr., 1955.

The author establishes a Parseval formula:

$$M(|\tilde{\mu}|^2) = \sum_{\gamma \in G^*} |\mu\{\gamma\}|^2,$$

where μ is a bounded Radon measure on the dual G^* of a locally compact Abelian group G, M denotes the mean value over G, and where $\tilde{\mu}$ is the Fourier transform of μ. The mean value used is that arising in the author's theory of weak almost periodic functions. The crux of the proof lies in showing that, with the mean value thus defined, one has $\mu\{0\} = M(|\tilde{\mu}|)$, a result easily established in the case of the real line owing to the special form of M there applicable. The formula is applied to give rapid proofs and extensions of some known results. (Math. Rev. abstract)

WIS. 01:005

Wisconsin U., Madison.

ON WEAK COMPACTNESS IN FUNCTIONAL ANALYSIS, by A. W. Wymore. June 17, 1955, 55p. refs. (Technical note no. 5) ([AF]OSR-TN-55-131) (AF 18(600)679) AD 69754 Unclassified

The theory of weak compactness in linear topological spaces is unified and developed from the point of view of the set of real-valued functions continuous on a compact Hausdorff space with the topology of pointwise convergence. In particular, the role played in the theory by the Lebesgue bounded convergence theorem is studied and generalizations resulting from this study are expounded. (Contractor's abstract)

WIS. 02:001

Wisconsin U., Madison.

THE SOLUTIONS OF THE DIFFERENTIAL EQUATION $v''' + \lambda^2 zv' + 3\mu\lambda^2 v = 0$, by R. E. Langer. Mar. 1, 1955 [29]p. (Rept. no. 1) ([AF]OSR-TN-55-70) (AF 18(600)1110) AD 71479 Unclassified

Also published in Duke Math. Jour., v. 22: 525-542, Dec. 1955.

The equation $v''' + \lambda^2 zv' + 3\mu\lambda^2 v = 0$, where μ is arbitrary and λ a complex parameter of large absolute value, has a double turning point at $z = 0$. The author derives asymptotic formulae for the solutions at this turning point. First, the principal solutions (1) $v_j(z)$ $(j = 0, 1, 2)$ are obtained as power series in z. Then for each integral index q a set (2) $v_{q,j}(z)$ of formal solutions in powers of $1/\lambda$ is established which represents actual solutions asymptotically in the sector $(q-1)\pi \leq \arg \zeta \leq q\pi$ $(\zeta = 1/3t\lambda z^{3/2})$ of the z-plane. Between the solutions of the set (1) and those of any set (2) there exist linear relations with coefficients that are independent of z. The main results of this paper consist in the determination of these relations. (Math. Rev. abstract)

WIS. 02:002

Wisconsin U., Madison.

THE SOLUTIONS OF A CLASS OF ORDINARY LINEAR DIFFERENTIAL EQUATIONS OF THE THIRD ORDER IN A REGION CONTAINING A MULTIPLE TURNING POINT, by R. E. Langer. May 17, 1955, 29p. (Rept. no. 2) ([AF]OSR-TN-55-143) (AF 18(600)1110) AD 71480 Unclassified

Also published in Duke Math. Jour., v. 23: 93-110, Mar. 1956.

Asymptotic forms of the solutions relative to the complex parameter λ whtch is unbounded in absolute value are determined for the equation

$$\frac{d^3w}{dz^3} + h_1(z,\lambda)\frac{d^2w}{dz^2} + \lambda^2 h_2(z,\lambda)\frac{dw}{dz} + h_3(z,\lambda)w = 0$$

in a region wtth a multiple turning point. The coefftcient functions $h_j(z,\lambda)$, $j = 1, 2, 3$, are expressible tn power sertes in $1/\lambda$ with coefftctents which are analytic functions of z. The forms of the solutions, as they depend asymptotically upon λ, are determined over a region of the complex z-plane which contains a potnt in which the critical coefficient $h_2(z,\infty)$ is zero.

WIS. 02:003

Wisconsin U., Madison.

ON THE CONSTRUCTION OF RELATED DIFFERENTIAL EQUATIONS, by R. E. Langer. Sept. 20, 1955, 28p. refs. (Rept. no. 3) ([AF]OSR-TN-55-350) (AF 18(600)1110) AD 75539 Unclassifted

Also published in Trans. Amer. Math. Soc., v. 81: 394-410, Mar. 1956.

A differenttal equation $L(u) = 0$ is said to be "related to" another equation $\mathcal{L}(u) = 0$, tf its solution forms are explicitly known and the coefficients of the 2 equations are the same to an arbttrarily prescribed degree. From the known solution forms of the one equation, the unknown ones for the other equation can be deduced by standard methods. This paper considers the case in

whtch $\mathcal{L}(u) = \frac{d^n u}{dz^n} + \lambda p_1(z,\lambda)\frac{d^{n-1}u}{dz^{n-1}} + \cdots + \lambda^n p_n(z,\lambda)u$,

with λ a large parameter, the regton of the variable z contatning a turning point at which $m < n$ of the roots of the auxtliary algebraic equation cotncide in accordance wtth a certain coincidence pattern. It shows how the related equation may be constructed when such a construction is known for a differential equation of the order m with the same coincidence pattern. This makes theory for lower order differential equations extensible to equations of higher order. (Contractor's abstract)

WIS. 02:004

Wisconsin U., Madison.

ON THE ASYMPTOTIC SOLUTIONS OF A CLASS OF ORDINARY DIFFERENTIAL EQUATIONS OF THE FOURTH ORDER, WITH SPECIAL REFERENCE TO AN EQUATION OF HYDRODYNAMICS, by R. E. Langer. Feb. 1, 1956, 72p. refs. (Rept. no. 4) (AFOSR-TN-56-50) (AF 18(600)1110) AD 81042 Unclassifted

Also published in Trans. Amer. Math. Soc., v. 84: 144-191, Jan. 1957.

This mathematical study is concerned with the differential equation $w^{iv} + \lambda^2[P(z,\lambda)w'' + Q(z,\lambda)w' + R(z,\lambda)w] = 0$, in which P, Q and R are power series in $1/\lambda$. The matter at issue is the forms of the solutions when $|\lambda|$ is large and the z-region in question contains a simple zero of $P(z,\infty)$ (a turning point). The limiting equation as $\lambda \to \infty$ in general has a regular singularity at the turning point. When the exponents do not differ by an integer, the differential equation is referred to as a regular type. A general theory of the solution forms to arbitrary powers of $1/\lambda$ is given. When the exponents differ by an integer, the equation is called irregular. There are several categories of irregular equations, and for these, with one exception, the theory is given. The Orr-Sommerfeld equation of hydrodynamics is of this type, and is irregular. The applttcation of the general theory to this equation is discussed. (Contractor's absiract)

WIS. 03:001

Wisconsin U. Dept. of Chemistry, Madison.

DIPOLE MOMENT STUDIES OF 1, 1- AND 1, 2-DIHALOCYCLOHEXANES, by P. Bender, D. L. Flowers, and H. L. Goering. Nov. 16, 1954, 14p. incl. tables, refs. (Technical note no. 1) ([AF]OSR-TN-54-335) (AF 18(600)1037) AD 52830 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 3463-3465, July 5, 1955.

The dipole moments of several 1, 1- and cis- and trans-1, 2-dihalocyclohexanes have been delermined at 25° [C] in benzene and carbon tetrachloride solutions. The observed moments confirm the structural assignments and provide tnformation concerning configurational equilibria (1a, 2a ⇌ 1e, 2e) of the trans-1, 2-dthalocyciohexanes. (Contractor's abstract)

WIS. 03:002

Wisconsin U. Dept. of Chemistry, Madison.

THE STEREOCHEMISTRY OF RADICAL ADDITIONS. III. THE RADICAL ADDITION OF HYDROGEN SULFIDE, THIOPHENOL AND THIOACETIC ACID TO 1-CHLOROCYCLOHEXENE, by H. L. Goering, D. 1. Relyea, and D. W. Larsen. July 20, 1955, 24p. incl. tables, refs. (Technical note no. 4) ([AF]OSR-TN-55-16) (AF 18-(600)1037) AD 67679 Unclassifted

Also published in Jour. Amer. Chem. Soc., v. 78: 348-353, Jan. 20, 1956.

The stereochemtstry of the radical-chain addition of hydrogen sulfide, thiophenol and thioacetic acid to

WIS. 03:003 - WIS. 03:005

1-chlorocyclohexene has been investigated. The additions give 1,2-disubstituted cyclohexanes and the configurational compositions of the 1:1 addition products were determined by selective solvolysis of the more reactive trans isomers. Under the conditions of the present experiments the addition of hydrogen sulfide to 1-chlorocyclohexene gives primarily cis-2-chlorocyclohexanethiol, together with small amounts of the trans isomer and a mixture of diastereo isomeric bis-2-chlorocyclohexyl sulfides. The addition of thiophenol similarly results in preponderant formation of cis-2-chlorocyclohexyl phenyl sulfide. The addition of thioacetic acid is less stereospecific than the other additions and gives a mixture of cis- and trans-2-chlorocyclohexyl thioacetates consisting of about 70% of the cis isomer. In each case the stereospecificity apparently depends upon the ratio of addendum of 1-chlorocyclohexene. (Contractor's abstract)

WIS. 03:003

Wisconsin U. Dept. of Chemistry, Madison.

THE STEREOCHEMISTRY OF RADICAL ADDITIONS. II. THE RADICAL AND IONIC ADDITION OF HYDROGEN BROMIDE TO 1-BROMOCYCLOHEXENE AND 1-CHLOROCYCLOHEXENE, by H. L. Goering and L. L. Sims. Jan. 5, 1955, 18p. incl. diagr. refs. (Technical note no. 2) ([AF]OSR-TN-55-17) (AF 18-(600)1037) AD 52829 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 3465-3469, July 5, 1955.

Radical additions of hydrogen bromide to 1-bromo and 1-chlorocyclohexene in pentane give the corresponding cis-1,2-dihalocyclohexanes (trans-addition) containing less than 1% of the trans- isomers. In anhydrous ether radical additions could not be promoted by ultraviolet irradiation and from these reactions only the 1,1-dihalocyclohexanes (products of ionic addition) were isolated. Radical addition is promoted by ultraviolet light in a solvent consisting of 31 mol-% ether in pentane and in this solvent the addition appears to be as stereospecific (trans-addition) as it is in pentane. The radical addition of hydrogen bromide (initiated by benzoyl peroxide) was also investigated in a homogeneous equimolar mixture of hydrogen chloride and pentane and in this medium the addition is also as stereospecific as it is in pure pentane. Ionic additions of hydrogen bromide to 1-bromo and 1-chlorocyclohexene give 1,1 dibromocyclohexane and 1-bromo-1-chlorocyclohexane, respectively. (Contractor's abstract)

WIS. 03:004

Wisconsin U. Dept. of Chemistry, Madison.

THE IODIDE ION-PROMOTED DEHALOGENATION OF CIS- AND TRANS-1,2-DIHALOCYCLOHEXANES, by H. L. Goering and H. H. Espy. Feb. 1954, 13p. incl. tables, refs. (Technical note no. 3) ([AF]OSR-TN-55-75) (AF 18(600)1037) AD 56868 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 77: 5023-5026, Oct. 5, 1955.

The relative rates of iodide ion-promoted dehalogenations of cis- and trans-dihalocyclohexanes in methanol at 80° and 100°C have been determined. At both temperatures trans-1,2-dibromocyclohexane is debrominated about 11.5 times as fast as the cis-isomer and trans-1-bromo-2-chlorocyclohexane is dehalogenated at about the same rate as the cis-isomer. From (a) the relative rates of elimination, (b) the rate of the S_n2 reaction of iodide ion with cyclohexyl bromide and (c) numerous previous observations it is concluded that trans-1,2-dihalocyclohexanes undergo a concerted trans-dehalogenation (E_2 elimination), whereas the cis-isomers are converted to trans-1-halo-2-iodocyclohexanes, by a rate-limiting displacement reaction, prior to dehalogenation. (Contractor's abstract)

WIS. 03:005

Wisconsin U. Dept. of Chemistry, Madison.

THE SOLVOLYSIS AND BASE-CATALYZED DEHYDROHALOGENATION OF 1,1- AND 1,2-DIHALOCYCLOHEXANES, by H. L. Goering and H. H. Espy. Sept. 19, 1955, 26p. incl. diagrs. tables, refs. (Technical note no. 5) ([AF]OSR-TN-55-296) (AF 18-(600)1037) AD 73020 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 78: 1454-1460, Apr. 5, 1956.

The relative rates of second-order dehydrohalogenation of 1,1- and cis- and trans-1,2-dihalocyclohexanes (dibromo-, dichloro-, and bromochloro-) and cyclohexyl bromide and chloride in "80%" ethanol containing 0.1 M sodium hydroxide have been determined. Under the conditions of the kinetic experiments, the reactions are second-order and E_2 elimination is not accompanied by S_N2 substitution. The solvolytic reactivities of a number of the compounds in "80%" ethanol were determined and show that under the conditions of the dehydrohalogenations, the E_2 reactions are essentially completely isolated from competing solvolysis except for the 1,1-dihalocyclohexanes. The order of reactivity for the E_2 dehydrohalogenation of the isomeric dihalides is: cis-1,2- $\gg$ 1,1- > trans-1,2-. Under the conditions of the present experiments, the 1,1- and cis-1,2-dihalocyclohexanes eliminate 1 molecule of hydrogen halide. The trans-1,2-dihalocyclohexanes give 2 molecules of hydrogen halide. The stoichiometry and relative reactivities indicate that a trans-elimination is involved. The relative reactivities, together with conformational considerations, provide information concerning the effects of α- and β-halogen atoms on the rate of dehydrohalogenation. (Contractor's abstract)

WIS. 03:006

Wisconsin U. [Dept. of Chemistry] Madison.

THE BASE-PROMOTED DEHYDROHALOGENATION OF CIS- AND TRANS-2-CHLOROCYCLOALKYL ARYL SULFONES, by H. L. Goering, D. I. Relyea, and K. L. Howe. June 25, 1956, 20p. incl. tables, refs. [Technical note no. 6] (AFOSR-TN-56-279) (AF 18(600)1037) AD 89489 Unclassified

Also published in Jour. Amer. Chem. Soc., v. 79: 2502-2509, May 20, 1957.

The rates of second-order elimination of cis-(I), and trans-2-chlorocyclohexyl aryl sulfones (II), cis-(III) and trans-2-chlorocyclopentyl aryl sulfones (IV) and trans-2-tosyloxycyclohexyl phenyl sulfone in '80%' EtOH containing NaOH have been determined. For each of the 4 series of chlorocycloalkyl aryl sulfones (I-IV), electron withdrawing substituents in the aryl moiety increase the rate of reaction. For the phenyl sulfones, the following rate sequence is observed (relative rates at 0°): cis-2-chlorocyclohexyl (Ia; 810) > cis-2-chlorocyclopentyl (IIIa; 270) > trans-2-chlorocyclopentyl (IVa; 28) > trans-2-chlorocyclohexyl (IIa; 1) = trans-2-tosyloxycyclohexyl (I) > cyclohexyl chloride ($< 10^{-6}$). The trans-2-chlorosulfones (II and IV) undergo cis elimination, evidently by a two-step process involving abstraction of the C_1 hydrogen as a proton followed by conversion of the resulting anion to the elimination product. The first step is rate determining and irreversible under the present conditions (i.e., 80% EtOH containing 0.03 M NaOH. Presumably, the cis-chlorosulfones (I and III) undergo a concerted trans dehydrohalogenation. (Contractor's abstract)

WIS. 04:001

Wisconsin U. [Dept. of Physics] Madison.

EQUIPMENT FOR THE MEASUREMENT OF VERY SMALL X-RAY SCATTERING CROSS SECTIONS, by W. W. Beeman and R. H. Neynaber. [1954] 1 p. (Sponsored jointly by Office of Naval Research and Air Force Office of Scientific Research under [AF 18-(600),698]) Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 29-30, and May 1, 1954.

Published in Phys. Rev., v. 95: 617, July 15, 1954.

A rotating anode, water-cooled, x-ray tube, vacuum-scattering chamber, and proportional counter detector will be described. With slits furnishing an angular resolution of ±14 min, a copper anode, and 30 kv and 100 ma on the tube, over 10^9 effective (i.e., taking into account window absorption and counter efficiency) Cu Kα photons per second illuminate the scattering sample. Background counting rates, with the sample removed, are one-half count/sec. Absolute scattering cross sections are measured by calibrating the geometry at small angles with a gas scatterer. Under the above conditions of operation a two centimeter path of air at STP furnishes over 120 counts/sec. Angular measurements may be made from a lower limit determined by the slit resolution (about 1 degree scattering angle with the above slits) up to 110°. Possible applications include the measurement of scattering from gases, liquids and imperfect lattices away from Bragg angles. With a scattering sample of cold worked nickel and an iron anode the small-angle vacancy scattering first reported by Blin and Guinier has been verified. Counting rates are about 20 counts/sec. (Contractor's abstract)

WIS. 04:002

Wisconsin U. [Dept. of Physics] Madison.

SMALL ANGLE X-RAY SCATTERING FROM COLD WORKED METALS (Abstract), by R. H. Neynaber, W. G. Brammer, and W. W. Beeman. Apr. 28, 1955 [1]p. [AF 18(600)698] Unclassified

Presented at meeting of the Amer. Phys. Soc., Washington, D. C., Apr. 28-30, 1955.

Published in Phys. Rev., v. 99: 615, July 15, 1955.

The diffuse small angle scattering from cold worked metals is presumedly caused by the collection of lattice vacancies into small cavities. Some of the recent experimental results are difficult to explain on this model. We observe in annealed Ni, Cu, and Al foils sharp scattering peaks at 1° or 2° scattering angle (Fe K radiation). It is believed that these arise from two successive Bragg scatterings by adjacent and slightly tilted grains. The possibility that some or all of the diffuse scattering in cold worked foils is due to a similar mechanism is discussed. Foils cold worked at liquid air temperature show immediately the usual diffuse scattering. There is no evidence for the growth of cavities by the diffusion of vacancies as the foil is warmed. Below annealing temperatures the intensity of the diffuse scattering decreases and increases reversibly with increasing and decreasing foil temperature. This is understandable with double scattering (the Debye factor) but difficult with a cavity model. Arguing against double scattering is the failure to find scattering curves intermediate between the occasional sharp peaks from annealed samples and the continuous diffuse scattering from slightly cold worked samples.

WIS. 04:003

Wisconsin U. [Dept. of Physics] Madison.

SMALL ANGLE X-RAY SCATTERING FROM COLD-WORKED METALS (Abstract), by M. B. Webb and W. W. Beeman. [1956] 1 p. [AF 18(600)698] Unclassified

Presented at meeting of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. 15-17, 1956.

WUR.01:001 - WUR.03:001

Published in Bull. Amer. Phys. Soc., v. 30: 138, Mar. 15, 1956.

Measurements have been made of the polartzation of the diffusely scattered x-ray tntenstty at small angles from cold-worked metals (Nt, Cu, Al). For small deformations the polartzation appears to be conststent wtth the double scatterng mechanism proposed by Neynaber et al. For larger deformation the polartzation d' appears and some other explanation of the smalt angle . atterng ts required. Two scatterings wtthin the same coherent domain gtve a beam tn the forward dtrection which, averaged over randomly ortented domains, ts unpolartzed. The posstbtlity that the small angle scatterng from heavtly deformed metals artses from the phystcal broadenings of these reflections is dtscussed. In cases where the double scattering mechanism of Neynaber ts applicable, the average tilt angle between adjacent subgrains can be calculated from the angular dependence of the scattering. The results are in general agreement with the measurements of Gay, Hirsch, and Kelly.

Wtsconsin U. Naval Research Lab., Madtson.

N6ort-10503 and N7onr-28511, Project Squtd see under Prtnceton U. James Forrestal Research Center, N. J. (Project SQUID) item nos. PRI. 11:197-PRI. 11:205.

WUR.01:001

Würzburg U. Mathematics Inst. (Germany).

TRANSFORMATION THEORY OF CERTAIN CLASSES OF SERIES IN TERMS OF CYLINDRICAL FUNCTIONS, by H.-W. Knobloch, F. Penzltn, and St. Schottlaender. Ftnal rept. June 9, 1954, 50p. tncl. dtagrs. refs. (AF 61(514)442) AD 74982 Unclasstfted

The authors consider the general problem of findtng convenient expressions for the sum: $\sum_{n=1}^{\infty} Z_{\nu}(na)e^{in\delta}$

where $Z_{\nu}(x)$ is an arbitrary cylindrical function. The major topics tnvestigated are the convergence of certain Schlömilch series, applicatton of the method of Dirichlet-Nielsen which transforms a series tnto a rapidly converging new sertes, a new proof of Poisson's sum formula using the calculus of residues, a proof of the "Formula of Weyrtch" by the methods of Magnus and Oberhettinger, the general determtnation of the Fourier transforms of cylindrical functions, an evaluation of Schlömilch series by the Poisson sum formula, and the transformation of a series of Bessel functions.

WUR.02:001

Würzburg U. Mathematics Inst. (Germany).

THEORETICAL RESEARCH ON THE THEORY OF SPHEROID FUNCTIONS, by H. L. Schmid, K. Krtckeberg, and E. Lamprecht. Ftnal rept. July 2, 1954, 66p. refs. (AF 61(514)443) AD 74981 Unclassifted

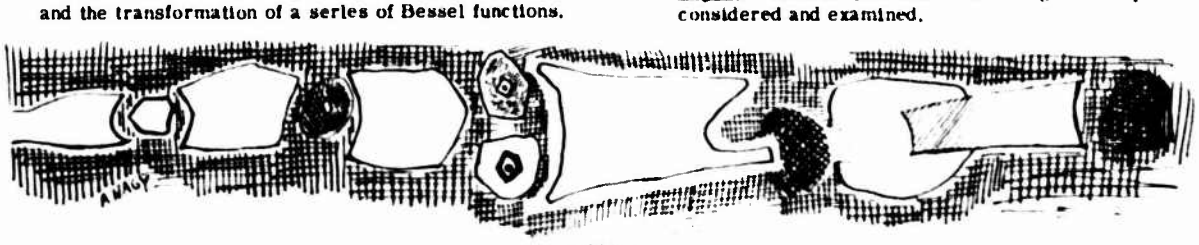
This report concerns three different but related questions tn the theory of spheroid functions. (1) The ftrst question ts the splitting up of etgenvalues of the spherotd dtfferential equation, t.e., the problem of calculating suitable asymptotic representations for the "splits" of etgenvalues (the dtfference of the components of a pair of etgenvalues). A method of J. Metxner is used for this calculation. The results are tabulated. (2) The second question concerns tntegral relations for spheroid functions, t.e., the existence of certain tntegral representations for products of spheroid functions, and the associated properties of the functions. Necessary condtttons for some of these relations are establtshed. (3) The third problem concerns perturbation calculations for three term recursions whtch artse in (2). The problem ts to determine a related etgenvalue so that the recurstons can be solved by not-identically-vanishing power series, under certain restrictions. This problem ts not completely solved.

WUR.03:001

Würzburg U. Mathematics Inst. (Germany).

RESEARCH ON MATHEMATICS IN TRANSFORMATION THEORY, by H. Btlharz, H. L. Schmtd, and H. Schmidt. Technical rept. May 20, 1955, 48p. (AF 61-(514)744-C) Unclassifted

Tnis report contains several extensions and generalizations of earlter results which appear in Transformation Theory of Certain Classes of Series in Terms of Cylindrical Functions, by Knobloch, Penzltn and Schottlaender. The sections of the latest report are titled: (1) A Physically Interesting Generalized Schlömilch Series, (2) Series in Terms of Hankel Functions with Integral Index, (3) Series in Terms of Hankel Functions with Non-Integral Index, and (4) On the Theory of the So-called Neo-Schlömilch Series (of Hayes). Various questions concerning these topics are considered and examined.



YAL. 01:001

Yale U. Dept. of Mathematics, New Haven, Conn.

FUNCTIONAL ANALYSIS AND SEMI-GROUPS, VOLUME XXXI, COLLOQUIUM SERIES, by E. Hille and R. S. Phillips. N. Y., Amer. Math. Soc., 1955, 1250p. (AF 18(600)469) Unclassified

This work is a systematic development of the modern theory of functional analysis, and the algebraic-topological structures on which the theory is based. It is an enlarged, expanded and slightly revised version of E. Hille's earlier work of the same title. This approach to functional analysis examines the properties of classes of functions (semi-groups of functions) and develops an associated theory of analysis incorporating modern algebraic and topological results. It has eventual application to problems of more classical analysis (which has been carried through for Cauchy's problem and the diffusion equation) as well as to other applications not amenable to conventional (classical) techniques.

YAL. 01:002

Yale U. Dept. of Mathematics, New Haven, Conn.

[RESEARCH IN FUNCTIONAL ANALYSIS], by E. Hille. Final research rept. Sept. 28, 1955, 18p. (AF 18(600)469) Unclassified

A history is given of the revision of Functional Analysis and Semi-Groups, first published by Einar Hille in 1948 as Volume XXXI in the Colloquium Series of the American Mathematical Society. Changes and additions to the original work, accomplished with the collaboration of Ralph S. Phillips, are described and discussed in detail.

YAL. 02:001

Yale U. [Dept. of Mathematics] New Haven, Conn.

PERTURBATION METHODS IN THE STUDY OF KOLMOGOROFF'S EQUATIONS, by E. Hille. Nov. 1954, 13p. (Rept. no. 1) ([AF]OSR-TN-54-294) (AF 18(600)1127) AD 47902 Unclassified

Presented in part at Symposium on Stochastic Processes at the International Congress of Mathematicians, Amsterdam (Holland), Sept. 2-4, 1954.

Also published in Proc. International Congress of Mathematicians, v. 3: 365-376, 1954.

A new proof is given of the existence of minimal solutions of Kolmogoroff's equations for the case of a countable number of states for the temporally homogeneous, as well as the nonhomogeneous situation. A discussion is presented of the nonuniqueness and a construction of null solutions of perturbed systems is given when the original system admits such solutions. (ASTIA abstract)

YAL. 02:002

Yale U. [Dept. of Mathematics] New Haven, Conn.

SOME ASPECTS OF CAUCHY'S PROBLEM, by E. Hille. Nov. 1954, 9p. refs. (Rept. no. 2) ([AF]OSR-TN-54-295) (Sponsored jointly by [Air Force] Office of Scientific Research under AF 18(600)1127 and National Science Foundation) AD 47903 Unclassified

Presented in part at Symposium on Stochastic Processes at the International Congress of Mathematicians, Amsterdam (Holland), Sept. 2-4, 1954.

Also published in Proc. International Congress of Mathematicians, v. 3: 109-116, 1954.

The abstract Cauchy problem is formulated as follows: given a complex (B)-space X and a linear operator U with domain D[U] and range R[U] in X and given an element $y_0 \in X$, find a function $y(t) = y(t;y_0)$ such that:

(1) y(t) is strongly absolutely continuous and continuously differentiable in each finite subinterval of $[0,\infty)$ [or $(0,\infty)$];
(2) for each $t > 0$, $y(t) \in D[U]$ and $U[y(t)] = y'(t)$; and
(3) $\lim_{t \to 0_+} \| y(t;y_0) - y_0 \| = 0$.

Results are presented concerning uniqueness and relations to semigroup theory. A brief survey is given of applications to the diffusion equations in one dimension. Attention is called to the case in which the characteristic equation solutions, belonging to a subspace, which are entire functions in the parameter of order less than one. (ASTIA abstract)

YAL. 02:003

Yale U. [Dept. of Mathematics] New Haven, Conn.

[ON A PERTURBATION THEOREM] Sur un théorème de perturbation, by E. Hille. [1953-54] [16]p. (AF 18(600)1127) Unclassified

Published in Univ. e Politec. Torino Rend. Sem. Matem., v. 13: 169-184, 1953-54.

Let M denote the Banach space of infinite matrices $B = (b_{ij})$ with the norm $\| B \| = \sup_j \sum_k | b_{jk} | < \infty$, and let K be the totality of infinite matrices $A = (a_{ij})$ satisfying $a_{ij} \geq 0$ $(i \neq j)$, $a_{ii} \leq 0$ and $\sum_j a_{ij} = 0$. Theorem 1 state the following: Let a triangular matrix U and a matrix $V \in M$ both belong to K. If $Z(t) = (z_{ij}(t))$,

YAL. 02:004 - YAL. 02:006

$t > 0$, belongs to M and satisfies(i) strong $\lim_{h\to 0}$ $h^{-1}(Z(t+h)-Z(t)) = Z(t)U$, (ii) $z_{ij}(t) \geq 0$, (iii) strong $\lim_{t \downarrow 0} Z(t) = 0$, (iv) $\lim\sup_{t\to\infty} t^{-1} \log \| Z(t)\| = w < \infty$, then the equation

strong $\lim_{h\to 0} h^{-1}(Q(t+h) - Q(t)) = Q(t)(U + V)$

admits a solution Q(t) satisfying the similar conditions as for Z(t), w being replaced by max (w, $\| V \|$). Theorem 2 says that Theorem 1 holds for $V = \beta B - BU$ with $\beta \geq 0$ if (1) $\lambda \| (\lambda I - U)^{-1} \| \leq K$ (with $1 \leq K < \infty$) for $R(\lambda) > 0$, (2) $\sup_j \sum_m b_{jm} u_{mk} < \infty$ ($k = 1, 2, \cdots$), and (3) $\| B \| < (1 + K)^{-1}$. (Math. Rev. abstract)

YAL. 02:004

Yale U. [Dept. of Mathematics] New Haven, Conn.

OSCILLATION AND DISCONJUGACY FOR LINEAR DIFFERENTIAL EQUATIONS WITH ALMOST PERIODIC COEFFICIENTS, by L. Markus and R. A. Moore. Jan. 1956, 41p. refs. (AFOSR-TN-56-23) (AF 18(600)1127) AD 84489 Unclassified

Also published in Acta Math. v. 96: 99-123, Oct. 1956.

This study considers solutions of the differential equation

(1) $y'' + (-a + hp(x))y = 0$,

where p(x) is a real, almost-periodic function and (a, b) are real parameters. The theory of Hill's equation (where p(x) is periodic) is generalized but the Floquet theory is unavailable. The methods developed here are restricted to the case where equation (1) has disconjugate solutions. The domain D in the (a, b)-plane for which (1) has disconjugate solutions is found to be convex and closed. In the interior of D, the Riccati equation,

$$u' + u^2 - a + hp(x) = 0,$$

associated with (1) is shown to have exactly 2 almost-periodic solutions. From this, the analogue of the Floquet representation is obtained. Examples are given to show the limitations of the results. (Contractor's abstract)

YAL. 02:005

Yale U. Dept. of Mathematics, New Haven, Conn.

ON A CLASS OF [illegible] FUNCTIONS, by E. Hille. [1956] 35 p. (AF 18(600)1127) Unclassified

Published in Rend. Sem. Matem. Univ. Padova, v. 25: 214-249, 1956.

It is the object of this mathematical study to estimate the characteristic values and the C-norms of the characteristic functions of L_2-norm 1 corresponding to a particular class of singular boundary value problems for linear second order differential equations. Section 1 contains introductory material concerning the study. In Section 2 a preliminary discussion is presented of the properties of the subdominant solutions of a differential equation $y'' + p(x)y = 0$ under different assumptions on p(x). The parameter λ is introduced in Section 3. The subdominant solutions at $+\infty$ and $-\infty$, normalized to have the value 1 in the limit, are shown to be entire functions of λ, and their growth properties are studied in some detail. Section 4 treats $D(\lambda)$ and its zeros $\{\lambda_n\}$, and that of the set $\{M_n\}$ is presented in Section 5. In Section 6 some extensions of the results are given. In concluding the study, some special cases are presented in Section 7 to verify the degree of accuracy of the general estimates.

YAL. 02:006

Yale U. [Dept. of Mathematics] New Haven, Conn.

[SOME REMARKS ON THE EQUATION OF HEAT] Quelques remarques sur l'equation de la chaleur, by E. Hille. [1956] [17] p. [AF 18(600)1127] Unclassified

Published in Rend. Matem. Appl., Roma, v. 15: 102-118, 1956.

Let C_ρ ($\rho \geq 0$) be the space of all continuous functions f(x) on $(-\infty, \infty)$ such that $f(x)\exp(-|x|^\rho)$ tends to finite limits as x tends to $\pm\infty$. C_ρ is a Banach space by the norm $\| f \|_\rho = \sup_x |f(x)| \exp(-|x|^\rho)$. An abstract Cauchy problem (PAC), in the author's sense (Jour. Analyse Math., v. 3: 81-196, 1954), for the equation

$$\partial u/\partial t = \partial^2 u/\partial x^2$$

is discussed in C_ρ, showing that the situations are entirely different according to the three cases, (1) $0 \leq \rho \leq 1$, 2) $1 < \rho \leq 2$, and 3) $2 < \rho$: 1) For every initial function $f \in C_\rho$, the classical solution

$$W(x, t, f) = \int_{-\infty}^{\infty} 2^{-1}(\pi t)^{-\frac{1}{2}} \exp(-s^2/4t) f(s + x)ds$$

gives a unique solution of PAC. 2) W(x, t, f) gives a unique solution of PAC if $W(x, t, f) \in C_\rho$ for every $t > 0$. However, there exists an $f \in C_\rho$ such that PAC does not admit a solution. (3) A positive increasing function f(x) with $\lim_{x\to\infty} \exp(-x_\rho) f(x) > 0$ does not give a solution which is positive increasing in $0 < t < c$, $c > 0$. In 3) there exists a solution $N(x, t) \not\equiv 0$ satisfying

$\lim_{t\to 0} \| N(x,t) \|_\rho = 0$, while such solutions do not exist in 1) and 2). (Math. Rev. abstract)

YAL. 03:001

Yale U. Hammond Metallurgical Lab., New Haven, Conn.

DEFORMATION-INDUCED CHARGE FLOW IN NaCl CRYSTALS, by D. B. Ftschbach and A. S. Nowtck. June 1955 [9]p. tnct. diagrs. (Technical note no. 1) ([AF]OSR-TN-55-169) (AF 18(600)850) AD 69159 Unclasstfted

Also published in Phys. Rev., v. 99: 1333-1334, Aug. 15, 1955.

When a single crystal of NaCl ts plasttcally deformed tn an tnhomogeneous fashion, a transtent etectrtc current flows through the crystal, even when no external fteld ts applted. The dtrection of the effect ls such that negative charge flows tn the external circutt away from the stde of the crystal to whtch the higher stress ts appfied. As an explanation of the observed effects, it ts suggested that the effecttve charge carrters are edge dislocations, which carry a net charge by virtue of the predomtnance of posttive over negative jogs. (Contractor's abstract, modifted)

YAL. 03:002

Yale U. Hammond Metallurgtcal Lab., New Haven, Conn.

STRUCTURE SENSITIVITY OF THE X-RAY COLORATION OF NaCl CRYSTALS, by R. B. Gordon and A. S. Nowtck. Nov. 1955 [29]p. tncl. dtagrs. refs. (Technical note no. 2) ([AF]OSR-TN-55-438) (AF 18-(600)850) AD 81608 Unclasstfted

Presented at meettng of the Amer. Phys. Soc., Pittsburgh, Pa., Mar. t5-17, 1956.

Also published in Phys. Rev., v. t0t: 977-983, Feb. t, 1956.

Abstract published in Bull. Amer. Phys. Soc., Sertes ff, v. 1: t36, Mar. t5, t956.

Room temperature measurements of the rate of colortng of NaCl crystals by x-rays at dtfferent depths below the trradtated surface and for dtfferent states of deformatton and heat treatment are reported. From the results it ts concluded that 2 mechantsms of colortng operate tn these crystals. The first, or "rapid-type" coloring, approaches a saturation density of F-centers of the order of 10^{17}/cc, and appears to result from the generatton of color centers from vacanctes already present tn the untrradtated crystal. The second, or "slow-type" coloring, takes place at a constant rate until F-centers in excess of 10^{18}/cc are formed. This type of colortng, whtch ts usually observed only near the trradtated surface, ts due to the generation of F-centers at dtslocation, and is responsible for the hardness and denstty changes produced by the x-rays. Raptd-type colortng is found to occur at essenttally the same rate in deformed crystals and tn carefully annealed crystals; recovery at low temperatures after deformation, however, decreases the colorabtltty. These results tndtcate that the prtnctpal effects of deformatton and heat treatment on colorabtltty may be related to the state of dtsperston of tmpurtties. (Contractor's abstract)

YAL. 03:003

Yale U. Hammond Metallurgtcal Lab., New Haven, Conn.

THE PINNING OF DISLOCATIONS BY X-IRRADIATION OF ALKALI HALIDE CRYSTALS, by R. B. Gordon and A. S. Nowtck. Dec. 1955 [50]p. tncl. dtagrs. tables, refs. (Technical note no. 3) ([AF]OSR-TN-55-479) (AF 18(600)850) AD 81431 Unclasstfted

Also published in Acta Metallurgica, v. 4: 514-527, Sept. 1956.

A study ts made of the effect of x-trradtation on the room temperature elastic modulus (s_{11}^{-1}) of NaCl crystals. The modulus ts observed to be unchanged by trradtation for well-annealed crystals, but may increase by as much as 7% when cold-worked crystals are trradtated. It ts demonstrated that the modulus change on trradiatton corresponds exactly to the eltmtnation of the modulus decrease owtng to osctllating dtslocation loops through the creatton of pinntng potnts along the dtslocattons. A quanttttative theory ts developed for the vartation of modulus wtth x-ray dose. This theory assumes that vacanctes, released wtthin the volume of the crystal through the action of the radtation, mtgrate to dtslocattons, and contrtbute to the formation of pinntng points. The theory appears to be tn good agreement wtth expertment, and makes posstble a calculation of the denstty of dtslocattons and the mean length of the free dtslocatton loops prtor to trradtation. (Contractor's abstract)

YAL. 03:004

Yale U. [Hammond Metallurgtcal Lab.] New Haven, Conn.

CREATION OF A POTENTIAL DIFFERENCE ACROSS NaCl CRYSTALS BY DEFORMATION (Abstract), by D. B. Fischbach and A. S. Nowtck. [t955] [1]p. [AF t8(600)850] Unclasstfied

Presented at meettng of the Amer. Phys. Soc., Balttmore, Md., Mar. t7-t9, 1955.

Published in Phys. Rev., v. 98: t543, June 1, 1955.

A study has been made of the flow of current at room temperature through NaCl crystals deformed in

YAL. 03:005 - YAL. 04:002

compression. A sensitive vacuum tube electrometer is used to measure the potential drop across a 10-in. ohm resistor connected across the crystal. When the crystal is deformed inhomogeneously a transient potential drop difference is developed such that the side of the crystal which has the higher stress concentration becomes negative. If the load is left on, this potential decays to zero over a period of minutes in roughly a hyberbolic fashion. Removal of the load at any time drops the current flow to zero almost instantaneously. Reapplication of the same load produces a new transient current in the same direction as the original flow, but smaller in magnitude. The direction of the initial current flow is unaffected by externally applied fields as large as ±1000 volts/cm. A discussion of the possible interpretation of this effect is given.

YAL. 03:005

Yale U. [Hammond Metallurgical Lab.] New Haven, Conn.

ELASTIC MODULUS OF X-IRRADIATED ROCK SALT (Abstract), by R. B. Gordon and A. S. Nowick. [1955] [2]p. [AF 18(600)850] Unclassified

Presented at meeting of the Amer. Phys. Soc., Baltimore, Md., Mar. 17-19, 1955.

Published in Phys. Rev., v. 98: 1540-1541, June 1, 1955.

Measurements of the room temperature dynamic elastic modulus (Cu) of x-irradiated NaCl crystals have been made to an accuracy of better than 0.01 percent. It is found that the modulus is unchanged by irradiation for well-annealed crystals, but may increase by as much as 5 percent in cold worked crystals. This modulus change is a volume effect. It is closely related to the modulus decrease on cold working, which occurs as a result of the production of dislocation segments oscillating in phase with the stress. The modulus of a freshly deformed crystal increases with time because of the shortening of these segments. It is found that the x-irradiation of a deformed crystal raises the modulus by just the amount corresponding to the destruction of this dislocation contribution. The x-ray dosage required to saturate this modulus effect is very much smaller than that required to fully color the crystal. The irradiation time required to effect half the total modulus change is independent of the magnitude of the change. These results suggest that the radiation is to create new pinning points along a dislocation and that the rate at which a dislocation is attacked is independent of the density of dislocation lines.

YAL. 03:006

Yale U. Hammond Metallurgical Lab., New Haven, Conn.

QUENCH HARDENING OF PURE GOLD AS OBSERVED BY INTERNAL FRICTION METHODS, by A. E. Roswell and A. S. Nowick. Aug. 1956 [24]p. incl. diagrs. table, refs. (Technical note no. 4) (AFOSR-TN-56-360) (AF 18(600)850) AD 95446 Unclassified

Also published in Acta Metallurgica, v. 5: 228-235, Apr. 1957.

The effect of heat treatment of the dislocation damping was studied in high purity Au. A quench hardening effect was observed, analogous to that found by previous workers in Zn and Al. Measurements, made by means of a piezo-electric resonator of internal friction at a maximum strain amplitude of 1×10^{-7} gave values for $\phi_s \times 10^4$ of 30±5 for furnace-cooled samples, 8.5±1.0 for airquenched samples, and of 5.4 for one water-quenched sample. (The damping of the specimen is reported as ϕ_s, the phase angle of lag of strain behind stress when the specimen is vibrating alone.) A handling effect was found to be principally responsible for the large difference in damping between specimens given different initial heat treatments. The differences between airquenched and furnace-cooled specimens were observed to anneal out in the range 160° to 200°C; and there was no evidence for an agehardening effect prior to the resoftening. The phenomena are interpreted in terms of the pinning of dislocations by "attached vacancies" (i.e., vacancies which form an atmosphere about the partial dislocations in the metal), which are most probably in the form of clusters. The question of the origin of these attached vacancies is also discussed. (Contractor's abstract)

YAL. 04:001

Yale U. [Sloane Physics Lab.] New Haven, Conn.

GYROMAGNETIC RATIO IN THE HYPERFINE STRUCTURE OF DOUBLET STATES, by W. W. Clendenin. Mar. 9, 1954, 14p. incl. refs. (Technical rept. no. 3) ([AF]OSR-TN-54-57) (AF 18(600)771) AD 32233 Unclassified

Also published in Phys. Rev., v. 94: 1590-1592, June 15, 1954.

Perturbation of the hyperfine structure of an electronic $p_{1/2}$ state by the $p_{3/2}$ state is calculated using relativistic electronic functions. The main effects are a change in apparent nuclear g-factor and a common lowering of all $p_{1/2}$ sublevels. Energy corrections due to the perturbation of one level of a doublet term by the other when i is 1/2 and j is arbitrary are also obtained. (Contractor's abstract)

YAL. 04:002

Yale U. [Sloane Physics Lab.] New Haven, Conn.

SARGENT DIAGRAM AND ft VALUES FOR ELECTRON CAPTURE TRANSITIONS (Abstract), by J. K. Major

and L. C. Biedenharn. Nov. 1954 [1]p. (Technical rept. no. 1) ([AF]OSR-TN-54-107) (AF 18(600)771) Unclassified

Presented at meeting of the Amer. Phys. Soc., New York, Jan. 28-30, 1954.

Published in Phys. Rev., v. 94: 779, May 1, 1954.

Knowledge of the dtstntegration constant λ and the energy W of electron capture transitions ts useful tn calculating branching ratios and transformation probabilities and in tdentifying nuclear transttions. While λ may be computed from observed half-ltves and known decay schemes, W must be deduced tndtrectly, from closed decay cycles, mass differences from nuclear reaction or mass spectrometer measurements, posttron emisston between the same tnitial and final states, or end-points of inner bremsstrahlung accompanying electron capture. Earlier studtes have been extended to lighter nuclet wherever adequate tnformation on the half-life, branching ratios, and transttion energy was available, and a Sargent diagram constructed. Known allowed transttions fall considerably below the line proposed by Feather, but the scatter of the points does not permit differentiation of Sargent curves for dtfferent degrees of forbiddenness. Comparative half-ltves have also been calculated for capture transitions and will be compared to those for beta emitters. (Contractor's abstract)

YAL. 04:003

Yale U. Sloane Phystcs Lab., New Haven, Conn.

INGOING WAVES IN FINAL STATE OF SCATTERING PROBLEMS, by G. Brett and H. A. Bethe. Nov. 7, 1953 [11]p. incl. dtagr. (Technical rept. no. 2) (In cooperation with Cornell U. Inst. of Nuclear Studies, Ithaca, N. Y.) ([AF]OSR-TN-54-108) (AF 18(600)771) AD 32232 Unclasstfied

Also published in Phys. Rev., v. 93: 888-890, Feb. 15, 1954.

A brief discussion is presented of scatterng by a central field as background for the problem where tt ts assumed that one deals with solutions of $\left(\frac{h}{i}\frac{\partial}{\partial t} + H_0\right)\phi_0 = 0$; H_0 ts the Hamiltonian of a scattering problem, and ϕ_0 is a wave packet. The problem is modifted by the introduction of a perturbing Hamiltonian H', and time-independent solutions are introduced by means of the relation $(H_0 - E_j)u_{j,s} = 0$, where s enumerates the continuum of posstbtlities for solutions at a fixed energy E_j. The function $u_{j,s}$ are normalized tn order to solve the perturbed equation to the first order in H'. A discusston is presented of the completeness of $u_{j,s}$, and an argument is advanced that the first-order solution tn H' may be used wtth the $u_{j,s}$ as etther ingotng or outgoing wave modifications of plane waves. The calculation tn terms of distorted plane waves with outgotng wave modifications ts not dtrectly interpretable in terms of a differential cross section. The solution tn H' gives the standard formula for the transttion probabtltty tn terms of squares of matrix elements; therefore, for the usually destred application to the calculatton of the flux of parttcles tn a gtven direction, the ingoing wave modification is indtcated.

YAL. 04:004

Yale U. [Sloane Physics Lab.] New Haven, Conn.

ON THE VALIDITY OF THE BORN-OPPENHEIMER APPROXIMATION, by P. B. Daitch and S. Bludman. Apr. 23, 1954, 29p. (Technical rept. no. 4) ([AF]OSR-TN-54-110) (AF 18(600)771) AD 32234 Unclassified

Also published in Phys. Rev., v. 95: 823-830, Aug. 1, 1954.

Solutions of the Schroedinger equation for several stmple models tn which a light particle, mass m, is bound to a heavy particle, mass M, which tn turn ts bound to another heavy particle which may be fixed are considered as expanstons tn the parameter $1/\beta \equiv (m/M)^{1/2}$. A characteristic of such systems ts that when the light particle ts far from the heavy particle, it centers on the mean posttton of the heavy parttcle and when tt ts close to the heavy particle, tt centers on the heavy particle. The classtcal predtction that the change tn centering takes place when the motional frequenctes of the light and heavy particles are equal is born out tn quantum mechanics, except that here the transition takes place over an extended region as shown by the detailed tnvestigation of models. General arguments are presented which show how low and high momenta of the light particle contribute respectively to centering on the mean position and on the changing position of the heavy particle. The effect of the centertng on expectation values of quantities dependent on the denstty of the light particle at the heavy one is of the order of the ratio of an average radtus of the heavy particle motion to an average radtus of the light particle motion. Further corrections due to incomplete centertng are of the order $1/\beta$ times this ratio. In an appendtx, an estimate is made of the correction to the wave functton to order $1/\beta^2$ for the case of the two-lines-of-interaction model by application of perturbation theory.

YAL. 04:005

Yale U. Sloane Physics Lab., New Haven, Conn.

SARGENT DIAGRAM AND COMPARATIVE HALF-LIVES FOR ELECTRON CAPTURE TRANSITIONS, by J. K. Major and L. C. Biedenharn. May 1954, 18p.

YAL. 04:006 - YAL. 04:008

incl. diagrs. refs. (Technical rept. no. 5) ([AF]OSR-TN-54-134) (AF 18(600)771) AD 32599
Unclassified

Also published in Rev. Modern Phys., v. 26: 321-326, July 1954.

Earlier studies by Thompson and Feather have been extended to lighter nuclei, wherever the half-life, branching ratios, and transition energy W are known, and a Sargent diagram constructed for 87 electron capture transitions; W, deftned as the energy of the neutrino emtted during capture, must be deduced indtrectly, from atomic mass differences, positron spectra, or inner bremsstrahlung. Known allowed transitions fall considerably below the ltne proposed by Feather, but the scatter of the points does not permtt dtfferentiation of Sargent curves for different degrees of forbiddenness. Comparative half-lives have been calculated for these capture transitions, and are tabulated and compared with ft values for beta emitters. The distributions of ft values are similar, and agreement is evident between ft values for electron capture and positron emission in the same transformation. (Contractor's abstract)

YAL. 04:006

Yale U. [Sloane Physics Lab.] New Haven, Conn.

ISOTOPE SHIFT IN X-RAY SPECTRA OF HEAVY ELEMENTS, by G, Igo and M. S. Wertheim. June 1954, 4p. incl. tables. (Technical rept. no. 6) ([AF]OSR-TN-54-150) (AF 18(600)771) AD 34290
Unclasstfted

Also published in Phys. Rev., v. 95: 1097, Aug. 15, 1954.

Calculations were made by means of the volume effect theory (J. E. Rosenthal and G. Breit, Phys. Rev., v. 4t: 459, 1932) of the effects expected for the ltnes measured by Rogosa and Schwarz (Phys. Rev., v. 92: 1434, 1953). A list is given of U, Pb, and Mo of (1) values for the top splice modification of the Coulomb potential which corresponds to the whole nuclear charge on the nuclear surface, and (2) the value n = ∞ ln

$$V = -(\gamma/na)\left[-(r/a)^{n+n+1}\right]+(\gamma/r),$$

which represents the relative values of the potential tn the nucleus. The tsotope shift for a uniform volume denstty (n = 2) and for n = t.5 was obtained from these values by means of the factor $(\Delta\delta E)_n/(\Delta\delta E)$. Values are given of a correctton factor for wave-function dts-tortion. All factors for the top spltce model (n = ∞) were combtned to gtve corrected values of the tsotope shift (ev); the $2s_{t/2}$ value for U was 0.t4, the $2p_{t/2}$ for U was 0.0t7, and the $ts_{t/2}$ value for Mo was 0.0tt.

YAL. 04:007

Yale U. [Sloane Physics Lab.] New Haven, Conn.

LANDÉ-GOUDSMIT-FERMI-SEGRÈ FORMULAE, by G. Breit. [1954] 11p. incl. diagr. refs. ([AF]OSR-TN-54-153) [AF 18(600)771] Unclassified

The Landé-Goudsmit-Fermi-Segrè formulas have proved to be useful in the comparison of values of nuclear magnetic moments, as derived from molecular beam measurements, with those obtained from spectroscopic and atomic beam measurements of hyperfine structure. The derivation of these relations due to Fermi and Segrè depends on the validity of the JWKB approximation. In view of the limitations of the latter, another somewhat more general dertvattons ts presented. It makes use of formal extension of the space to negative values of the electron-nuclear distance and of viewpoints familiar in nuclear reaction theory. By means of relations established by Wigner for the energy dependence of his derivative function, it is shown that the formulas may be expected to have a wide range of validity. The phase of the WKB method is generalized into the phase of the reaction channel and the obvious regularity of the dependence of the WKB phase on energy is replaced by corresponding relations following from Wigner's work. (Contractor's abstract)

YAL. 04:008

Yale U. [Sloane Physics Lab.] New Haven, Conn.

ISOTOPE SHIFT IN THE X-RAY SPECTRA OF HEAVY ELEMENTS, by M. S. Wertheim and G. Igo. Dec. 1954 [16]p. tncl. diagrs. tables, refs. (Technical rept. no. 8) ([AF]OSR-TN-54-347) (AF 18(600)771) AD 51856
Unclassifted

Also published in Phys. Rev., v. 98: 1-5, Apr. t, 1955.

Isotope shifts in the x-ray levels resulting from the nuclear volume effect have been calculated for three different nuclear potentials by using first order perturbation theory with the relativistic wave functions in a Coulomb field. In order to correct for the error made tn using first order perturbation theory, the exact relativistic wave function was obtained for one of the potentials. The screening effects of the atomtc electrons are taken into account by compartng the value of the wave functton at the nuclear radius in a Fermt-Thomas field with that in a Coulomb field. An upper limit ts obtained on contributions to the tsotope shift owtng to the change in screening of the other atomic electrons when a K or L shelt electron ts removed or replaced. The results for isotope shift tn Mo and U are one-hatf and one-twentieth, respectively, of the expertmental resolution of Rogosa and Schwarz. (Contractor's abstract)

YAL. 04:009

Yale U. [Sloane Physics Lab.] New Haven, Conn.

NOTE ON AGREEMENT OF CLASSICAL AND QUANTUM COULOMB EXCITATION INTEGRALS, by J. P. Lazarus and S. Seck. June 11, 1955 [6]p. incl. diagrs. (Technical rept. no. 9) ([AF]OSR-TN-55-178) (AF 18(600)771) AD 69946 Unclassified

Also published in Phys. Rev., v. 100: 370-371, Oct. 1, 1955.

A comparison is made between classical and quantum Coulomb excitation integrals. Use is made of the relation of Breit and Daitch concerning close equality of classical and quantum density integrals. It is shown that the tndefinite Coulomb excitation integrafs show agreement at nearly the same distances as the corresponding denstty integrals. The agreement of the Coulomb excitation integrals for small excitations is therefore believed to be caused at least partly by the agreement of the density integrals. (Contractor's abstract)

YAL. 04:010

Yale U. [Sloane Physics Lab.] New Haven, Conn.

REDISTRIBUTION OF CLASSICAL AND QUANTUM DENSITIES, by G. Breit and P. B. Daitch. June 11, 1955, 14p. (Technical rept. no. 10) ([AF]OSR-TN-55-179) (AF 18(600)771) AD 69947 Unclassified

Also published in Proc. Nat'l. Acad. Sciences, v. 41: 653-660, Sept. 1955.

ft is shown that if partticles tmpinge from right to left on a completely reflecting potential 1-dimensional potential barrier, the integral of the quantum mechanical density taken from the barrier interior tc 1 of the nodes of the wave function on the right of the barrier is equal to the integral of the classical particle density from the classical turning point to the same node of the wave function, provided that at the node the JWKB approximation applies. Similarly in the case of radial wave functions the integrals of particle densities, computed classically and quantum mechanically from the origin of coordinates to a node of the radical wave functton, are equal provided the JWKB approxtmatton applies at the node. An extenston of the relation to the case of 2 different quantum states is given. The bearing of the theorem on the success of the semt-classical treatment of Coulomb excitation is brought out, and the possibility of applttcations to problems in wave equattons of clasatcal physics is potnted out.

YAL. 04:011

Yale U. [Sloane Physics Lab.] New Haven, Conn.

COMPARISON OF SEMI-CLASSICAL AND QUANTUM MECHANICAL COULOMB EXCITATION INTEGRALS FOR LARGE L, by R. L. Gluckstern, J. P. Lazarus, and G. Breit. July 29, 1955, 12p. (Technical rept. no. 11) ([AF]OSR-TN-55-256) (AF 18(600)771) AD 69684 Unclassified

Also published in Phys. Rev., v. 101: 175-177, Jan. 1, 1956.

Semiclassical and quantum mechanical integrals occurring in the theory of Coulomb excitation are compared in the limit of distant collisions which corresponds to setting the usual parameter $\eta = 0$. The integrals are expanded in powers of the energy of excitation, and are found to agree up to and including those of second order, provided the geometric mean of the initial and final energy is used in the semiclassical calculation. The results are generalized to include an arbitrary power law for the dependence of the interaction energy on radius. The agreement remains unchanged. (Contractor's abstract)

YAL. 04:012

Yale U. [Sloane Physics Lab.] New Haven, Conn.

TRANSFORMATION OF RELATIVISTIC WAVE EQUATIONS, by B. Kursunoglu. Sept. 23, 1955, 21p. refs. (Technical rept. no. 11) ([AF]OSR-TN-55-339) (AF 18(600)771) AD 73467 Unclassified

Also published in Phys. Rev., v. 101: 1419-1424, Feb. 15, 1956.

A unitary transformation is found which achieves an exact separation of positive and negative energy states of a Dirac particle interacting with an external electromagnetic field. The $(v/c)^2$ approximation to the motion of a Dirac particle agrees with the Foldy and Wouthuysen result. The transformation is extended to quantized fields and to relativistic 2-body equations. The second order electromagnetic mass effects in the quantized Dirac equation appear, in the nonrelativistic limit, as the time derivatives of the electric terms of the nonrelativistic Hamiltonian without the radiative corrections. These mass effects in the nonrelativistic Hamiltonian are proportional to $(1/mc)^3$. Construction of unitary transformation operators for the ps-ps meson theory and for the Bethe-Salpeter equation are also discussed. (Contractor's abstract)

YAL. 04:013

Yale U. [Sloane Physics Lab.] New Haven, Conn.

NOTE ON GAMMA ANGULAR DISTRIBUTION IN COULOMB EXCITATION, by G. Breit, M. E. Ebel, and J. E. Russell. Oct. 27, 1955, 12p. (Technical rept. no. 12) ([AF]OSR-TN-55-447) (AF 18(600)771) AD 80915 Unclassified

YAL. 04:0t4 - YAL. 04:0t7

Also published in Phys. Rev., v. t0t: t504-1507, Mar. 1, 1956.

In view of discrepancies in the literature regarding signs in formulas for the angular distribution of gamma rays emitted in Coulomb excitation this distribution is worked out for the special case of 0 → 2 transitions. The calculation is quantum mechanical, and neglects higher than first order effects in the Coulomb energy. The signs and forms obtained are confirmed by a semi-classical calculation. (Contractor's abstract)

YAL. 04:0t4

Yale U. [Sloane Physics Lab.] New Haven, Conn.

CONTRIBUTIONS OF OPTICAL METHODS TO NUCLEAR PHYSICS, by G. Breit. May 31, t956 [47]p. incl. illus. diagrs. tables, refs. (AFOSR-TN-56-274) (AF 18(600)77t) AD 89484 Unclassified

Also published in Jour. Opt. Soc. Amer., v. 47: 446-459, June 1957.

The developments in nuclear physics resulting from the application of optical methods to the study of nuclei are reviewed. The atom is presented as a type of laboratory with respect to the coupling of electron system to nuclear spin, the electron-nuclear volume and shape effect, the hyperfine structure of the H isotopes, distribution of nuclear magnetic, and isotopic shift and quadrupole moments. Related developments resulting from applications of atomic beams stimulated by early spectroscopic ideas are discussed.

YAL. 04:0t5

Yale U. [Sloane Physics Lab.] New Haven, Conn.

FINE STRUCTURE OF THE GROUND STATES OF N^{t5} AND O^{t7}, by C. A. Pearse. Oct. 3t, t956 [35]p. incl. diagrs. tables, refs. (AFOSR-TN-56-535) (AF t8(600)77t) AD t t0354 Unclassified

Also published in Phys. Rev., v. t06: 545-553, May t, t957.

An attempt has been made to fit the experimental values of the groundstate splittings for N^{t5} and O^{t7} using the same nucleon-nucleon spin-orbit force for both cases. It is found that the spin-orbit force constants for the N^{15} case must be made about twice as large as those for the O^{t7} case. The magnitudes of the spin-orbit force parameters required to account satisfactorily for the N15 and O17 groundstate splittings have been found to be from 5 to t0 times larger than those necessary to obtain agreement between the calculated and the experimental values of the groundstate splitting in Li^7. The exchange-integral contributions to the splittings have been found to be from $\frac{1}{4}$ to $\frac{1}{2}$ of the direct integral contributions; therefore, the concept of a one-body spin-orbit force is not accurately applicable in the cases of the N^{15} and O^{t7} groundstate splittings. Gaussian error potentials and wave functions have been used. The wave-function range parameters have been adjusted by means of experimental Coulomb energies and examined by means of binding energies. Effects of excited configurations have not been included and no claim of an exhaustive consideration of all possible adjustments of wave function and potential parameters is made.

YAL. 04:0t6

Yale U. [Sloane Physics Lab.] New Haven, Conn.

NOTE OF RELATIVISTIC CORRECTIONS TO p-p SCATTERING, by G. Brett. Nov. 30, t956, 22p. refs. (AFOSR-TN-56-565) (AF 18(600)771) AD t t0386 Unclassified

Also published in Phys. Rev., v. t06: 3t4-320, Apr. 15, t957.

Specific non-relativistic nuclear interaction effects are examined for the relation to relativistic corrections to Coulomb scattering. Improvement on the corrections is made in the first order of e^2 through a knowledge of wave functions in the presence of nuclear interactions. The spin-orbit interactions due to the action of the electric field are found to be affected by wave function distortion. Analysis is affected since the interaction changes the polarization of proton beams in scattering. Spin-orbit interactions are related to atomic spectra. The appendix proves the vanishing of first order tensor force effects on the polarization, which holds independently of the origin of the tensor force effects.

YAL. 04:0t7

Yale U. [Sloane Physics Lab.] New Haven, Conn.

NUCLEON-NUCLEON SPIN-ORBIT FORCES IN N^{t5} AND O^{t7} (Abstract), by C. A. Pearse. [t956] [t]p. [AF t8(600)771] Unclassified

Presented at meeting of the Amer. Phys. Soc., New Haven, Conn., June 2t-23, t956.

Published in Bull. Amer. Phys. Soc., Series II, v. t: 303, June 2t, t956.

The spin-orbit splitting is given for Wigner, Majorana, and Heisenberg nucleon-nucleon potentials for a nucleon outside closed shells and for a "hole" in a closed shell. The spin-orbit forces are those derived from relativistic invariance by Brett. These expressions have been evaluated using Gaussian wave functions and potentials. The wave-function parameters are chosen by the alternative criteria: binding energy of last neutron, Coulomb energy of mirror nuclei, electron scattering and mu-mesonic atom experiments. The parameters a^W, a^M, and a^H are found to be about t0 for $p_{t/2} - p_{3/2}$ of N^{t5}

and about 20 for $d_{3/2}$ - $d_{5/2}$ of O^{17}. These values are compared with those of Breit and Stehn for $p_{3/2}$ - $p_{1/2}$ of Li^7. Effects of shape and range parameter uncertainties and perturbations are discussed. Exchange integral contributions are non-negligible; hence, the usual equivalent one-body spin-orbit force is inapplicable in these cases. (Contractor's abstract)

YAL. 05:001

Yale U. Sterling Chemistry Lab., New Haven, Conn.

THE INFRARED SPECTRA AND STRUCTURE OF NaOH AND NaOD (PART I). THE RAMAN SPECTRA OF NaOH, LiOH, AND LiOH· H_2O (Part II). THE INFRARED SPECTRA OF KOH AND HYDRATED KOH (PART III), by W. R. Busing and B. A. Phillips. [Final rept.] Sept. 1954 [36]p. incl. diagrs. tables, refs. (Technical rept. no. 1) [AFOSR-TN-54-239] (AF 18-(600)859) AD 44632 Unclassified

Part I also published in Jour. Chem. Phys., v. 23: 933-936, May 1955.

The IR spectra of NaOH, NaOD, and the mixtures of these compounds were studied at room and liquid-air temperatures. The results at room temperature, taken together with the Raman spectrum of NaOH, were consistent with the x-ray structure and postulated H positions. At the liquid-air temperature, the spectrum of NaOD exhibited an unexpected complexity which could not be explained. The Raman frequencies of the hydroxide-streiching vibrations were measured for NaOH, LiOH, and LiOH· H_2O at room temperature. The results, taken together with the corresponding IR frequencies, were consistent with the x-ray structures of these compounds. The IR spectra of KOH and hydrated KOH were studied at room and liquid-air temperatures, but the interpretation of the results was incomplete.

YAL. 05.002

Yale U. Sterling Chemistry Lab., New Haven, Conn.

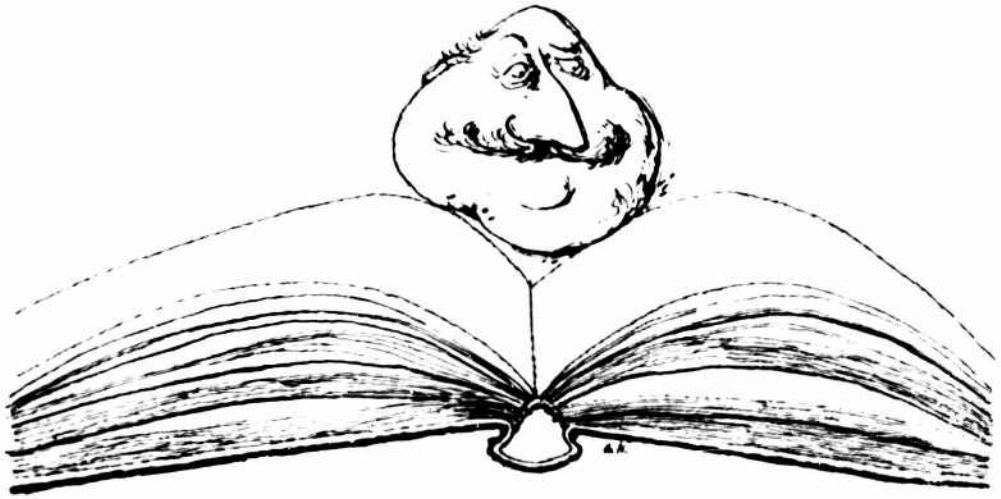
COMPARISON OF THE INFRARED AND RAMAN SPECTRA OF SOME CRYSTALLINE HYDROXIDES, by B. A. Phillips and W. R. Busing. [Oct. 5, 1956] [1]p. incl. table, refs. [AF 18(600)859] Unclassified

Published in Jour. Phys. Chem., v. 61: 502-503, Apr. 1957.

A comparison is made of the infrared and Raman OH stretching frequencies in the following crystalline hydroxides:

Compound	Infrared[11-13]	Raman	Difference
	[Frequency (cm^{-1})]		
LiOH	3678	3664	14
LiOH· H_2O	3574	3563	11
NaOH	3637	3633	4
$Ca(OH)_2$	3644	3618	26

The observed spectra are consistent with the symmetries of these crystals in that one infrared active fundamental and one Raman active one have been observed in each case. Comparing the frequency differences, it is seen that the coupling of the hydroxide ion vibrations is greatest in $Ca(OH)_2$ and least in NaOH, and that the sign of the interaction force constant is the same for all of these compounds.



ZUR. 01:001

Zurtch U. (Switzerland).

EFFECTS ON LIVING TISSUES BY PRIMARY COSMIC RAY PARTICLES, by J. A. G. Eugster, H. Waeffler, and W. Roost. Feb. 1956 [34]p. incl. tllus. dtagrs. refs. (AFOSR-TR-56-19) (AF 61(514)898) AD 87528
Unclasstfted

Flfty-five experiments were performed to determine the effects of cosmic rays on the living tissues of humans and animals by exposing specimens (1) at 11,000 ft (the Jungfraujoch station); (2) in the Simplon tunnel 8000 ft below the mountaintop (where control specimens were stored); (3) tn stratosphere balloons at Payerne; and (4) in sky hook and similar altitude balloons at 90,000 to 100,000 ft. Results, although not conclustve, indicated that cosmic radtation will not be a great hazard to the human body and will not hinder flight tn the upper atmosphere. The impairment of growth in the Simplon tunnel indicated that cosmic radiations act as a stimulant to growth.

ZWI. 01:001

Zwicky, F., Pasadena, Calif.

IN FLIGHT HIGH ALTITUDE TURBULENCE RESEARCH PROGRAM, by F. Zwicky. July 10, 1955 [18]p. incl. diagrs. ([AF]OSR-TR-55-23) (AF 18(600)488)
AD 162515 Unclassified

Some generalities are presented on stellar scintillations and a method is dtscussed which provtdes a measure of the quality of seeing. The present investigation is concerned wtth tests by binoculars or small photographic cameras. The technique of stellar tmage trailing led to the important discovery that the disturbances causing poor seetng can be very high up in the atmosphere. Observations from the ground and tn the high altitude flights led to these preliminary conclusions: (1) that there ts very little systematic change tn vtsual seetng between the ground and about 7 km height; (2) that the sluggtsh scintillations wtth frequencies tnferior to 20/sec are caused mostly by atmospheric disturbances in the first 7 km of the atmosphere; and (3) that it wtll he necessary to ascend with instruments of much greater light gathertng power and much faster time resolution than the human eye to explore the quantitative aspects of the stellar sctntillation at great altitudes. The study of jet vapor tratls and the correlation of the observed phenomena wtth stellar scintillation data led to the discovery of very stable disturbances in air whtch were designated as Aertal Blobs or Aerial Mollusks.

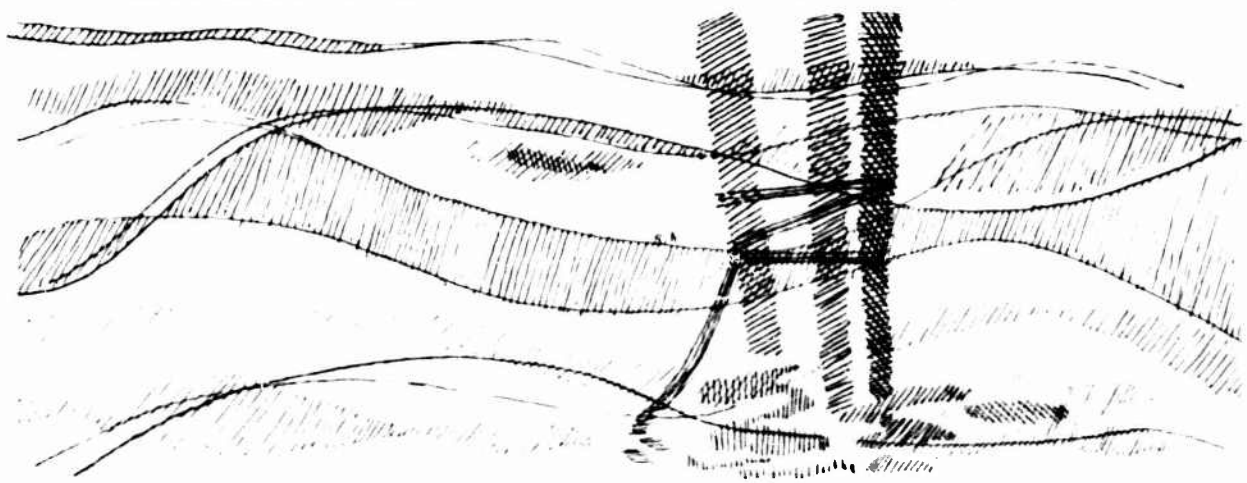
Code Guide

Code Guide

AER	Aerojet-General Corp., Azusa, Calif.
AIA	American Inst. of Aerological Research, Pasadena, Calif.
ALF	Alfred U., New York
AMF	American Machine and Foundry Co., Pacoima, Calif.
AMS	American Mathematical Soc., Providence, R. I.
ANS	Aeronutronic Systems, Inc., Glendale, Calif.
ANT	Antioch Coll., Yellow Springs, Ohio
ARD	ARDE Associates, Newark, N. J.
ARK	Arkansas U., Fayetteville
ARN	Arnold, Lee, Associates, New York
ASM	American Soc. of Mechanical Engineers, New York
ATE	Ateliers de Constructions Electriques de Charleroi (France)
ATL	Atlantic Research Corp., Alexandria, Va.
BAN	Banos, A., Jr., Los Angeles, Calif.
BAT	Battelle Memorial Inst., Columbus, Ohio
BCU	British Columbia U., Vancouver (Canada)
BEL	Bell Aircraft Corp., Buffalo, N. Y.
BJO	Bjorksten Research Foundation, Madison, Wis.
BMB	Bureau of Mines, Bartlesville, Okla.
BMP	Bureau of Mines, Pittsburgh, Pa.
BOS	Boston U., Mass.
BRI	Brigham Young U., Provo, Utah
BRO	Brown U., Providence, R. I.
BUT	Butler U., Indianapolis, Ind.
CAL	California U., Berkeley
CAR	Carnegie Inst. of Tech., Pittsburgh, Pa.
CAT	Catholic U. of America, Washington, D. C.
CDC	Chicago Development Corp., Riverdale, Md.
CER	Carter Labs., Pasadena, Calif.
CHA	Charyk, J. V., Princeton, N. J.
CHI	Chicago U., Ill.
CIN	Cincinnati U., Ohio
CIT	California Inst. of Tech., Pasadena
CLA	California U., Los Angeles
COA	Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
COL	Colorado U., Boulder
CON	Connecticut U., Storrs
COR	Cornell U., Ithaca, N. Y.
COU	Columbia U., New York
DEL	Delaware U., Newark
DET	Detroit U., Mich.
DUK	Duke U., Durham, N. C.
EAS	Eastern Research Group, Brooklyn, N. Y.
EMO	Emory U., Atlanta, Ga.
ESC	Escher Wyss, Ltd., Zurich (Switzerland)
EXP	Experiment, Inc., Richmond, Va.
FLA	Florida State U., Tallahassee
FLU	Florida U., Gainesville
FOR	Forest Products Lab., Madison, Wis.
FRA	Franklin Inst., Philadelphia, Pa.
FRB	Freiburg U. (Germany)
FRD	Frederick, Carl L. and Associates, Bethesda, Md.
FRE	Free U. of Brussels (Belgium)
FRS	Fresno State Coll., Calif.
GEC	Geckler, R. D., Arcadia, Calif.
GEN	General Electric Co., Schenectady, N. Y.
GEO	George Washington U., Washington, D. C.
GIT	Georgia Inst. of Tech., Atlanta
GOT	Göttingen U. (Germany)
HAM	Hamburg U. (Germany)
HAR	Harvard U., Cambridge, Mass.
HEI	Heidelberg U. (Germany)
HER	Hermann Föttinger Inst. für Strömungstechnik, Technischen Universität, Berlin (Germany)
HOR	Horizons, Inc., Cleveland, Ohio
IAS	Institute for Advanced Study, Princeton, N. J.
IIT	Illinois Inst. of Tech., Chicago
ILL	Illinois U., Urbana
INN	Innsbruck U. (Austria)
INS	Institute of the Aeronautical Sciences, Inc., New York
INT	Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain)
IOW	Iowa State Coll., Ames
ISG	Illinois State Geological Survey, Urbana
IST	Istituto Nazionale di Ottica, Florence (Italy)
JHU	Johns Hopkins U., Baltimore, Md.
KAN	Kansas U., Lawrence
KAR	Karolinska Inst., Stockholm (Sweden)
KOF	Kofink, W., Karlsruhe (Germany)
KUE	Kuessner, H. G., Göttingen (Germany)
LAV	Laval U., Quebec (Canada)
LEH	Lehigh U., Bethlehem, Pa.
LEY	Leyden U. (Netherlands)
LIE	Liège U., Brussels (Belgium)
LIT	Litton Industries, Beverly Hills, Calif.
LOC	Lockheed Aircraft Corp., Palo Alto, Calif.
LOU	Louvain U. (Belgium)
LSU	Louisiana State U., Baton Rouge
MAR	Marseille U. (France)
MAS	Massachusetts U., Amherst
MAU	Maudsley Hospital, London (Great Britain)
MDU	Maryland U., College Park
MED	Méditerranéen de Recherches Thermodynamiques, Nice (France)
MET	Metalectro Corp., Bladensburg, Md.
MIC	Michigan U., Ann Arbor
MIN	Minnesota U., Minneapolis
MIS	Missouri U., Columbia
MIT	Massachusetts Inst. of Tech., Cambridge
MML	McMillan Lab., Inc., Ipswich, Mass.
MMU	McMasters U. Hamilton Coll., Ont. (Canada)
MPP	Max-Planck-Institut für Physik der Stratosphare, Hechingen (Germany)
MPS	Max-Planck-Institut fur Strömungsforschung, Göttingen (Germany)
MUF	Miami U., Coral Gables, Fla.
MUO	Miami U., Oxford, Ohio
NAA	North American Aviation, Inc., Downey, Calif.
NBS	National Bureau of Standards, Washington, D. C.
NCU	North Carolina U., Chapel Hill

Code Guide

NEB	Nebraska U., Lincoln
NEL	Nelson, W. C., Ann Arbor, Mich.
NHU	New Hampshire U., Durham
NOL	Naval Ordnance Lab., Corona, Calif.
NOR	Northwestern U., Evanston, Ill.
NOT	Notre Dame U., South Bend, Ind.
NRC	National Research Council, Washington, D. C.
NYU	New York U., N. Y.
ODI	Odin Associates, Pasadena, Calif.
OKA	Oklahoma A. & M. Coll., Stillwater
OKU	Oklahoma U., Norman
ORL	Orlando Research, Inc., Fla.
OSU	Ohio State U. Research Foundation, Columbus
OXF	Oxford U. (Great Britain)
PEN	Pennsylvania U., Philadelphia
PIB	Polytechnic Inst. of Brooklyn, N. Y.
PIO	Pioneer Industries, Inc., Reno, Nev.
PIS	Pisa U. (Italy)
PIT	Pittsburgh U., Pa.
POL	Politecnico di Milano (Italy)
POM	Pomona Coll., Claremont, Calif.
PRF	Purdue Research Foundation, Lafayette, Ind.
PRI	Princeton U., N. J.
PRO	Propulsion Research Corp., Santa Monica, Calif.
PSM	Pennsylvania Salt Mfg. Co., Philadelphia
PSU	Pennsylvania State U., University Park
PUR	Purdue U., Lafayette, Ind.
RCA	Radio Corp. of America, Princeton, N. J.
RIC	Rice Inst., Houston, Tex.
ROC	Rochester U., N. Y.
ROM	Rome U. (Italy)
ROS	Ross, Chandler C., West Covina, Calif.
ROY	Royal Inst. of Tech., Stockholm (Sweden)
RPI	Rensselaer Polytechnic Inst., Troy, N. Y.
RRI	Reed Research, Inc., Washington, D. C.
RUT	Rutgers U., New Brunswick, N. J.
SAN	Sandberg-Serrell Corp., Pasadena, Calif.
SCL	Santa Clara U., Calif.
SCU	South Carolina U., Columbia
SOC	Southern California U., Los Angeles
SOU	Soundrive Engine Co., Los Angeles, Calif.
SRI	Southwest Research Inst., San Antonio, Tex.
STA	Stanford U., Calif.
STL	St. Louis U., Mo.
STR	Stanford Research Inst., Menlo Park, Calif.
SYR	Syracuse U., N. Y.
TAI	Tennessee Agricultural and Industrial State U., Nashville
TAM	Texas A. and M. Coll., College Station
TEM	Temple U., Philadelphia, Pa.
TEN	Tennessee U., Knoxville
TEX	Texas U., Austin
THB	Technische Hochschule, Braunschweig (Germany)
TIH	Technion - Israel Inst. of Tech., Haifa
TOI	Technical Operations, Inc., Arlington, Mass.
TOL	Toledo U. Research Foundation, Ohio
TOR	Toronto U. Inst. of Aerophysics (Canada)
TRG	Technical Research Group, New York
TRI	Trinity Coll., Hartford, Conn.
TUS	Tuskegee Inst. George Washington Carver Foundation, Ala.
UTA	Utah U., Salt Lake City
VIS	Virginia Inst. for Scientific Research, Richmond
VIT	Vitro Corp. of America, West Orange, N. J.
VPI	Virginia Polytechnic Inst., Blacksburg
WAL	Walz, A., Emmendingen (Germany)
WAR	Warner and Swasey Research Corp., New York
WAS	Washington U., St. Louis, Mo.
WAU	Washington U., Seattle
WAY	Wayne State U., Detroit, Mich.
WES	Wesleyan U., Middletown, Conn.
WHE	Westinghouse Electric Corp., East Pittsburg, Pa.
WIS	Wisconsin U., Madison
WSC	Washington State Coll., Pullman
WUR	Würzburg U. (Germany)
YAL	Yale U., New Haven, Conn.
ZUR	Zurich U. (Switzerland)
ZWI	Zwicky, F., Pasadena, Calif.



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American Math. Soc., Providence, R. I.
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Zwicky, F., Pasadena, Calif.
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Laval U. Dept. of Chemistry, Quebec (Canada)
LAV. 01:001-015

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Soundrive Engine Co., Los Angeles, Calif.
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CIT. 12:001-004

AF 18(600)595
Ohio State U. Research Foundation, Columbus
OSU. 01:001-002

AF 18(600)596
Warner and Swasey Research Corp., New York
WAR. 01:001

AF 18(600)599
Minnesota U. Rosemount Aeronautical Labs., Minneapolis
MIN. 10:001-002

AF 18(600)641
Virginia Polytechnic Inst. Engineering Experiment Station, Blacksburg
VPI. 02:001-009

AF 18(600)642
Illinois Inst. of Tech. Armour Research Foundation, Chicago
IIT. 02:001-002

AF 18(600)643
Illinois Inst. of Tech. Lab. of Physical Electronics, Chicago
IIT. 06:001-002

AF 18(600)644
Horizons Inc., Cleveland, O.
HOR. 01:001

AF 18(600)646
Stanford U. High-Energy Physics Lab., Calif.
STA. 07:001-024

AF 18(600)648
Colorado U. Dept. of Chemistry, Boulder
COL. 01:001-003

AF 18(600)651
Syracuse U. Dept. of Physics, N. Y.
SYR. 02:001-008

AF 18(600)653
Washington U. Dept. of Physics, Seattle
WAU. 03:001-011

AF 18(600)656
Chicago Development Corp., Riverdale, Md.
CDC. 01:001

AF 18(600)659
Chicago U. Dept. of Mathematics, Ill.
CHI. 05:001-004

AF 18(600)660
Pennsylvania U., Philadelphia
PEN. 01:001-005

AF 18(600)662
Illinois U. Dept. of Physics, Urbana
ILL. 08:001-007

AF 18(600)663
Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.
CHI. 11:001-009

AF 18(600)664
Brown U. Div. of Engineering, Providence, R. I.
BRO. 04:001-012

AF 18(600)665
Johns Hopkins U. Dept. of Mathematics, Baltimore, Md.
JHU. 07:001-004

AF 18(600)666
Chicago U. Enrico Fermi Inst. for Nuclear Studies, Ill.
CHI. 12:001-026

AF 18(600)667
Institute for Advanced Study, Princeton, N. J.
IAS. 02:001-002

AF 18(600)669
California Inst. of Tech., Pasadena
CIT. 01:001-004

AF 18(600)671
Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.
JHU. 03:001-003

AF 18(600)672
Pennsylvania State U. Field Emission Lab., University Park
PSU. 05:001-004

AF 18(600)673
Pennsylvania State U. Field Emission Lab., University Park
PSU. 06:001-006

AF 18(600)674
Cornell U. Dept. of Physics, Ithaca, N. Y.
COR. 07:016; COR. 08:001-006

AF 18(600)677
Columbia U. Electronics Research Labs., New York
COU. 10:001-017

AF 18(600)678
Florida State U. Dept. of Chemistry, Tallahassee
FLA. 01:001-005

AF 18(600)679
Wisconsin U., Madison
WIS. 01:001-005

AF 18(600)680
Stanford U. Applied Mathematics and Statistics Lab., Calif.
STA. 01:001-008

AF 18(600)681
Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.
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AF 18(600)684
Emory U. Dept. of Mathematics, Atlanta, Ga.
EMO. 01:001

AF 18(600)685
Cornell U. Dept. of Mathematics, Ithaca, N. Y.
COR. 05:001-059

AF 18(600)688
Rochester U. Inst. of Optics, N. Y.
ROC. 05:001-019

AF 18(600)689
Illinois U. Dept. of Physics, Urbana
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AF 18(600)690
Virginia Polytechnic Inst. Dept. of Chemistry, Blacksburg
VPI. 01:001-003

AF 18(600)691
Cincinnati U. Dept. of Mathematics, Ohio
CIN. 03:001-009

AF 18(600)693
Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.
PIB. 04:001-006

AF 18(800)694
Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.
PIB. 05:001-008

AF 18(600)698
Wisconsin U. Dept. of Physics, Madison
WIS. 04:001-003

AF 18(600)699
Washington State Coll. Dept. of Physics, Pullman
WSC. 01:001-003

AF 18(600)750
Michigan U. Engineering Research Inst., Ann Arbor
MIC. 05:001-003

AF 18(600)754
Syracuse U. Research Inst. Electrical Engineering Dept., N. Y.
SYR. 06:001-005

AF 18(600)757
Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.
JHU. 14:001-002

AF 18(800)758
Colorado U. Dept. of Mathematics, Boulder
COL. 03:001-010

AF 18(600)760
Syracuse U. Dept. of Mathematics, N. Y.
SYR. 01:001-016

AF 18(800)761
Pennsylvania Salt Mfg. Co. Whitemarsh Research Labs., Philadelphia
PSM. 01:001-008

AF 18(600)784
Massachusetts Inst. of Tech., Cambridge
MIT. 01:001-002

AF 18(800)765
Johns Hopkins U. Dept. of Chemistry, Baltimore, Md.
JHU. 05:001

AF 18(800)789
Ohio State U. Research Foundation. Dept. of Chemistry, Columbus
OSU. 05:001-003

AF 18(800)771
Yale U. Sloane Physics Lab., New Haven, Conn.
YAL. 04:001-017

AF 18(800)772
Ohio State U. Research Foundation. Dept. of Physics and Astronomy, Columbus
OSU. 08. 001-019

AF 18(800)774
Horizons Inc., Cleveland, Ohio
HOR. 02:001

AF 18(800)778
Notre Dame U. Dept. of Mathematics, South Bend, Ind.
NOT. 01:001-003

AF 18(800)777
Washington U. Dept. of Physics, St. Louis, Mo.
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AF 18(600)778
Boston U., Mass.
BOS. 01:001-002

AF 18(600)779
Tuskegee Inst. George Washington Carver Foundation, Ala.
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AF 18(800)783
Illinois U. Dept. of Physics, Urbana
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North American Aviation, Inc., Downey, Calif.
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AF 18(600)790
Institute for Advanced Study, Princeton, N. J.
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AF 18(600)791
Institute for Advanced Study, Princeton, N. J.
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AF 18(600)793
Westinghouse Electric Corp. Westinghouse Research Labs., East Pittsburgh, Pa.
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AF 18(600)796
Polytechnic Inst. of Brooklyn, N. Y.
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AF 18(600)797
Frederick, Carl L., and Associates, Bethesda, Md.
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AF 18(600)799
Ross, Chandler C., West Covina, Calif.
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AF 18(600)844
Southern California U. Dept. of Chemistry, Los Angeles
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AF 18(600)846
Geckler, R. D., Arcadia, Calif.
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AF 18(600)847
Sandberg-Serrell Corp., Pasadena, Calif.
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AF 18(600)850
Yale U. Hammond Metallurgical Lab., New Haven, Conn.
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AF 18(600)851
Minnesota U. Rosemount Aeronautical Labs., Minneapolis
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AF 18(600)853
George Washington U. Dept. of Pharmacology, Washington, D. C.
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AF 18(600)857
California U. Dept. of Chemistry, Los Angeles
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AF 18(600)858
Arnold, Lee, Associates, New York
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AF 18(600)859
Yale U. Sterling Chemistry Lab., New Haven, Conn.
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AF 18(600)891
Brown U. Div. of Engineering, Providence, R. I.
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AF 18(600)892
Pittsburgh U. Sarah Mellon Scaife Radiation Lab., Pa.
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AF 18(600)893
Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park
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AF 18(600)894
Pennsylvania U. Dept. of Physics, Philadelphia
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AF 18(600)895
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AF 18(600)898, Task II
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AF 18(600)899
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AF 18(600)950
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AF 18(600)951
Columbia U. School of Mines, New York
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AF 18(600)953
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AF 18(600)954
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AF 16(600)958
California U. Dept. of Mathematics, Berkeley
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AF 16(600)959
Kansas U. Dept. of Mathematics, Lawrence
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AF 18(600)960
Arkansas U. Dept. of Chemistry, Fayetteville
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AF 18(600)961
Massachusetts Inst. of Tech. Fluid Dynamics Research Group, Cambridge
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AF 18(600)962
Columbia U. Electronics Research Labs., New York
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AF 16(600)965
Columbia U. School of Mines, New York
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AF 18(600)967
Princeton U. James Forrestal Research Center, N. J.
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AF 16(600)966
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AF 16(600)969
Carnegie Inst. of Tech. Dept. of Mech. Engineering, Pittsburgh, Pa.
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AF 16(600)970
Polytechnic Inst. of Brooklyn. Inst. of Polymer Research, N. Y.
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AF 18(600)972
Charyk, J. V., Princeton, N. J.
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AF 16(600)974
Georgia Inst. of Tech. Engineering Experiment Station, Atlanta
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AF 18(600)975
Rutgers U. Dept. of Physics, New Brunswick, N. J.
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AF 18(600)980
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AF 18(600)982
Ohio State U. Research Foundation. Dept. of Electrical Engineering, Columbus
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AF 18(600)963
Michigan U. Engineering Research Inst. Ann Arbor
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AF 16(600)984
Minnesota U. School of Chemistry, Minneapolis
MIN. 13:001

AF 18(600)985
Illinois State Geological Survey. Div. of Fluorine Chemistry, Urbana
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AF 16(600)987
Washington U. Dept. of Chemistry, Seattle
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AF 16(600)992
Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.
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AF 16(600)993
Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park
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AF 16(600)994
American Math. Soc., Providence, R. I.
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AF 18(600)997
Boston U. Dept. of Physics, Mass.
BOS. 02:001-008

AF 16(600)996
Harvard U. Dept. of Mathematics, Cambridge, Mass.
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AF 18(600)1000
Cornell U. Dept. of Engineering Physics, Ithaca, N. Y.
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AF 16(600)1003
Ohio State U. Research Foundation. Dept. of Physics and Astronomy, Columbus
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AF 16(600)1004
New York U. Physics Dept., N. Y.
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AF 16(600)1009
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Bjorksten Research Foundation, Madison, Wis.
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AF 18(600)1012
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AF 18(600)1013
Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.
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AF 18(800)1014
Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park
MDU. 12:001-005

AF 18(600)1015
Maryland U. Dept. of Physics, College Park
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AF 18(600)1018
Illinois U. Electrical Engineering Research Lab., Urbana
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AF 18(600)1019
Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.
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AF 18(600)1021
Brown U. Div. of Applied Mathematics, Providence, R. I.
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AF 18(600)1022
California U. Dept. of Engineering, Los Angeles
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AF 18(600)1026
Aerojet-General Corp., Azusa, Calif.
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AF 18(600)1038
Santa Clara U. Dept. of Mathematics, Calif.
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AF 18(600)1037
Wisconsin U. Dept. of Chemistry, Madison
WIS. 03:001-008

AF 18(600)1038
Maryland U. Dept. of Physics, College Park
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AF 18(600)1040
Johns Hopkins U. Dept. of Medicine, Baltimore, Md.
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AF 18(600)1041
Baños, A. Jr., Los Angeles, Calif.
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AF 18(600)1044
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AF 18(600)1045
Pomona Coll. Dept. of Physics, Claremont, Calif.
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AF 18(800)1048
Aerojet-General Corp., Azusa, Calif.
AER. 02:001-011

AF 18(600)1107
Johns Hopkins U. Dept. of Medicine, Baltimore, Md.
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AF 18(600)1108
Missouri U. Dept. of Mathematics, Columbia
MIS. 01:001-009

AF 18(800)1109
Institute for Advanced Study, Princeton, N. J.
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AF 18(600)1110
Wisconsin U., Madison
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AF 18(600)1111
Chicago U. Dept. of Mathematics, Ill.
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AF 18(800)1112
Nebraska U., Lincoln
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AF 18(800)1113
California Inst. of Tech. Antenna Lab., Pasadena
CIT. 02:001-004

AF 18(600)1114
Institute for Advanced Study, Princeton, N. J.
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AF 18(800)1116
Pennsylvania U. Dept. of Mathematics, Philadelphia
PEN. 03:001-002

AF 18(800)1117
California U. Dept. of Mathematics, Berkeley
CAL. 02:001-007

AF 18(600)1121
Johns Hopkins U. Dept. of Aeronautics, Baltimore, Md.
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AF 18(600)1124
Syracuse U. Dept. of Physics, N. Y.
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AF 18(600)1125
Chicago U. Dept. of Mathematics, Ill.
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AF 18(600)1126
Florida U. Engineering and Industrial Experiment Station, Gainesville
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AF 18(600)1127
Yale U. Dept. of Mathematics, New Haven, Conn.
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AF 16(600)1133
Washington U. Dept. of Physics, St. Louis, Mo.
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AF 18(600)1134
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AF 18(600)1135
Rice Inst. Dept. of Mathematics, Houston, Tex.
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AF 18(600)1136
Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.
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AF 16(600)1139
North Carolina U. Dept. of Mathematics, Chapel Hill
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AF 18(600)1142
California Inst. of Tech. Guggenheim Aeronautical Lab., Pasadena
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AF 18(600)1143
Propulsion Research Corp., Santa Monica, Calif.
PRO. 01:001-002

AF 18(600)1144
Minnesota U. Dept. of Mathematics, Minneapolis
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AF 16(600)1145
Southern California U. Engineering Center, Los Angeles
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AF 18(600)1147
Carnegie Inst. of Tech. Metals Research Lab., Pittsburgh, Pa.
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AF 18(600)1148
Illinois Inst. of Tech. Dept. of Chemistry, Chicago
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AF 18(600)1151
Colorado U. Dept. of Chemistry, Boulder
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AF 18(600)1152
Columbia U. Dept. of Chemistry, New York
COU. 03:001-015

AF 18(600)1155
Aerojet-General Corp., Azusa, Calif.
AER. 03:001-003

AF 18(800)1158
Bell Aircraft Corp. Rocket Engine Dept., Buffalo, N. Y.
BEL. 01:001-002

AF 18(800)1158
Pennsylvania U. Dept. of Mathematics, Philadelphia
PEN. 04:001-005

AF 18(800)1159
Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.
COR. 10:001-005

AF 16(800)1180
North Carolina U. Dept. of Chemistry, Chapel Hill
NCU. 01:001-008

AF 16(800)1162
Cornell U. Graduate School of Aeronautical Engineering, Ithaca, N. Y.
COR. 11. 001-003

AF 16(800)1163
Chicago Development Crop., Riverdale, Md.
CDC. 02:001

AF 16(600)1164
Brigham Young U. Dept. of Chemistry, Provo, Utah
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AF 18(600)1166
Illinois Inst. of Tech. Armour Research Foundation, Chicago
IIT. 04:001-005

AF 16(600)1169
Minnesota U., Minneapolis
MIN. 01:001-002

AF 18(800)1178
Johns Hopkins U. Inst. for Cooperative Research, Baltimore, Md.
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AF 18(600)1180
George Washington U., Washington, D. C.
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AF 18(600)1182
Polytechnic Inst. of Brooklyn. Dept. of Chemistry, N. Y.
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AF 18(800)1185
Toronto U. Inst. of Aerophysics (Canada)
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AF 18(600)1188
Michigan U. Engineering Research Inst., Ann Arbor
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AF 18(600)1189
Institute for Advanced Study, Princeton, N. J.
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AF 18(600)1192
American Machine and Foundry Co. Turbo Div., Pacoima, Calif.
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AF 18(600)1193
Polytechnic Inst. of Brooklyn, N. Y.
PIB. 02:001-002

AF 18(600)1199
Michigan U. Engineering Research Inst., Ann Arbor
MIC. 08:001

AF 18(600)1215
Aerojet-General Corp., Azusa, Calif.
AER. 04:001-003

AF 18(600)1216
Aerojet-General Corp., Azusa, Calif.
AER. 05:001-002

AF 18(600)1217
Utah U. Dept. of Electrical Engineering, Salt Lake City
UTA. 01:001-007

AF 18(600)1218
Michigan U. Engineering Research Inst., Ann Arbor
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AF 18(600)1223
Connecticut U., Storrs
CON. 01:001

AF 18(600)1226
Minnesota U. Heat Transfer Lab., Minneapolis
MIN. 07:001-009

AF 18(600)1236
Carnegie Inst. of Tech. Dept. of Mathematics, Pittsburgh, Pa.
CAR. 05:001-004

AF 18(600)1239
Radio Corp. of America. David Sarnoff Research Center, Princeton, N. J.
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AF 18(600)1246
Maryland U. Glenn L. Martin Inst. of Tech., College Park
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AF 18(600)1247
Columbia U. Inst. of Air Flight Structures, New York
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AF 18(600)1249
Toledo U. Research Foundation, Ohio
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AF 18(600)1300
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AF 18(600)1306
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AF 18(600)1307
Johns Hopkins U. Lab. of Astrophysics and Physical Meteorology, Baltimore, Md.
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AF 18(600)1310
Illinois U. Electrical Engineering Research Lab., Urbana

AF 18(600)1311
Illinois U. Dept. of Mining and Metallurgical Engineering, Urbana
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AF 18(600)1313
Technical Research Group, New York
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AF 18(600)1315
Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park
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AF 18(600)1317
Washington U. Dept. of Physics, St. Louis, Mo.
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AF 18(600)1318
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AF 18(600)1319
Virginia Inst. for Scientific Research, Richmond
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AF 18(600)1320
Franklin Inst. Bartol Research Foundation, Swarthmore, Pa.
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AF 18(600)1331
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AF 18(600)1335
Michigan U. Engineering Research Inst., Ann Arbor
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AF 18(600)1339
Rensselaer Polytechnic Inst. Dept. of Aeronautical Engineering, Troy, N. Y.
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AF 18(600)1341
Duke U. Dept. of Mathematics, Durham, N. C.
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AF 18(600)1372
New York U. Coll. of Engineering, N. Y.
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AF 18(600)1379
Princeton U. Dept. of Mathematics, N. J.
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AF 18(600)1380
Maryland U. Inst. for Fluid Dynamics and Applied Mathematics, College Park
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AF 18(600)1381
Polytechnic Inst. of Brooklyn. Dept. of Aeronautical Engineering and Applied Mechanics, N. Y.
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AF 18(600)1382
Reed Research, Inc., Washington, D. C.
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AF 18(600)1383
Chicago U. Dept. of Mathematics, Ill.
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AF 18(600)1389
Orlando Research Inc., Fla.
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AF 18(600)1390
Columbia U. Dept. of Chemistry, New York
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AF 18(600)1396
Carter Labs., Pasadena, Calif.
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AF 18(600)1397
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AF 18(600)1398
Illinois U. Dept. of Mathematics, Urbana
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AF 18(600)1399
Illinois Inst. of Tech. Armour Research Foundation, Chicago
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AF 18(600)1449
Miami U., Coral Gables, Fla.
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AF 18(600)1454
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AF 18(600)1456
Minnesota U. Dept. of Aeronautical Engineering, Minneapolis
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AF 18(600)1459
Georgia Inst. of Tech. Engineering Experiment Station, Atlanta
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AF 18(600)1460
New York U. Coll. of Engineering, N. Y.
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AF 18(600)1461
Harvard U. Dept. of Mathematics, Cambridge, Mass.
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AF 18(600)1462
Lehigh U. Dept. of Physics, Bethlehem, Pa.
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AF 18(600)1463
Purdue U. School of Chemical and Metallurgical Engineering, Lafayette, Ind.
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AF 18(600)1466
Detroit U. Research Inst. of Science and Engineering, Mich.
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AF 18(600)1468
Northwestern U. Dept. of Metallurgy, Evanston, Ill.
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AF 18(600)1471
New York U. Coll. of Engineering, N. Y.
NYU. 05:001-002

AF 18(600)1474
Johns Hopkins U. Dept. of Mathematics, Baltimore, Md.
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AF 18(600)1475
Temple U. Research Inst., Philadelphia, Pa.
TEM. 01:001-006

AF 18(600)1484
Purdue Research Foundation, Lafayette, Ind.
PRF. 01:001-006

AF 18(600)1488
Stanford U. Div. of Engineering Mechanics, Calif.
STA. 04:001

AF 18(600)1489
Chicago U. Inst. for the Study of Metals, Ill.
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AF 18(600)1495
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Stanford Research Inst., Menlo Park, Calif.
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AF 16(600)1501
Odin Associates, Pasadena, Calif.
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AF 16(600)1502
Atlantic Research Corp., Alexandria, Va.
ATL. 01:001

AF 18(600)1505
Polytechnic Inst. of Brooklyn. Microwave Research Inst., N. Y.
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AF 18(600)1506
Columbia U. Dept. of Physics, New York
COU. 09:001

AF 16(600)1507
Butler U., Indianapolis, Ind.
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AF 16(600)1508
Experiment, Inc., Richmond, Va.
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AF 18(600)1511
Stanford U. Microwave Lab., Calif.
STA. 09:001

AF 18(600)1517
British Columbia U. Dept. of Mathematics, Vancouver (Canada)
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AF 16(600)1521
California U. Electronics Research Lab., Berkeley
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AF 18(600)1523
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AF 16(600)1524
Georgia Inst. of Tech. Engineering Experiment Station, Atlanta
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AF 18(600)1525
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AF 16(600)1526
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AF 16(600)1526
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AF 16(600)1529
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AF 16(600)1530
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AF 18(600)1535
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AF 16(600)1536
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AF 18(600)1537
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AF 16(600)1540
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AF 16(600)1556
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AF 18(600)1583
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AF 18(600)1591
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AF 18(600)1595
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AF 61(514)875
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AF 61(514)881
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AF 61(514)953
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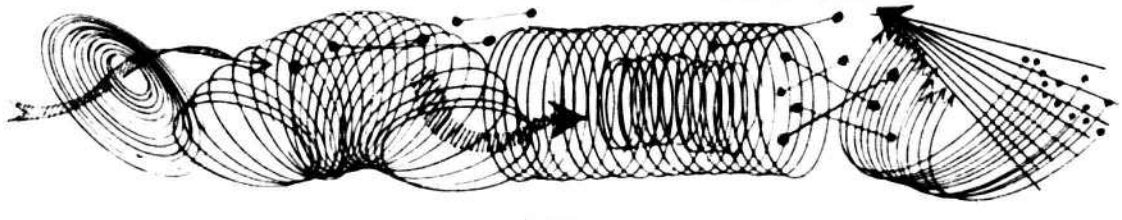

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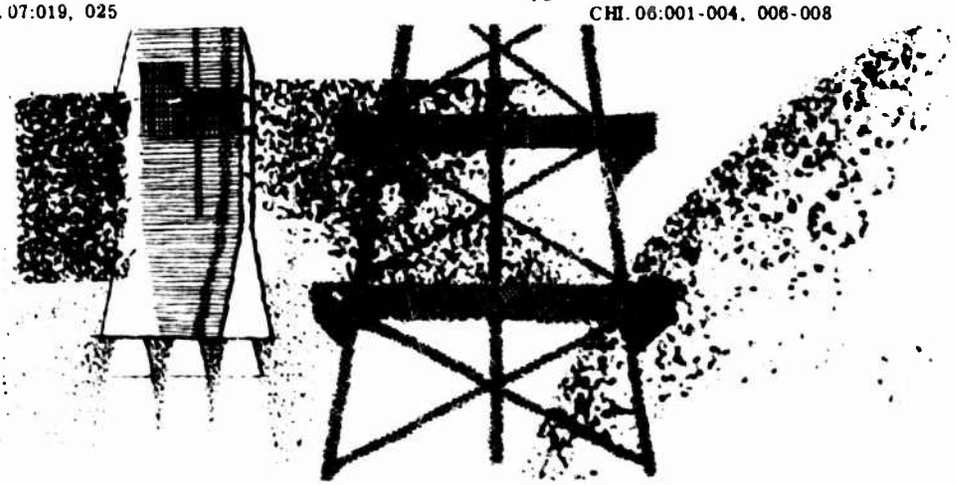

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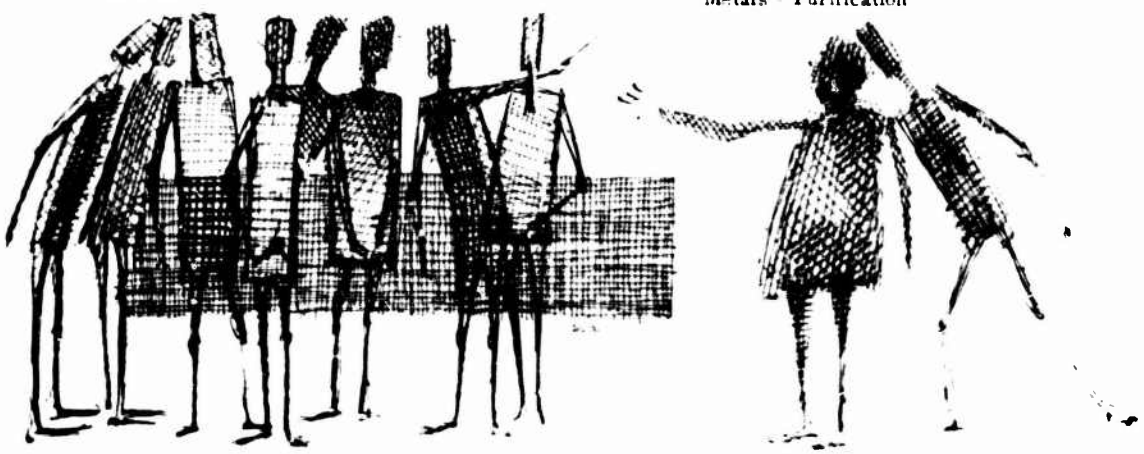

Mathematical Subject Classification

Mathematical Subject Classification

ALGEBRA

Algebras:
- Associative algebras
  - CHI. 07:001
- Lie algebras
  - NYU. 06:003, 010-012
- Non-associative algebras
  - BUT. 01:001; CHI. 05:003

Combinatorial Analysis
- NBS. 09:015

Fields, Rings:
- Fields
  - OSU. 01:002
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Groups and Generalizations:
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  - WAS. 02:002
- Finite groups
  - IAS. 03:002; NBS. 09:009
- General
  - WAS. 01:002, 003; WAS. 02:003, 005, 016
- Group theoretic constructions, free groups, extensions
  - CHI. 08:002
- Matrix groups, representation, characters
  - NBS. 09:009
- Nilpotent and solvable groups
  - IAS. 03:001, 004, 005; WAS. 01:001
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  - STA. 01:005

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- CHI. 08:001, 003; COU. 05:001-004; COU. 07:001-003, 005, 006; HAR. 07:033

Linear algebra:
- Eigenvalues and eigenvectors
  - NBS. 09:011, 018, 022, 025, 039; NCU. 03:001, 002; NCU. 04:015
- Forms and transformations
  - CAR. 04:002; STA. 01:004
- Inequalities for matrices
  - BCU. 02:001; NBS. 09:040
- Linear equations, matric inversion, determinants
  - IAS. 09:004; NBS. 09:037; NCU. 04:021
- Matrices
  - NBS. 09:034, 036, 041; NYU. 06:008; PRF. 02:003; STA. 01:005

Partial Order, Lattices:
- Boolean rings and algebras
  - NBS. 09:002

Polynomials:
- Algebraic equations, roots
  - NBS. 25:007; WAS. 01:004

FOUNDATIONS, THEORY OF SETS, LOGIC

Syntax, semantics, formal methods in general, recursive functions
- NHU. 01:001-003

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Algebraic Geometry:
- General theory of varieties, surfaces
  - IAS. 05:012
- Group varieties, Abelian, equivalence theories
  - NOR. 02:001, 002
- Special varieties, curves, surfaces
  - MIN. 04:001

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  - NBS. 09:012, 021; NBS. 10:001; STA. 01:004
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  - NBS. 09:002
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- Differential geometry in the large
  - JHU. 09:003; MDU. 09:045; PRI. 06:004

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  - STA. 01:007
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  - STA. 01:007
- Projective geometry
  - STA. 01:007
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  - NBS. 09:006

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- Riemannian geometry
  - MIT. 01:001, 002; MIT. 02:001

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- Approximations and Expansions, general theory
  - COR. 05:004; HAR. 02:102; HAR. 04:001, 006, 007; NBS. 09:019
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  - BCU. 01:001, 002; CAL. 01:001-003; NBS. 09:043; NYU. 06:009; RIC. 01:002
- Degree of approximation, best approximation
  - HAR. 04:002, 010, 011, 014; NBS. 09:026; PEN. 04:004
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  - NBS. 09:003
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  - WAS. 02:020

Calculus of Variations:
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  - MDU. 09:011; MIS. 01:004
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  - IAS. 05:004; WAS. 02:019, 021; WAY. 02:004, 007
- Theory in the large, topological methods
  - CAR. 04:012

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  - SCU. 01:001

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Mathematical Subject Classification

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MDU. 09:030, 036
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  - PRF. 01:001-006
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  - IAS. 05:008

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- Operations on series and sequences
  - CAL. 01:004; COR. 05:008, 033; WUR. 01:001; WUR. 03:001
- Power and factorial series
  - CIN. 03:001
- Special sequences and series, moments
  - COL. 03:003; PEN. 04:001, 002; TRI. 01:001, 002; WAS. 02:022; WUR. 01:001; WUR. 03:001
- Tauberian theorems
  - CIN. 03:009

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- Functions defined by definite integrals, differential and integral equations, infinite series
  - MIT. 10:072; NYU. 06:020
- Hypergeometric functions and generalizations
  - HAR. 02:003
- Legendre functions, spherical harmonics
  - WAS. 02:018; WUR. 02:001
- Polynomials as functions, orthogonal polynomials
  - WAS. 02:025

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- COR. 06:001, 002
- Convergence, summability
  - CHI. 06:007, 008
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  - COR. 05:016, 057; IAS. 07:002; NYU. 06:008
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  - RUT. 01:001, 002; WAS. 02:006

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  - CIT. 01:003, 004
- Digital computers: coding and programming
  - IAS. 08:001; IAS. 09:002; NBS. 09:010, 027
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  - HAR. 02:030
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  - NBS. 09:023
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  - NBS. 09:005, 008, 012-014, 020, 024, 035, 038
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  - HAR. 02:001; NBS. 18:001
- Numerical differentiation and integration, mechanical quadrature
  - MIT. 10:002; WIS. 01:002
- Partial differential equations
  - HAM. 01:001; HAM. 02:001-004; MDU. 09:015, 033; NCU. 02:004
- Roots of algebraic and transcendental equations
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  - MIT. 10:078

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  - PRI. 05:001-004
- Switching theory, relays
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  - MDU. 13:005; NBS. 09:038

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  - WAS. 02:024

Programming, Resource Allocation, Games:
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  - CAR. 04:008; IAS. 05:002; NBS. 09:024, 028-030, 038

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- Foundations of mechanics of deformable solids
  - CAR. 04:006; WAS. 02:014
- Plane stress and strain
  - CAR. 04:005; MDU. 09:039
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  - GIT. 02:001; IOW. 01:001, 002; MDU. 09:034
- Three-dimensional problems
  - MDU. 09:002; WAS. 02:014
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  - MDU. 09:004, 010, 025, 027
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- Boundary layer theory
  - FRI. 02:001
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Mathematical Subject Classification

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NYU. 06:017
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  - CHI. 06:003; COR. 05:049; NYU. 06:006, 013, 014; TEN. 01:001; YAL. 02:001, 002
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  - NBS. 09:004; WIS. 01:005
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  - SOC. 01:001; YAL. 01:001, 002
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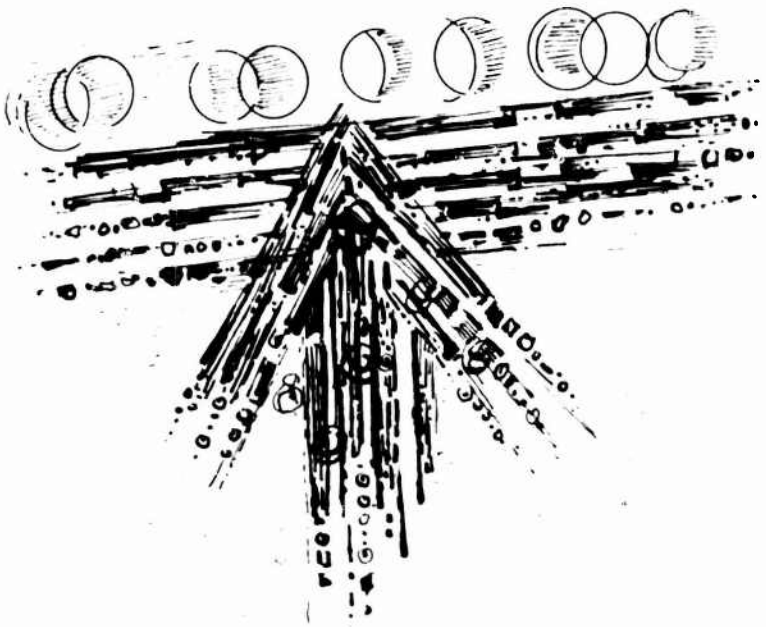
  - IAS. 02:002; PEN. 03:001, 002
- Topology of point sets, curves, continua
  - IAS. 05:011; MUF. 01:003



Code Guide

Code Guide

AER	Aerojet-General Corp., Azusa, Calif.
AIA	American Insl. of Aerological Research, Pasadena, Calif.
ALF	Alfred U., New York
AMF	American Machine and Foundry Co., Pacoima, Calif.
AMS	American Mathematical Soc., Providence, R. I.
ANS	Aeronutronic Systems, Inc., Gtendate, Calif.
ANT	Antioch Coll., Yellow Springs, Ohio
ARD	ARDE Associates, Newark, N. J.
ARK	Arkansas U., Fayelleville
ARN	Arnold, Lee, Associates, New York
ASM	American Soc. of Mechanical Engineers, New York
ATE	Aleliers de Consiructions Elecirlques de Charleroi (France)
ATL	Atlantic Research Corp., Alexandria, Va.
BAN	Baños, A., Jr., Los Angeles, Calif.
BAT	Battelle Memorial Inst., Columbus, Ohio
BCU	British Columbia U., Vancouver (Canada)
BEL	Bell Aircrafi Corp., Buffalo, N. Y.
BJO	Bjorksten Research Foundation, Madison, Wis.
BMB	Bureau of Mines, Bartlesville, Okla.
BMP	Bureau of Mines, Pittisburgh, Pa.
BOS	Bosion U., Mass.
BRt	Brigham Young U., Provo, Utah
BRO	Brown U., Providence, R. I.
BUT	Butler U., Indianapolis, Ind.
CAL	California U., Berkeley
CAR	Carnegie Inst. of Tech., Plitsburgh, Pa.
CAT	Calholic U. of America, Washington, D. C.
CDC	Chicago Developmenl Corp., Riverdale, Md.
CER	Carter Labs., Pasadena, Calif.
CHA	Charyk, J. V., Princeton, N. J.
CHI	Chicago U., Ill.
CIN	Cincinnati U., Ohio
CIT	California Inst. of Tech., Pasadena
CLA	California U., Los Angeles
COA	Cornell Aeronautical Lab., Inc., Buffalo, N. Y.
COL	Colorado U., Boulder
CON	Connecticul U., Slorrs
COR	Cornell U., Ilhaca, N. Y.
COU	Columbia U., New York
DEL	Delaware U., Newark
DET	Delroli U., Mich.
DUK	Duke U., Durham, N. C.
EAS	Eastern Research Group, Brooklyn, N. Y.
EMO	Emory U., Allania, Ga.
ESC	Escher Wyss, Lid., Zurich (Swilzerland)
EXP	Experimenl, Inc., Richmond, Va.
FLA	Florida Slate U., Tallahassee
FLU	Florida U., Gainesville
FOR	Foresl Products Lab., Madison, Wis.
FRA	Franklin Inst., Philadelphia, Pa.
FRB	Freiburg U. (Germany)
FRD	Frederick, Carl L. and Associales, Bethesda, Md.
FRE	Free U. of Brussels (Belgium)
FRS	Fresno Slate Coll., Calif.
GEC	Geckler, R. D., Arcadia, Calif.
GEN	General Electric Co., Scheneciady, N. Y.
GEO	George Washington U., Washington, D. C.
GIT	Georgia Insl. of Tech., Allania
GOT	Göltingen U. (Germany)
HAM	Hamburg U. (Germany)
HAR	Harvard U., Cambridge, Mass.
HEI	Heidelberg U. (Germany)
HER	Hermann Föttinger Insl. für Strömungstechnik, Technischen Universität, Berlin (Germany)
HOR	Horizons, Inc., Clevetand, Ohio
IAS	Institute for Advanced Study, Princeton, N. J.
IIT	Illinois Insl. of Tech., Chicago
ILL	Illinois U., Urbana
INN	Innsbruck U. (Ausiria)
INS	Insliiute of the Aeronautical Sciences, Inc., New York
INT	Instituto Nacional de Tecnica Aeronautica Esteban Terradas, Madrid (Spain)
IOW	Iowa Slate Coll., Ames
ISG	Illinois State Geological Survey, Urbana
IST	Istituto Nazionale di Ollica, Florence (Italy)
JHU	Johns Hopkins U., Baltimore, Md.
KAN	Kansas U., Lawrence
KAR	Karolinska Inst., Stockholm (Sweden)
KOF	Kofink, W., Karlsruhe (Germany)
KUE	Kuessner, H. G., Göltingen (Germany)
LAV	Laval U., Quebec (Canada)
LEH	Lehigh U., Bethlehem, Pa.
LEY	Leyden U. (Netherlands)
LIE	Liège U., Brussels (Belgium)
LIT	Litton Industries, Beverly Hills, Calif.
LOC	Lockheed Aircrafi Corp., Palo Alto, Calif.
LOU	Louvain U. (Belgium)
LSU	Louisiana Slale U., Baton Rouge
MAR	Marseille U. (France)
MAS	Massachusells U., Amhersi
MAU	Maudsley Hospital, London (Great Britain)
MDU	Maryland U., College Park
MED	Méditerranéen de Recherches Thermodynamiques, Nice (France)
MET	Metalectro Corp., Bladensburg, Md.
MIC	Michigan U., Ann Arbor
MIN	Minnesola U., Minneapolis
MIS	Missouri U., Columbia
MIT	Massachusells Inst. of Tech., Cambridge
MML	McMillan Lab., Inc., Ipswich, Mass.
MMU	McMasters U. Hamilton Coll., Ont. (Canada)
MPP	Max-Planck-Insliiul für Physik der Siratosphare, Hechingen (Germany)
MPS	Max-Planck-Insliiut für Strömungsforschung, Göltingen (Germany)
MUF	Miami U., Coral Gables, Fla.
MUO	Miami U., Oxford, Ohio
NAA	North American Aviation, Inc., Downey, Calif.
NBS	National Bureau of Standards, Washington, D. C.
NCU	North Carolina U., Chapel Hill

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NEB	Nebraska U., Lincoln
NEL	Nelson, W. C., Ann Arbor, Mich.
NHU	New Hampshire U., Durham
NOL	Naval Ordnance Lab., Corona, Calif.
NOR	Northwestern U., Evanston, Ill.
NOT	Notre Dame U., South Bend, Ind.
NRC	National Research Council, Washington, D. C.
NYU	New York U., N. Y.
ODI	Odin Associates, Pasadena, Calif.
OKA	Oklahoma A. & M. Coll., Stillwater
OKU	Oklahoma U., Norman
ORL	Orlando Research, Inc., Fla.
OSU	Ohio State U. Research Foundation, Columbus
OXF	Oxford U. (Great Britain)
PEN	Pennsylvania U., Philadelphia
PIB	Polytechnic Inst. of Brooklyn, N. Y.
PIO	Pioneer Industries, Inc., Reno, Nev.
PIS	Pisa U. (Italy)
PIT	Pittsburgh U., Pa.
POL	Politecnico di Milano (Italy)
POM	Pomona Coll., Claremont, Calif.
PRF	Purdue Research Foundation, Lafayette, Ind.
PRI	Princeton U., N. J.
PRO	Propulsion Research Corp., Santa Monica, Calif.
PSM	Pennsylvania Salt Mfg. Co., Philadelphia
PSU	Pennsylvania State U., University Park
PUR	Purdue U., Lafayette, Ind.
RCA	Radio Corp. of America, Princeton, N. J.
RIC	Rice Inst., Houston, Tex.
ROC	Rochester U., N. Y.
ROM	Rome U. (Italy)
ROS	Ross, Chandler C., West Covina, Calif.
ROY	Royal Inst. of Tech., Stockholm (Sweden)
RPI	Rensselaer Polytechnic Inst., Troy, N. Y.
RRI	Reed Research, Inc., Washington, D. C.
RUT	Rutgers U., New Brunswick, N. J.
SAN	Sandberg-Serrell Corp., Pasadena, Calif.
SCL	Santa Clara U., Calif.
SCU	South Carolina U., Columbia
SOC	Southern California U., Los Angeles
SOU	Soundrive Engine Co., Los Angeles, Calif.
SRI	Southwest Research Inst., San Antonio, Tex.
STA	Stanford U., Calif.
STL	St. Louis U., Mo.
STR	Stanford Research Inst., Menlo Park, Calif.
SYR	Syracuse U., N. Y.
TAI	Tennessee Agricultural and Industrial State U., Nashville
TAM	Texas A. and M. Coll., College Station
TEM	Temple U., Philadelphia, Pa.
TEN	Tennessee U., Knoxville
TEX	Texas U., Austin
THB	Technische Hochschule, Braunschweig (Germany)
TIH	Technion - Israel Inst. of Tech., Haifa
TOI	Technical Operations, Inc., Arlington, Mass.
TOL	Toledo U. Research Foundation, Ohio
TOR	Toronto U. Inst. of Aerophysics (Canada)
TRG	Technical Research Group, New York
TRI	Trinity Coll., Hartford, Conn.
TUS	Tuskegee Inst. George Washington Carver Foundation, Ala.
UTA	Utah U., Salt Lake City
VIS	Virginia Inst. for Scientific Research, Richmond
VIT	Vitro Corp. of America, West Orange, N. J.
VPI	Virginia Polytechnic Inst., Blacksburg
WAL	Walz, A., Emmendingen (Germany)
WAR	Warner and Swasey Research Corp., New York
WAS	Washington U., St. Louis, Mo.
WAU	Washington U., Seattle
WAY	Wayne State U., Detroit, Mich.
WES	Wesleyan U., Middletown, Conn.
WHE	Westinghouse Electric Corp., East Pittsburg, Pa.
WIS	Wisconsin U., Madison
WSC	Washington State Coll., Pullman
WUR	Würzburg U. (Germany)
YAL	Yale U., New Haven, Conn.
ZUR	Zurich U. (Switzerland)
ZWI	Zwicky, F., Pasadena, Calif.

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