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AGARD INDEX OF PUBLICATIONS (1952-1970). PART I. ABSTRACT SECTION

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Advisory Group for Aerospace Research and Development
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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

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AGARD Index of Publications 1952-1970

Part I: Abstract Section

NORTH ATLANTIC TREATY ORGANIZATION

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NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARD INDEX OF PUBLICATIONS

1952–1970

PART I : ABSTRACT SECTION

This Index has been prepared as part of the programme of the
Technical Information Panel of AGARD

THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field.
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each Member Nation. The mission of AGARD is carried out through the Panels which are composed for experts appointed by the National Delegates, the Consultant and Exchange Program and the Aerospace Applications Studies Program. The results of AGARD work are reported to the Member Nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

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PREFACE

The original Index of AGARD Publications (1952–1962) and its subsequent extension (1952–1963) with its Supplements 1 to 5 are now out-of-print, out-of-date, and too unwieldy for convenient use. A new Consolidated Index has now been prepared and, at the same time, the system of indexing has been changed, so as to bring it more into line with the other Indexes in which AGARD publications are listed. To this end, the same division as used in the STAR Index was adopted, so making cross reference between the two lists far easier than before.

Owing to the great increase in the number of publications listed, as compared with the original Index, it has proved necessary to divide this version into two parts, of which this is Part I, containing the Bibliography section with the Abstracts of all the documents included, divided according to their series, and arranged numerically within each series. It is printed on different coloured papers for each section, to simplify the finding of the various entries. Part II contains the Subject Index, the headings of which have been chosen to be compatible with those used in the STAR Index.

It is believed that this publication will not only be useful strictly as an Index, but also as a reference book in its own right; in many cases the Abstracts will provide sufficient information, without the necessity of going directly to the original document itself.

It is intended to publish Supplements to this Index, as to the previous one, until once again, a new and thorough revision becomes necessary.

Alec Jones, Chairman
Technical Information Panel, AGARD

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PART I

PART II

ADVISORY REPORTS

AR1 **A Survey on Panel Flutter.** D.J.JOHNS.
AD-804-641 AGARD Advisory Rep. 1, 123 pp., 339 refs., 1965.
N67-15160 Pt. 1 of this report presents a survey of panel flutter, and related research in the NATO countries as determined by visits made during 1965. A discussion on panel flutter criteria is included, and certain conclusions are drawn, and recommendations are made for future work. Pt. 2 is devoted to the results of the visits to individual research establishments and workers. The appendices constitute an extensive bibliography.

AR2 **Unresolved Problems in Brittle Material Design: A Critical Literature Review.** W.H.DUKES.
AD-654-119 AGARD Advisory Rep. 2, 24 pp., 72 refs., 1966.
N67-29477 Extensive benefits are to be derived from the use of certain non-metallic refractory materials in structural applications, particularly where severe temperature environments are experienced. Because of difficulties encountered in using these materials (e.g. lack of ductility and susceptibility to flaws), the AGARD Structures and Materials Panel has embarked upon a programme to refine design procedures and techniques. This critical literature review is an early result of this programme and covers such topics as: fracture theory, statistical theory, stress analysis methods, test methods, and design criteria.

AR3 **Report on Gas Turbines.**
AD-397-136 AGARD Advisory Rep. 3, 1966.
The subject of gas turbines was one of the technical areas selected by the AGARD Steering Committee on which a report was required for the information of the NATO Military Authorities. This report gives an outline of the present state of the art and capabilities to be expected from gas turbines for military purposes.

AR4 **Report on Hypersonic Aircraft.**
AD-397-143 AGARD Advisory Rep. 4, 1966.
"Hypersonic aircraft" was one of the subjects selected by the AGARD Steering Committee as requiring review for the information of the NATO Military Authorities. This report provides a concise summary of the status of development and research appropriate to hypersonic aircraft, advance recommendations for study and practical work.

AR5 **Report on Helicopter Developments.**
AD-397-137 AGARD Advisory Rep. 5, 1966.
"Helicopter developments" was one of the subjects selected by the AGARD Steering Committee as requiring review for the information of the NATO Military Authorities. This report contains information presented at a classified technical meeting of experts collectively covering all important aspects in the rotary wing field.

AR6 **Dissemination of AGARD Information and Publications in the Netherlands.**
AD-661-163 AGARD Advisory Rep. 6, 8 pp., 1966.
N69-72807 Experience has shown that the deficiencies in the distribution of AGARD publications are least in the Netherlands, and this report is intended to advise other countries of the methods used in the Netherlands. A short account of the organization and functions of the Netherlands national AGARD office is followed by details of the publications distribution system including the distribution records maintained and the methods used for selecting recipients (only a very short standard distribution is made).

AR8 **The Influence of Fretting on Fatigue.** W.J.HARRIS.
AD-663-783 AGARD Advisory Rep. 8, 31 pp., 27 refs., 1967.
N68-13553 A primary objective of the report was to consider the evidence to support the claim that fretting must be ranked in importance with such factors as geometric stress concentration when considering structural fatigue. Thus, mean structures curves, crack propagation and non-propagating cracks, and some fundamental fretting fatigue researches have been described and interpreted with the bias towards the mechanism of fretting fatigue. A survey of some anti-fret techniques has also been included.

AR9 **Flash Blindness.** J.F.LANGER.
AD-398-047 AGARD Advisory Rep. 9, NATO Secret (available from National Centres to Authorised
N-37722 applicants), 1967.
This paper was produced under the auspices of the Specialist Working Group on Flash Blindness of the AGARD Medical Panel to evaluate the effects of flash blindness on the personnel in various operational conditions.

AR10/1
AD-668-253
N68-19228

The Potentials of Composite Structures in the Design of Aircraft: Some Structural Design Aspects of Filamentary Composites. G.GERARD.
AGARD Advisory Rep. 10, 1-28, 10 refs., 1967.
The following are treated: structural analysis methods for filamentary composites under uniaxial loads, and design of filamentary composites under biaxial loads (mechanics of a bilayer composite sheet, mechanics of bilayer laminates, some design possibilities with filamentary bilayer laminates).

AR10/2

The Potentials of Composite Structures in the Design of Aircraft: Applications and Optimizations of Structural Composites for Aircraft Wings. N.F.DOW, B.W.ROSEN, H.B.KINGSBURY.
AGARD Advisory Rep. 10, 29-49, 18 refs., 1967.
By structural efficiency evaluations the potential of advanced filamentary composites for improvements in aircraft wing construction is assessed. Various optimized structural approaches are considered, but it is shown that really only through the utilization of such enhanced stiffness/density and strength/density properties as the composites make accessible can substantial weight savings be achieved.

AR10/3

The Potentials of Composite Structures in the Design of Aircraft: Some Design Problems in Introducing Composite Materials into Airborne Structures. A.W.THOMPSON.
AGARD Advisory Rep. 10, 51-69, 4 refs., 1967.
Considers: present status of materials; applications in other industries; problems of design; problems of consistency; problems of stiffness; the prospects for new fibres.

AR11
AD-669-772
N68-23762

Residual Strength in the Presence of Fatigue Cracks. P.KUHN.
AGARD Advisory Rep. 11, 87 pp., 40 refs., 1967.
This report is the result of a survey (including visits to aeronautical organizations) undertaken to review the state of knowledge with respect to the residual strength of material specimens containing fatigue crack failure initiation of known proportions, and to ascertain the present knowledge existing with respect to the residual strength of typical structures using various types of materials. The report concentrates on the presentation and critical analysis of methods of calculation.

AR12
AD-676-577
N68-37761

Thermophysical Protection of Materials. E.FITZER.
AGARD Advisory Rep. 12, 117 pp., 168 refs., 1967.
The first report on a series of visits to organizations in NATO countries, undertaken by the author under the sponsorship of the Structures and Materials Panel of AGARD. It contains a survey of measurement techniques, a related bibliography and a limited compilation of data and theory on selected thermophysical properties of high temperature materials.

AR13
AD-669-767
N68-23761

Aspects of V/STOL Aircraft Development.
AGARD Advisory Rep. 13, 117 pp., 1967.
This report comprises three papers presented during the joint session of the AGARD Fluid Dynamics and Flight Mechanics Panel held in Göttingen, Germany, on 13th September, 1967. The first paper is in two parts, contributed by two separate authors. All the papers are of a survey nature, and cover aerodynamic problems, propulsion problems, and the problems of development of this type of aircraft from the flight mechanics aspects. This Advisory Report should be considered in conjunction with AGARD Conference Proceedings CP 22 and CP 27. Abstracts of the individual papers in this Report are given in the succeeding items.

AR13/1

Rotor Aerodynamics – Retrospect and Prospect. (Paper 1, Pt. I). J.P.JONES.
AGARD Advisory Rep. 13, 1-23, 6 refs., 1967.
It is argued that the great variety of "compound" VTOL aircraft being developed is a direct consequence of the fact that not enough basic research to improve the helicopter rotor has been done. Specifically, rotor-induced flows, and blade section characteristics are examined.

AR13/2

Quo Vadimus. (Paper 1, Pt. II). R.HAFNER.
AGARD Advisory Rep. 13, 25-69, 14 refs., 1967.
The title question is posed in face of the large number of VTOL configurations that have been proposed. The basic concepts of a number of these configurations are discussed. With the equivalent flat plate area as a common yardstick, a comparison of aerodynamic performance of these configurations is made. The merits and most suitable applications of the various types are indicated.

AR13/3

Survey Paper on VTOL Propulsion Covering Research Problems in Attaining Progressive Technological Advancement. M.R.COMBERIATE.
AGARD Advisory Rep. 13, 71-92, 2 refs., 1967.
Progress in the cruise specific fuel consumption, specific weight, and specific volume is examined, and predictions made for near-future characteristics. The basic gas turbine engine component technology and engine cycle improvements necessary to attain the engine performance progress are discussed. Problems associated with VTOL propulsion system installation are also considered.

AR13/4 **Survey Paper on the Application of Technology to the Flight Mechanics of Aircraft Development.** L.P.GREENE, C.C.WEISSMAN, J.D.BREWER.
AGARD Advisory Rep. 13, 93-117, 15 refs., 1967.
This paper presents an outline of the areas of technical interest to the AGARD Flight Mechanics Panel and the relationship of those technological areas to the overall problems of aircraft development. Specific examples are presented of the technologies applicable to aircraft in conventional modes of flight, as well as VTOL modes. Emphasis is on the relationship of propulsion systems integration into the total vehicle development.

AR14
AD-688-679
N69-23107 **Research and Development in the Handling of Scientific and Technical Information in the United Kingdom.** A.H.HOLLOWAY.
AGARD Advisory Rep. 14, 38 pp., 3 refs., 1968.
This survey contains notes about a number of developments in the field which are taking place in the United Kingdom. The list is known to be incomplete because at the time of writing adequate information was not available about some of the work which was known to be going on, because some of the projects were thought to be of insufficient interest and because some important developments have started since the document was compiled. So far as is known, no more complete list is available, but it is hoped that these notes will be kept up-to-date and extended and that similar lists will be compiled in other countries, since knowledge of work being done elsewhere is of vital importance to all developments.

AR15/1 **The ACV Concept and its Military Application.**
AD-685-583 AGARD Advisory Rep. 15, Part I, 41 pp., 4 refs., 1968.
N69-22548 This report provides a review of the principles and research background, the present state of the art and the experience that has been gained with air cushion vehicles. It attempts to forecast the future trends in development. Their probable military applications are outlined. It is recommended that they should be the subject of further study and consultation within NATO and that early consideration should be given to formulating military requirements as a guide to further development and research.

AR15/2 **The ACV Concept and its Military Application.**
AD-685-584 AGARD Advisory Rep. 15, Part II, 27 pp., 1968.
N69-22549 Contains 75 diagrams and illustration to the text of AR15 Part I.

AR16 **The Interaction of Handling Qualities, Stability, Control and Structural Loads.** W.H.AUSTIN,
AD-692-202 J.M.GRIFFIN.
N69-38666 AGARD Advisory Rep. 16, 22 pp., 11 refs., 1968.
The interaction of handling qualities, stability, control and structural loads is a vital consideration in the design and development of aeronautical systems. Lack of sufficient recognition of this interaction has caused catastrophic results on some aircraft. Structural problems have arisen from both static stability and dynamic stability and control problems. Use of stability augmentation systems for solution of the interaction problems appears to be most satisfactory. New analysis techniques are now available that will permit integrated design of the airframe and its control system to optimize handling qualities and to take advantage of significant structural loads reductions.

AR17 **Technical Evaluation Report on AGARD Specialists' Meeting on Transonic Aerodynamics.**
AD-699-866 D.KÜCHEMANN.
AGARD Advisory Rep. 17, 13 pp., 24 refs., 1969.
At the 5th AGARD Chairman's Conference on 11th September, 1968, it was suggested that Panels should attempt to evaluate and to assess the scientific outcome of the various AGARD specialists meeting and symposia that they conduct. This is the first of such evaluations and deals with the Specialists' Meeting on Transonic Aerodynamics sponsored by the Fluid Dynamics Panel and held in Paris from 18th to 20th September, 1968. This meeting is recorded in CP 35 and CP 35S.

AR18 **V/STOL Comparison Study.**
AGARD Advisory Rep. 18, 104 pp., 1969. NATO-Restricted (circulation restricted).
This Report was prepared by a group of specialists at the request of the Research and Development Activity of AGARD. Its purpose is to define the comparative status of V/STOL aircraft technology. It presents first a status of the technology and a description of the more recent V/STOL configurations which have reached, or are close to, flight status, together with a brief discussion of the experience gained in their development. The potential advances in the various subsystems technologies are then discussed and the mission applications described. A summary of required research to support the technology concludes the report. The main findings of the report are regrouped in a resume followed by conclusions and specific recommendations for future activities.

AR19 **Aeromedical Aspects of Radio Communication and Flight Safety.**
AD-699-052 AGARD Advisory Rep. 19, 14 papers, 144 pp., many refs., 1969.
N70-16962 Records 14 papers presented at a symposium held by the Aerospace Medical Panel, with the participation of the Avionics Panel and Guidance and Control Panel, of AGARD at Brooks Air Force Base, U.S.A., on 13th-14th May, 1969.

The aim of the Conference was to see whether new developments in science and technology could be applied in the field of radio communications to improve their operational efficiency and reliability. The conclusions were that new techniques were available which, if applied by Operational Commanders, would lead to advances in increased flight safety and information transfer by radio communication. The two main areas of discussion were:

(i) Scientific and technological aspects of the generation and perception of speech, along with methods by which radio voice-communication circuits could be improved, and
(ii) analyses of the factors of flight safety which could be improved with training, appropriate indoctrination and/or computerised automation techniques.

The 14 papers are dealt with individually in the following abstracts numbered AR19/1 to AR19/16.

AR19/1 **Binaural Hearing in Aeronautical Applications.** H.J.ZETZMANN.
AGARD Advisory Rep. 19, Paper 1, pp. 1-1 to 1-8, 22 refs., 1969.
Early reports are presented on an experiment to determine the effect of providing pilot or air controllers with an optimum perception of sound direction. Values of binaural delay, amplitude disparity and reverberation were studied to determine optimum conditions to allow three separate information channels to reach the observer simultaneously. It is stated that when correctly adjusted the circuitry provides significant progress to a better adaption of headset equipment to man.

AR19/2 **The Interaction of Communication with Cockpit Workload and Safety.** H.P.RUFFEL SMITH, B.D.PARKER.
AGARD Advisory Rep. 19, Paper 2, pp. 2-1 to 2-6, 6 refs. and Appendix, 1969.
The shortcomings of radio-telephone communication are discussed and it is suggested that there is a loss of pilot skill with a high rate of air to ground transmission which could turn a difficult situation into a dangerous one. It is suggested that much of the information could be transmitted automatically and that perhaps 5 per cent only would require voice. A special purpose data link for this purpose is described.

AR19/3 **Philosophies of Voice Communication Systems Design.** R.T.CAMP.
AGARD Advisory Rep. 19, Paper 3, pp. 3-1 to 3-2, 1969.
A short paper criticising present standards of voice communication systems; it refutes the promise that peak-clipping is beneficial to speech intelligibility and recommends high quality transmission and reception. The lecturer used tape recordings from various sources to support the arguments and claimed that it was possible to get 90 per cent intelligibility in 120 db noise.

AR19/4 **Speech Intelligibility in Noisy Environments.** J.C.WEBSTER.
AGARD Advisory Rep. 19, Paper 4, pp. 4-1 to 4-14, 25 refs., 1969.
Describes work done in an attempt to suggest simplified procedures in estimating the speech interfering aspects of noise. This work has resulted in new specifications of allowable noise levels in ship compartments and air control towers. The paper also describes the development of a flight deck radio system, experience with it and the current requirements for an up-dated system.

AR19/5 **The Effects of Ear Defenders on Speech Perception in Military Transport Aircraft.** G.FROHLICH.
AGARD Advisory Rep. 19, Paper 5, pp. 5-1 to 5-4, 1969.
Describes an investigation by the German Air Force to provide good noise protection and speech communication during aeromedical evacuation in noisy military transport aircraft. The conclusions are that non-rated personnel who are ordered to participate in regular and frequent aerial flights should wear Willson earmuffs. Troops and patients should use the Com-Fit earplugs shortly to be issued to every soldier in the German Forces. The low pass Filters Selectone K are not recommended.

AR19/6 **Speech Intelligibility Improvement via Selective Loudspeaker Placement.** J.V.TOBIAS.
AGARD Advisory Rep. 19, Paper 6, pp. 6-1 to 6-8, 12 refs., 1969.
The report states that most pilots of light aircraft and some air transport pilots prefer to use loudspeakers rather than earphones. The report describes methods by which speech intelligibility may be improved under these conditions. A 5 db increase in signal to noise ratio by using two loudspeakers driven from the same equipment but wired in opposite phase is claimed.

AR19/7 **Radio Communication Problems and Aviation Accidents in the U.S. Navy.** R.A.ALKOV.
AGARD Advisory Rep. 19, Paper 7, pp. 7-1 to 7-2, 1969.
A review of aircraft accidents involving radio communication shows that in many incidents where a breakdown in communications occurred individuals who spoke the same language failed to convey meaning in an adequate fashion. The reasons for such failure are discussed.

AR19/9 **In-Flight Manikin Recordings for Evaluating the Efficiency of Flight Helmets and Radio Communication Systems.** C.E.WILLIAMS, J.R.FORSTALL, J.W.GREENE.
AGARD Advisory Rep. 19, Paper 9, pp. 9-1 to 9-9, 2 refs., 1969.
Intelligibility words and phases were transmitted to six air-borne subjects and a manikin as each was fitted with different flight helmets. Similar tests were presented to the same six subjects in a simulated flight situation. Comparison of listener scores obtained in the three tests situations showed that scores obtained for the manikin recordings approximated those obtained during the in-flight tests. It is concluded that in-flight manikin recording may provide valuable information for evaluating flight helmets and radio communication systems.

AR19/10 **The Intelligibility of Shouted Speech.** D.J.MACLEAN, A.M.NOLL.
AGARD Advisory Rep. 19, Paper 10, pp. 10-1 to 10-13, 2 refs., 1969.
Laboratory tests indicate that extremely-shouted speech is less intelligible than normal speech. But while infinite peak clipping degrades the intelligibility of normal speech, the same infinite peak clipping of shouted speech makes it almost as intelligible as normal speech.

AR19/11 **A Discussion of Color Signals and their Flight Safety Relationship to Radio Communication in Civil Aviation.** H.L.GIBBONS, M.F.LEWIS.
AGARD Advisory Rep. 19, Paper 11, pp. 11-1 to 11-3, 8 refs., 1969.
Suggestions for the use of an automated system of colour signals for air traffic control are considered. A previous study indicates that colour signals which are complex, or not frequently used, can be dangerous. Other data indicates that 4.5 per cent of military pilots have colour vision deficiences which would cause difficulty. The replacement of voice communication by colour signals is not recommended.

AR19/12 **Automatic Flight Management of Future High Performance Aircraft.** D.M.PETRIE.
AGARD Advisory Rep. 19, Paper 12, pp. 12-1 to 12-9, 1969.
A development programme to demonstrate the feasibility of automation as a means of improving the safety and profitability of commercial aircraft operations is described. A central computer is used to control flight path, to operate the controls and subsystems and to provide information for semimanual operation. It is concluded that automated flight management is possible in the near future.

AR19/14 **Operational Aspects of Advanced Avionic Control and Display Systems.** R.K.SMYTH, K.G.CONNOR.
AGARD Advisory Rep. 19, Paper 14, pp. 14-1 to 14-10, 1969.
The purpose of this paper is to describe the crew action required during a typical low attitude strike mission in order that the human factors can be better understood. The design of cockpit controls and displays has a significant effect on the overall weapon system effectiveness and must be such that the aircrew can use the avionics efficiently. Mission analysis and simulation studies are required in optimization of the man-machine interface and it is considered important, during the progress of design, that experienced operational aircrew should frequently evaluate the design.

AR19/15 **Vocal Indications of Emotional Stress in Aircraft Pilots.** (As perceived by Air Traffic Controllers.) S.E.STUNTZ.
AGARD Advisory Rep. 19, Paper 15, pp. 15-1 to 15-4, 6 refs., 1969.
Air Traffic Controllers frequently recognise and use emotional state indications in the speech of pilots during air to ground communication. When confronted with apparent emotional stress in a pilot controllers often modify their speech behaviour to re-assure and to make the pilot more amenable to assistance. This report describes a preliminary study of civil air traffic controllers' practices and suggests an approach to the problem of assessing speakers emotional state by listener judgement.

AR19/16 **Factors of Training, Sidetone and Circuit Modifications Yielding more Efficient Communications.** G.C.TOLHURST.
AGARD Advisory Rep. 19, Paper 16, pp. 16-1 to 16-4, 1969.
Discusses available methods of improving speech intelligibility. The most preferred is a distortion free frequency response extending to 12–15KHZ but certain circuit changes and training methods are possible to improve existing systems. It is suggested that using two ears the message channels might be split and that distortion introduced to one ear. Improvement to the speaker's sidetone is also possible.

AR20 **Air Breathing Missiles and their Military Interest.**
AGARD Advisory Rep. 20, Classified, 300 pp., April 1970.
The purpose of this report is to make a comprehensive review of the potentialities of air breathing engines with a view to their use in the military field. Part I is devoted to a discussion of the feasible applications of this type of engine for the next generation of tactical missiles. It is more specifically intended for military authorities and concludes with recommendations for possible action by NATO. Part II is purely technical. It presents the state-of-the-art of air breathing engines and tries to delineate the promising areas of additional research. This part constitutes the technical support of the ideas developed in Part I. The study was conducted by a small group of experts from the United States, Germany and France, during 1968-1969.

AR21 **The Influence of Fretting on Fatigue.** W.J.HARRIS.
N70-29902 AGARD Advisory Rep. 21, 11 pp., March 1970.
A recapitulation of the characteristics of the fretting fatigue phenomenon described in AGARD Advisory Report No. 8, with a re-appraisal of the theory of the basic mechanism in the light of recent research, tend to confirm:
1. the significance of the residual tensile stress field remanent after plastic compression of the asperities,
2. the analysis of the fatigue results indicating that, the sensitivity of fretting fatigue to the contact pressure is similar to the "notch sensitivity" of the material,
3. by microscopical studies, the nucleation of fretting fatigue cracks near the plastic zones surrounding the scars and, their propagation along 45° planes rather than normal to the fatigue stress axis,
4. that the modest target of achieving "anti-fret" resistance up to 150°C (suitable for Mach 2.2 civil aircraft) can be met by the use of "cured" polymeric – MoS_2 films interposed between the contact faces.

AR22 **Technical Evaluation Report: Aircraft Engine Noise and Sonic Boom.** W.R.SEARS.
N70-18259 AGARD Advisory Rep. 22, January 1970.
The purpose of this report is to evaluate and assess the scientific and technical content of the meeting and to draw conclusions that may assist AGARD and those directing research in planning future work and follow-up activities.

The meeting was concerned with two related but nevertheless distinct subjects, engine noise and sonic boom, and each session was devoted to one or the other of these subjects, except for Session I, which constituted a survey of the whole situation.

AR23 **A Study of Copyright.** A.H.HOLLOWAY.
AGARD Advisory Rep. 23, (limited distribution), April 1970.
The origin of copyright is described and the present copyright legislation in the United Kingdom summarized and discussed, essentially from the point of view of photocopying in libraries. The practical effect of the legislation is considered and some defects indicated; some noteworthy publications on the subject are discussed.

The legislation, practice and publications in the United States are similarly dealt with, and other countries, including France, the German Federal Republic and the Netherlands are considered, chiefly in the light of publications.

The implication of copyright legislation on translation of scientific and technical papers is discussed.

The Universal Copyright Convention and a survey of its operation are considered.

AR24 **The Aerodynamics of Atmospheric Shear.** J.E.CERMAK and B.W.MARSCHNER.
AD-708-698 AGARD Advisory Rep. 24, 6 pp., May 1970.
N70-40736 This report reviews the purpose, scope and conclusions of the meeting, which was stimulated by the need to coordinate the efforts of atmospheric scientists and aeronautical engineers, through the common language of fluid dynamics, in attacking the basic and applied problems of atmospheric motion near the earth's surface. A list of the papers presented is included, with brief comments on their content and value. One of the main recommendations is for a coordinated field and laboratory study to verify similarity between wind-tunnel generated flow and the corresponding atmospheric shear flow.

AR25 **Standardization of Test Methods for Stress-Corrosion Cracking.** D.E.PIPER.
N71-14611 AGARD Advisory Rep. 25, 12 pp., December 1970.
This report is a synopsis of the survey which was carried out in Norway, The Netherlands, Belgium, France, Italy, Germany, the U.K. and North America. The survey revealed that several organizations in Europe and North America were either examining the feasibility of standardizing test techniques or actually conducting comparative testing programs at different laboratories. It was generally agreed that standardization would be extremely useful provided that the tests yielded data that were acceptable from an engineering and scientific viewpoint.

AR26 **Aircraft Engine Noise and Sonic Boom.**
AD-710-888 AGARD Advisory Rep. 26, June 1970.
N70-38782 This technical evaluation report on the AGARD Specialist Meeting, held during May 1969, on "Aircraft Engine Noise and Sonic Boom" contains a critical review of the presentations on engine noise. The report summarizes the conclusions to be drawn on the current state of affairs and makes recommendations as to the desirable directions of future work.

AR27 **The Use of Microfiche for Scientific and Technical Reports.** H.F.VESSEY.
N70-39851 AGARD Advisory Rep. 27, 12 pp., August 1970.
Considers the use of the 105 x 148 mm microfiche for reports. It emphasizes the economies that are possible once user acceptance has been obtained and discusses the reluctance of scientists to use this form of report material which requires a special reader. Readers and reader-printers are discussed and advice is given on their choice. Much of the American report material is only available in Europe as microfiche and some of the AGARD unpublished reports which are in short supply are more readily available as microfiche. It is recommended that European Documentation Centres should increase the circulation of microfiche and should encourage their customers to make full use of them. Possible action by AGARD is discussed.

AR28 **Fatigue Load Monitoring of Military Aircraft.**
AD-710-259 AGARD Advisory Rep. 28, 4 pp., August 1970.
N70-40069 The report has been prepared for the benefit of the NATO Military Committee by the Netherlands National Aerospace Laboratory on behalf of the Structures and Materials Panel of AGARD.
This document is the result of a study conducted by AGARD on the topic "Fatigue Level Control of Tactical Aircraft" which was submitted by the Military Committee to the AGARD Steering Committee in September 1968. In this short advisory report the NATO Military Authorities will find the summarized views of the AGARD Structures and Materials Panel on the subject and precise recommendations for further cooperative action within NATO.

AR30 **Fluid Dynamics of Blood Circulation and Respiratory Flow.** J.F.GROSS and K.GERSTEN.
N71-12290 AGARD Advisory Rep. 30, 16 pp., December 1970.
This report reviews the purpose, scope and results of the Specialists Meeting on the above subject, held 4th-6th May, 1970, in Naples, Italy, and which dealt with sciences in the field of fluid mechanics and in medicine. It highlights the need for coordinated efforts of engineers and physicists and provides new insights in the behaviour of all fluids in living systems.

REPORTS

RP1
AD-126-713
N-51809
The Ingestion of Sea Water. P.D.G.V.WHITTINGHAM.
AGARD Rep. 1, 7 pp., 18 refs., 1955.
The importance of the difference in the composition of urine and sea-water is discussed. Methods of reducing the loss of body water are stressed in their importance in survival. The conclusions are that sea-water must never be drunk.

RP2
AD-116-960
N-47981
Thermal Problems in Aircraft Structures. N.J.HOFF.
AGARD Rep. 2, 25 pp., 19 refs., 1955.
Summarizes problems in structural design and analysis of aircraft subjected to heating at high supersonic speeds. Experimental methods and equipment used by American research organizations are described.

RP3
AD-116-949
N-39013
Aircraft Structures Research at Elevated Temperatures. J.E.DUBERG.
AGARD Rep. 3, 20 pp., 10 refs., 1955.
A review of the test techniques developed and used at NACA (NASA). Presents experimental results and discusses model scaling for the testing of structures at high temperatures.

RP4
AD-126-714
N-51810
Flutter Research at the Royal Aircraft Establishment, Farnborough. H.TEMPLETON.
AGARD Rep. 4, 30 pp., 20 refs., 1955.
Outlines the basic objective and the main activities of flutter research at the Royal Aircraft Establishment, Farnborough. Some examples of these activities are described.

RP5
AD-154-757
N-42559
Strain Gauge Balances for Wind Tunnels: An Outline of Practice in the United Kingdom.
J.R.ANDERSON.
AGARD Rep. 5, 67 pp., 6 refs., 1956.
A brief survey of developments in strain gauge balance practice in the United Kingdom is made, with notes on the various types of balance used, their design and fabrication. Descriptions of twelve particular strain gauge balances are included.

RP6
AD-133-973
N-54068
Some Strain Gauge Balances used in French Wind Tunnels. P.REBUFFET.
AGARD Rep. 6, (in French), 63 pp., 8 refs., 1956. (Also translated into the English language in AGARD Rep. 6-T.)
After examining some of the principal types of analyzing load-measuring devices using strain gauges and reviewing the general principles of application, the author considers some of the strain gauge balances of sting and wall type used in French wind tunnels.

RP7
AD-154-759
N-53713
Special Types of Internal Strain Gage Balances. T.L.SMITH.
AGARD Rep. 7, 11 pp., 1956.
Descriptions of a three-component balance with special design to give small interaction of normal forces on drag, a four-component balance for measuring damping in pitch, and a balance for giving front and rear normal force designed for long slender bodies.

RP8
AD-144-210
N-43744
Special Applications of Strain-Gage Balances used in the Supersonic and Hypersonic Wind Tunnels at the U.S. Naval Ordnance Laboratory. J.R.LIGHTFOOT, C.E.WHITE.
AGARD Rep. 8, 13 pp., 6 refs., 1956.
Describes the purpose, functional description and operation of three types of strain-gage balances developed at the NOL: the balance for spinning models, the aerodynamic damping balance, and the temperature-controlled balance.

RP9
AD-144-208
N-41204
Mechanical Design and Fabrication of Strain-Gage Balances. R.M.HANSEN.
AGARD Rep. 9, 14 pp., 1956.
Considers wire-strain-gage-balance design concepts from a practical standpoint. A typical balance illustrates how the concepts were applied in practice.

RP10
AD-144-211
N-45062
Development of Half-Model Wind Tunnel Balances. NATIONAL AERONAUTICAL ESTABLISHMENT, CANADA.
AGARD Rep. 10, 28 pp., 1956.
Describes three designs of three-component balances using strain gauge transducers, of the bonded and unbonded type, for the measurement of forces and moments. The operation of two types was checked in the N.A.E. high-speed, vacuum-type intermittent wind tunnels. The d.c. millivolt outputs were measured with the Leeds and Northrup 'Speedomax' self-balancing chart potentiometers.

RP11 **A Note on a Half-Model Strain-Gauge Balance.** N.C.LAMBOURNE.
AD-144-215 AGARD Rep. 11, 7 pp., 1956.
N-42553 Briefly describes a general-purpose strain gauge wall balance constructed at the National Physical Laboratory. The equipment is designed for measuring normal force, longitudinal force, pitching moment, and rolling moment on half-models.

RP12 **Problems Involved in Precision Measurements with Resistance Strain Gages.** K.H.McFARLAND, J.DIMOFF.
AD-144-207 AGARD Rep. 12, 17 pp., 13 refs., 1956.
N-41610 Surveys the electrical, mechanical, and thermal errors which may affect the accuracy of these gages. Also, a brief description is given of the methods currently used to correct these errors.

RP13 **Evaluation and Calibration of Wire-Strain-Gage Wind-Tunnel Balances Under Load.** R.M.HANSEN.
AD-144-206 AGARD Rep. 13, 17 pp., 1956.
N-41203 Discusses the manner in which loads are applied to strain-gage balances in the laboratory and the reduction of the resulting data to a convenient form.

RP14 **Measurements and Recording of Measurements on Aerodynamic Balances and Strain Gauges.**
AD-156-858 M.BASSIERE.
N-43152 AGARD Rep. 14, (in French), 18 pp., 1956.
O.N.E.R.A. have combined a wind tunnel recorder, using strain gauge bridges, with a coding device for recording measurements on punched cards or teletype. Measurements are effective for working stresses of the order of 80 g/sq.mm.

RP15 **Elevated Stagnation Temperature and Strain Gauge Balances in the Instrumentation of a Supersonic Wind Tunnel.** G.P.TONKIN.
AD-150-320
N-54069 AGARD Rep. 15, 52 pp., 11 refs., 1956.
Describes the design and production of a strain gauge for use in a wind tunnel of stagnation temperature greater than 200°C. It is of the wire and ceramic type and can be stored in plain grid form. The balances are also described, with references to other supersonic tunnel auxiliary services.

RP16 **Automatic Indicating and Recording Data Systems for Wind Tunnels.** J.B.D'ANDREA.
AD-118-974 AGARD Rep. 16, 39 pp., 8 refs., 1956.
N-43739 Describes simpler systems which utilize data in tabulated punched card and/or tape, and plotted form. The system used in the 10 ft. WADC transonic tunnel is described, and a review is included of other types of equipment that could similarly be used.

RP17 **High Speed Systems of Wind Tunnel Data Handling.** J.LUKASIEWICZ, J.A. van der BLIEK, J.G.SCOTT.
AD-126-715
N-45064 AGARD Rep. 17, 24 pp., 11 refs., 1956.
Force and pressure data handling systems are described which consist of commercially available components, and with which it is possible to handle data at a rate of better than one point per second per channel and to record it simultaneously in analogue or digital form.

RP18 **Short Notes on Model-Making and Force-Measuring Techniques.** E.DOBBINGA, G.PRAST.
AD-150-306 AGARD Rep. 18, 26 pp., 1956.
N-57063 Equipment and methods used at N.L.L. are described for: copy-machining propeller blades, shaping concave walls of slots, casting wing-fuselage fairings, barreling, planing and duplicating, force-measuring, and strain-gage calibration.

RP19 **Wind Tunnel Models.** R.P.DAVIE.
AD-116-950 AGARD Rep. 19, 56 pp., 1956.
N-43188 Deals with the design and construction of models based on experiences gained at North American Aviation, Inc.

RP20 **Design and Construction of Wind Tunnel Models.** J.J.MUNCEY, D.M.POTE.
AD-144-217 AGARD Rep. 20, 20 pp., 1956.
N-52441 The Cornell Aeronautical Laboratory major wind tunnel is prescheduled to operate on an around-the-clock schedule. The achievement of accurate results under pressure of such a schedule has posed many problems in the design and construction of wind tunnel models. This paper discusses some methods and techniques which have been evolved.

RP21
AD-144-203
N-52440
Model Selection and Design Practices Applicable to the Development of Specific Aircraft. D.D.BAALS.
AGARD Rep. 21, 27 pp., 14 refs., 1956.
Factors pertinent to a specific model development programme are discussed together with the major aerodynamic and mechanical requirements of model design. Airframe aerodynamic requirements including the influence of inlets are considered. The study is applied to the development of a supersonic fighter aircraft.

RP22
AD-150-295
N-43153
Fabrication of Models by the use of Plastics. G.DIXMIER.
AGARD Rep. 22, (in French), 35 pp., 1956.
Describes techniques using low-pressure polymerisable resin with glass textile reinforcement. Most of the models are formed as shells. The interior is then filled as required for strength, weight and instrumentation. Examples range from single lifting surfaces to scaled free-flight models.

RP23
AD-144-220
N-43181
Precision Machining Techniques as Applied to the Manufacture of Supersonic Wind Tunnel Models. G.W.RAWLINGS.
AGARD Rep. 23, 21 pp., 1956.
This report deals with the problems associated with the manufacture of scale models for supersonic and transonic wind tunnels and outlines methods employed to deal with these problems.

RP24
AD-158-798
N-42554
Inspection Techniques Applied to the Metrology of Aerodynamic Models. H.T.HILL.
AGARD Rep. 24, 21 pp., 1956. (Formerly R.A.E. Tech. Note ADW.1.)
An appreciation of the problem confronting the metrologist in inspection techniques for wind tunnel models. Details are given of the present inspecting methods employed by the Royal Aircraft Establishment, and thoughts on further development to improve the accuracy and speed at which these three-dimensional models can be inspected.

RP25
AD-127-401
N-40046
A New Standard for the Prediction of Full Scale Spin and Recovery Characteristics from Model Tests. T.H.KERR.
AGARD Rep. 25, 19 pp., 9 refs., 1956. (Formerly R.A.E. Report No. Aero 2538.)
Features of a model which affect these characteristics are discussed. These features have been shown to be the non-dimensional rate of rotation of the spin, the thickness/chord ratio of the wing, and the inertia ratio of the model. Using these parameters, a new standard for the prediction of spin and recovery is presented.

RP26
AD-144-209
N-52438
Some Results of Comparison of Model and Full Scale Spinning Tests. A.J.MARX.
AGARD Rep. 26, 9 pp., 1956.
Results are presented for the Fokker S-11 primary trainer. In general, agreement on the steady spin and recovery characteristics between wind tunnel and free-flight is satisfactory. Yawing moment coefficients calculated from wind tunnel and free flight tests are also compared.

RP27
AD-144-205
N-52437
Notes on Correlation of Model and Full-Scale Spin and Recovery Characteristics. M.N.GOUGH.
AGARD Rep. 27, 20 pp., 9 refs., 1956.
The usefulness of spin tunnel results as an aid to flying is discussed. The need for better correlation through more detailed flight data and pilot reports is emphasized. The value and limitations of existing spin tunnel results are reported as an aid to pilots.

RP28
AD-150-293
N-52436
"Dead Stick" Landing Testing Techniques. A.E.HOLCOMBE.
AGARD Rep. 28, 10 pp., 1956.
Information gained during United States Navy experiments with dead-stick landings on ten different jet aircraft is presented. Testing methods, glide range determination and landing techniques are discussed.

RP29
AD-116-959
N-42673
The Quantitative Evaluation of an Aircraft Control System. R.R.DUDDY.
AGARD Rep. 29, 4 pp., 1956.
An introduction to the problem of making a quantitative assessment of the ability of an aircraft-pilot system to perform a given task. Measurements should be made of the effort expended by the pilot in performing a given task and also quantities related to the pilot's mental effort. A promising line of attack appears to be measurement of the pilot's transfer function, which is known to vary according to the task imposed upon the pilot.

RP30
AD-150-294
N-44501
Increasing the Precision of Landing by use of an Angle of Attack Indicator. P.LECOMTE.
AGARD Rep. 30, (in French), 4 pp., 1956.
Describes the use of an indicator during approach to short runways. Two types of indicator are discussed: the K.36 which is basically a manometer of variable sensitivity with a sonde set at incidence; and the B.I.P. which registers a given pressure differential on warning signal lamps.

RP31 **Some Problems Associated with the Measurement of Landing Distance.** D.A.LANG.
AD-144-218 AGARD Rep. 31, 20 pp., 2 refs., 1956.
N-42674 Proposes a standard method of measuring landing distance which is related to runway length required, and enables comparison of results for different aircraft. Factors affecting landing distance such as approach technique, braking, runway friction and tyre variables are also discussed.

RP32 **Assessment of the Aircraft for its Part in a Defence System.** R.P.DICKINSON.
AD-118-973 AGARD Rep. 32, 8 pp., 1956.
N-42672 Discusses the relative importance of the various aspects of the behaviour of the interceptor fighter aircraft in relation to its part in the overall defence system. Features governing the success of the aircraft in using its weapons effectively are discussed.

RP33 **French Telemetering Equipment.** J.IDRAC.
AD-150-305 AGARD Rep. 33, (in French), 18 pp., 1956.
N-57064 The four main types described are those of O.N.E.R.A., S.F.E.N.A., Turck and D.E.F.A. These are compared, for use in aircraft flight testing, with each other and with previously used equipment.

RP34 **Aerodynamic Theory and its Application to Flutter.** I.E.GARRICK.
AD-158-799 AGARD Rep. 34, 33 pp., 33 refs., 1956.
N-41875 A survey is given of the present status of aerodynamic theory in relation to flutter analysis with a discussion of concepts implied in the structural and aerodynamical background. Applications of some recent developments in the theory of oscillating wings, offering promise for the flutter analysis of low-aspect-ratio wings, are indicated. Problems of the subsonic and supersonic speed ranges are included.

RP35 **Measurement of the Aerodynamic Forces on Oscillating Aerofoils.** W.G.MOLYNEUX.
AD-661-957 AGARD Rep. 35, 30 pp., 35 refs., 1956.
N-42773 Considers various techniques for oscillatory force measurements in relation to their application to the measurements of the aerodynamic coefficients for a rectangular wing oscillating in modes of vertical translation and uniform pitch. Discusses also the corrections which must be applied to such measurements.

RP36 **The Theoretical Determination of Normal Modes and Frequencies of Vibration.** I.T.MINHINNICK.
AD-661-988 AGARD Rep. 36, 29 pp., 1956.
N-52439 The various methods that have been devised for the determination of the natural frequencies and normal modes of aircraft are discussed and their accuracy and the amount of work that they entail are compared. An extensive bibliography is given in Appendix 1.

RP37 **Recent Research on the Determination of Natural Modes and Frequencies of Aircraft Wing Structures.**
AD-490-735 J.M.HEDGEPETH.
N-52446 AGARD Rep. 37, 24 pp., 17 refs., 1956.
Discusses theoretical and experimental studies of the vibration of aircraft wing structures. Assesses the importance of various secondary effects and outlines methods of including them. Compares experimental values for natural frequencies of box-beam specimens with theoretical calculations and shows that, particularly for the higher modes, good agreement requires the inclusion of secondary effects.

RP38 **A Method for Solving Dynamic Problems of Modern Transonic and Supersonic Wings.** L.BROGLIO.
AD-126-716 AGARD Rep. 38, 4 pp., 1956.
N-51811 The method applies to delta, swept or crescent wings, and determines frequencies and modes of vibration, with the influence coefficients and mass distribution assumed known. The calculation of the influence functions is discussed and the methods are applied to practical problems.

RP39 **A Variational Approach to Pure Mode Excitation Based on Characteristic Phase Lag Theory.**
AD-144-219 B.M.FRAEIJS de VEUBEKE.
N-45138 AGARD Rep. 39, 23 pp., 11 refs., 1956.
Preliminary remarks on structural damping are followed by a discussion of the simplifying assumption which makes the damping matrix proportional to the stiffness matrix. This procedure allows a gradual presentation of the general analysis based on the concept of characteristic phase lag. Both the torsional and the flexural response of a beam to single point excitation are presented as examples for the influence of internal damping on continuous structures

RP40 **Some Aspects of Ground and Flight Vibration Tests.** R.MAZET.
AD-158-800 AGARD Rep. 40, (in French), 14 pp., 7 refs., 1956. (Also translated into English language in
N-45198 AGARD Rep. 40-T.)
Discusses the technique at O.N.E.R.A. for calculating the critical velocities of prototype aircraft from the results of ground vibration tests and for flight verification of the aeroelastic stability of these aircraft. The method used is that of "frequency displacement" which assumes that the natural mode has been isolated at phase resonance by means of an appropriate excitation.

RP41 **Determination of Influence Coefficients.** S.LEVY.
AD-118-975 AGARD Rep. 41, 5 pp., 7 refs., 1956.
N-43735 The method of consistent deformations for determining influence coefficients of delta wings is reviewed. A discussion is given of computational difficulties which may arise in applying this method. A review is given of strain energy and differential equation methods for computing influence coefficients.

RP42 **Divergence of Delta and Swept Surfaces in the Transonic and Supersonic Speed Ranges.**
AD-150-297 F.W.DIEDERICH.
N-41948X AGARD Rep. 42, 38 pp., 32 refs., 1956.
Discusses divergence and methods of analysis including subcritical aeroelastic phenomena. An approximate method of analyzing the latter is presented and used to calculate a delta wing at supersonic speeds. It is concluded that swept wings cannot converge, but thin delta wings can at supersonic speeds.

RP44 **Flutter Prediction in Practice.** E.G.BROADBENT.
AD-126-717 AGARD Rep. 44, 29 pp., 1956.
N63-17770 Gives a brief summary of the resources available for flutter prediction, both experimental and theoretical. Specific flutter investigations are described for four actual recent flutter incidents. Conclusions are drawn from all the examples, and a few points are given from a more general statistical survey of recent incidents.

RP45 **The Measurement and Assessment of Repeated Loads on Airplane Components.** P.DONELY.
AD-158-801 AGARD Rep. 45, 35 pp., 23 refs., 1956.
N-45472 Factors affecting the load statistics of modern aircraft are assessed on the basis of the NACA studies of the repeated load problem. The loads arising from various sources are discussed and their importance to aircraft with various missions are shown to vary.

RP46 **Review of Current Machine Systems for Handling Information.** G.M.BEDFORD.
AD-138-063 AGARD Rep. 46, 17 pp., 12 refs., 1956.
N-52467 Reviews and compares current mechanical systems for processing, storing and retrieving information and determines criteria for their valuation. Discusses the feasibility of the systems reviewed with respect to the particular project under consideration.

RP47 **Needed Research for Machine Information Systems.** J.W.KUIPERS.
AD-126-718 AGARD Rep. 47, 18 pp., 23 refs., 1956.
N-51812 Explains the difficulties which have arisen in using machines for documentation purposes and analyzes their causes. Emphasizes the need for research on the nature of the units to be handled and indicates lines along which research should be directed to overcome these difficulties.

RP48 **Operational Problems Requiring Documentation Research.** V.W.CLAPP.
AD-126-719 AGARD Rep. 48, 7 pp., 1956.
N-51813 It is pointed out that operations in documentation should form a "seamless whole". No part therefore must be taken in isolation, or for granted. Suggestions are made to improve methods of documentation by working on these lines.

RP49 **Matching of Operational Languages in Documentary Systems.** R.A.FAIRTHORNE.
AD-134-966 AGARD Rep. 49, 12 pp., 6 refs., 1956.
N-52434 Discusses the problem of clerical tasks as sequences of elementary observations, identifications, and manipulations of marked objects. It is shown how all clerical tasks, including marshalling and retrieval, can be studied as chains of transcriptions and transliterations.

RP50 **Mechanical Storage, Handling, Retrieval and Supply of Information.** R.R.SHAW.
AD-144-216 AGARD Rep. 50, 34 pp., 1956.
N-52435 Present equipment is reviewed with particular reference to technical and administrative problems. Storage devices such as books, microfilm, prints, mechanical and electrical sorters, electronic readers, and translating machines are discussed. A higher reduction in microfilming would reduce storage problems, it is suggested.

RP51
AD-144-201
N-41829
Tire-Runway Braking Friction Coefficients. M.N.GOUGH, R.H.SAWYER, J.P.TRANT, Jr.
AGARD Rep. 51, 20 pp., 3 refs., 1956.
A brief review of methods of measuring the coefficient of friction with particular regard to the N.A.C.A. methods and instruments used on full-scale aeroplane landings. A friction-measuring chart for investigating surfaces of interest is described. This device may afford a relatively inexpensive means of obtaining data for airport operators suitable for briefing pilots.

RP52
AD-150-301
N-57184
Thermal Effects in the Calculation of the Strength of Aircraft and Missile Structures. N.J.HOFF.
AGARD Rep. 52, (in French), 111 pp., 60 refs., 1956. (Includes Reports 53, 54 and 55.)
After reviewing the laws governing aerodynamic heating of supersonic missiles and aircraft, the author discusses heat transmission inside wings, by conduction and radiation. The effects of thermal stresses on the buckling of rods and thin plates are examined, also the problem of creep and its effect on stress distribution.

RP56
AD-154-677
N-55070
Sources of Translations of Aeronautical Interest in NATO Countries. L.J.H.HAYLOR, R.A.KENNEDY.
AGARD Rep. 56, 50 pp., 1956.
Government departments, industrial research organizations, universities, professional institutions and private organizations making and/or indexing translations of aeronautical interest in the NATO countries are included. The main indexing centres are: N.R.C. (Canada); C.N.R.S. and S.D.I.T. (France); ASLIB (U.K.); S.L.A. -- John Crerar Library and S.T.C. (U.S.A.).

RP57
AD-150-308
N-57062
A Review of the Present Position on Flutter. H.TEMPLETON.
AGARD Rep. 57, 16 pp., 10 refs., 1956.
An edited version of the author's verbal contribution to the discussions on flutter at the third meeting of the Advisory Group for Aeronautical Research and Development (A.G.A.R.D., N.A.T.O.) held in Washington in April 1956. A summary of the present position on the flutter problem is given and recommendations made for further action.

RP58
AD-138-020
N-52442
Philosophy of Airworthiness. W.TYE.
AGARD Rep. 58, 14 pp., 1956.
The matching of airworthiness with external operating conditions is discussed. The problem is approached from the acceptable level of airworthiness, relation of accident rate and accident probability, and structural requirements.

RP59
AD-129-278
N-53001
Test Installations Brought into Operation for the Flying Atar. G.EGGERS, J.JARDINIER.
AGARD Rep. 59, (in French), 15 pp., 5 refs., 1956.
Installations described are for tests on (1) operation of the turbojet in any position, but especially vertically, (2) ground effect on the exhaust jet, (3) efficiency of control by means of exhaust jet, (4) artifical stabilization device, (5) verification of exhaust control and stabilization, (6) free manoeuvring of the Flying Atar about the centre of gravity, (7) free flight tests under a frame, and (8) a training unit with free flight simulator.

RP60
AD-218-282
N-49493X
Post Buckling Behaviour of Structures. A. van der NEUT.
AGARD Rep. 60, 33 pp., 29 refs., 1956.
For aircraft structures, flat plates differ favourably from columns and curved plates. The aim is to find the relation between the edge displacements of a panel and its load, including the relation between the increments of buckling and stiffness. Solutions established for a flat plate at constant temperature and for thermal loading are discussed and compared with available experimental evidence.

RP61
AD-144-202
N-45617
Techniques for Testing Models of VTOL and STOL Airplanes. J.P.CAMPBELL.
AGARD Rep. 61, 31 pp., 21 refs., 1956.
Describes briefly some of the techniques used by N.A.C.A. in research on VTOL and STOL aeroplanes ("vertical take-off and landing" and "short take-off and landing"). Deals mainly with free flying model technique but a brief description is also given of some of the force-testing techniques.

RP62
AD-144-204
N-55072
Some Correlations of Flight-Measured and Wind-Tunnel Measured Stability and Control Characteristics of High-Speed Airplanes. W.C.WILLIAMS, H.M.DRAKE, J.FISCHEL.
AGARD Rep. 62, 11 pp., 2 refs., 1956.
Comparisons are made of some of the more important stability and control characteristics of swept wing aircraft as measured in flight and in a variety of wind tunnels. Wind tunnels predict trends of characteristics reasonably well although there are differences in the actual values. Some of the problems of non-linear derivatives obtained in tunnel tests are discussed.

RP63 AD-158-802 N-46250 **Some Comments on High-Lift Testing in Wind Tunnels with Particular Reference to Jet-Blowing Models.** A.ANSCOMBE, J.WILLIAMS.
AGARD Rep. 63, 19 pp., 1956.
Considers some of the special problems of wind tunnel testing which arise in high-lift work. Discussion refers mainly to tests on blowing over flaps or jet-flaps. Comments are made on suitable size of model, methods of feeding compressed air into models without affecting balance readings, and general test technique. Methods of model construction are not specifically discussed.

RP64 AD-106-218 N-52445 **Note on Strain Gauge Recording Equipment for the R.A.E. Intermittent Supersonic Wind Tunnels.** K.G.WINTER, E.J.PETHERICK.
AGARD Rep. 64, 11 pp., 1956. (Formerly R.A.E. Report No. Aero 2461.)
A description is given of a simple system for photographing, up to six times per second, revolution counters driven from strain-gauge balance indicators. A further proposed system using punched cards is also described.

RP65 AD-158-050 N-48957 **Loads on a Model During Starting and Stopping of an Intermittent Supersonic Wind Tunnel.** K.G.WINTER, C.S.BROWN.
AGARD Rep. 65, 16 pp., 1 ref., 1956. (Formerly R.A.E. Tech. Note Aero 2453.)
Measurements are given of the loads on a model during starting and stopping of an intermittent supersonic wind tunnel at Mach numbers of 2.00 and 2.48. Qualitative agreement is obtained with a simple theory but a need is evident for further measurements at higher Mach numbers. The use of a model loading coefficient in terms of tunnel stagnation pressure is proposed.

RP66 AD-158-803 N-48958 **Brief Description of the R.A.E. Intermittent Supersonic Wind Tunnel Plant.** K.G.WINTER.
AGARD Rep. 66, 14 pp., 2 refs., 1956.
The plant is vacuum-operated on a closed circuit with storage of the air in a flexible container. The useful Mach number range is up to about 4.5. For the largest of the tunnels (15 in. x 16 in.) the maximum running time is of the order of 20 seconds over the whole Mach number range.

RP67 AD-151-271 N-45841 **Design and Development of the North American Aviation Trisonic Wind Tunnel.** W.DANIELS, Jr.
AGARD Rep. 67, 18 pp., 2 refs., 1956.
The test section of this tunnel is 7 ft x 7 ft and the speed range from Mach 0.2 to 3.5. Models are large enough to contain all necessary instrumentation and components, and produce data which are suitable for full-scale conditions. The description contains information on some of the unusual design features, acoustical treatment, automatic data handling, and the variety of tests which are to be made.

RP68 AD-144-212 N-55071 **English Electric Proposed Blow-Down Wind Tunnel.** F.E.ROE.
AGARD Rep. 68, 21 pp., 1956.
The basic design data for the two tunnels are outlined, and an estimate of the optimum characteristics obtained showing the economic and technical advantage of utilising a single power source for both tunnels. The performance of such a joint facility is indicated.

RP69 AD-154-678 N-47899X **The Blow-Down Wind Tunnel at Aachen.** A.NAUMANN, A.HEYSER, W.TROMMSDORFF.
AGARD Rep. 69, 20 pp., 1956.
The construction, installation and operation of the first stage of the blow-down wind tunnel at Aachen is described. The general layout of the complete tunnel, as finally intended, is also described, and a simple analytical estimation is given of the aerodynamic performance of such a tunnel.

RP70 AD-150-309 N-46302 **A Supersonic Wind Tunnel for Mach Numbers up to 3.5.** L.E.LEAVY.
AGARD Rep. 70, 31 pp., 4 refs., 1956.
Describes the requirements design and construction of the AVRO 27 in. x 36 in. intermittent blow-down supersonic tunnel. Factors governing the size of this Mach 3.5 tunnel are given including the reasons for the choice of low pressure storage. An estimate of tunnel utilisation and cost is also included.

RP71 AD-158-804 N-46303 **The Flight Simulator in Aircraft Control and Design.** W.J.G.PINSKER.
AGARD Rep. 71, 31 pp., 12 refs., 1956.
The possibilities of simulating manually controlled flight are discussed and the principal types of flight simulators are described. Particular attention is given to the importance of realistic visual and physical flight impressions. It is shown that useful conclusions on the handling characteristics of an aircraft can be drawn for experiments on relatively simple simulators.

RP72
AD-206-238
N-47555

A Search for Definitions and Criteria Relating to Non-Oscillatory Divergence in Near Steady Flight Conditions. E.BILLION.
AGARD Rep. 72, (in French), 10 pp., 2 refs., 1956. (Also translated into the English language in AGARD Rep. 72-T.)
The author isolates from the phenomena, following a disturbance, those which have a non-oscillatory character. Only the real roots of the characteristic equation governing the system are thus taken into consideration. It is shown how the criterion of non-oscillatory divergence can be obtained from this basis, and the method is applied to straight flight in the earth's field, curvilinear flight outside the earth's field, and steady flight in the earth's field.

RP73
AD-158-805
N-46129

The Determination of Aileron Effectiveness. R.R.DUDDY.
AGARD Rep. 73, 8 pp., 1956.
Describes two alternative methods of measuring aileron effectiveness in flight for comparison with the results of estimates and wind tunnel measurements. Results obtained on four aircraft show that the agreement obtained is not particularly good but the tunnel measurements do indicate the reduction in aileron effectiveness to be expected in flight at high lift coefficients on swept wing aircraft.

RP74
AD-150-303
N-46307

Use of Improvised Runways. S.LEFEBVRE.
AGARD Rep. 74, (in French), 31 pp., 1956.
A digest of information from various tests on the use of earth runways. Aircraft behaviour in relation to the characteristics of the soil, tyres and fittings such as skis are discussed, together with mechanical deterioration of the aircraft using such terrain.

RP77
AD-150-292
N-46309

Calibration of Incidence and Sideslip. A.BOISSON.
AGARD Rep. 77, (in French), 35 pp., 1956.
Incidence is measured by a sonde which gives a reading of pressure differential against dynamic pressure. Sideslip is measured similarly. Calibration is obtained by measuring sideslip as a difference between the course recorded directly and the path obtained by integration of its derivative. Calibration of incidence is determined experimentally by flight tests at steady speed utilizing the ratio of pressure differential and dynamic pressure.

RP78
AD-151-274
N-55068

A Report on the Arado AR 232 Transport Aircraft. W. van NES.
AGARD Rep. 78, 27 pp., 1956.
An account is given of the Arado Ar 232 transport aircraft. The special ailerons and the unusual cross-country undercarriage are described and detailed performance figures are given. Description is given of the Göttingen test aeroplane fitted with suction over the inner wings and blowing over the outer wings and ailerons. The application of this system to the Arado Ar 232 is also described. Finally, a comparison of the suction, suction-blowing and direct thrust methods of decreasing the take-off run is made.

RP79
AD-157-000
N-46124

On the Stabilization of Cohesive Soil by Means of Cement and Bituminous Binding Agents. R.KLEIN.
AGARD Rep. 79, 18 pp., 18 refs., 1956.
The purpose of soil stabilization and the basic principles involved are explained. A brief historical review is given of work on soil stabilization carried out mainly in Germany. It is shown that soils have optimal ranges of stabilization which lie within relatively small limits and the conclusion is drawn that machinery for soil stabilization should be specially designed.

RP80
AD-151-272
N-51496

United States Army Experience in Operations from Unprepared Fields. J.F. DENHART.
AGARD Rep. 80, 28 pp., 1956.
This non-technical presentation is based on the use of light aircraft to support the army aviation mission. Although it may not be related to the use of heavier and faster aircraft which normally support the air force mission, some of the requirements and methods considered by the army for the accomplishment of its mission may be applicable to high-performance aircraft.

RP81
AD-138-019
N-52444

Factors Affecting the Field Length of STOL Aircraft. G.W.JOHNSTON.
AGARD Rep. 81, 15 pp., 2 refs., 1956.
Describes qualitatively some of the consequences of extending existing short field aircraft, to the STOL class. The note is concerned only with the performance implications as reflected by the requirement of operating the aircraft from a 500 foot field.

RP82
AD-150-302
N-47793

Notes on the Ground-Run of Jet-Propelled Aircraft During Landing and Take-off. G.S.ALIAS.
AGARD Rep. 82, 23 pp., 15 refs., 1956.
Equations for ground-run distances on an inclined runway are derived. These take into account the use of rockets during take-off, and reversed thrust and braking parachutes during landing. Graphical methods are also described and recommended. By dividing the ground-run distance by a basic horizontal distance, a ratio is obtained which may be used to analyse separate effects. Application of the method is given.

RP83
AD-150-300
N-53351X

The Function of Magnetic Tape in Flight Test Data Recording and Processing Systems. A.T.SNYDER.
AGARD Rep. 83, 12 pp., 1956.
The advantages of magnetic tape for recording flight test data are discussed in detail. A brief description of several systems which are in common use is given, and one of the Boeing Data Recording and processing systems is fully described.

RP84
AD-150-296
N-57164

Flight Techniques for Determining Airplane Drag at High Mach Numbers. De E.BEELER, D.R.BELLMAN, E.J.SALTZMAN.
AGARD Rep. 84, 24 pp., 23 refs., 1956.
Discusses techniques used by the NACA High-Speed Flight Station for measuring the drag of high-speed research and fighter aircraft for comparison with wind tunnel data. The accelerometer method was found to be the most successful, and the factors upon which this method depends are discussed.

RP85
AD-158-793
N-45852X

Some Unique Aspects of Flight Test Instrumentation for Vertical Take-off Aircraft. E.R.HINZ, R.A.FUHRMAN.
AGARD Rep. 85, 24 pp., 6 refs., 1956.
Describes those aspects of flight test instrumentation which are unique to VTO aircraft, as distinct from conventional aircraft. These aspects are discussed under three headings: hovering flight; transitional flight; and conventional flight. A suggestion is put forward for the establishment of a new stable platform attitude reference.

RP86
AD-158-794
CN-51495X

American Development in STOL and VTOL Aircraft. C.W.MESHIER.
AGARD Rep. 86, 15 pp., 6 refs., 1956.
To date most research activity on short take-off and vertical take-off aircraft has been directed towards the development of basic configurations to achieve the required performance. This paper discusses the low speed control problems of such aircraft, to which little effort has been applied until recently.

RP87
AD-150-304
N-51164

Philosophy of Safety in the Supersonic Age. N.J.HOFF.
AGARD Rep. 87, 15 pp., 1956.
Present and past principles governing the proof of the structural strength of aircraft are reviewed. It is suggested that the safety of the airplane in the presence of rarely occurring unusually large loads, of fatigue, and of creep can be judged on a common basis only if the probability of the failure of the structure is accepted as the safety criterion.

RP88
AD-150-299
N-47742X

Air Supply for Blow-Down Wind Tunnels. E.J.STOLLENWERK.
AGARD Rep. 88, 19 pp., 4 refs., 1956.
An air-supply system for a blow-down wind tunnel is described with particular emphasis on the problem of air storage and pressure control, flow equalization downstream of the control valve, and temperature control.

RP89
AD-151-273
N-52443

A Study Toward a System of Classification of Unprepared Landing Areas. W.G.DUNCAN.
AGARD Rep. 89, 6 pp., 1956.
Describes a study toward a method of classifying unprepared landing areas, undertaken by the Air Research and Development Command, U.S.A.F. Preliminary results show the problem susceptible to solution and indicate several further study areas.

RP90
AD-150-314
N-52875X

Some Remarks Upon the Problem of Temperature Shock in Aircraft. F.BOLLENRATH.
AGARD Rep. 90, 12 pp., 1956.
The thermal stresses due to a non-stationary distribution of temperature are calculated for a plate cooled on one surface and heated on the other by a gas moving at high speed. The cases for a plate completely free and restrained in one direction are discussed. Formulae are given which, under these conditions of restraint, make a quick comparison for different materials.

RP91
AD-144-213
N-55069

The Variable Density High Speed Cascade Wind Tunnel of the Deutsche Forschungsanstalt für Luftfahrt Braunschweig. H.SCHLICHTING.
AGARD Rep. 91, 5 pp., 2 refs., 1956.
Describes briefly the new variable density high speed cascade wind tunnel of the Deutsche Forschungsanstalt für Luftfahrt at Braunschweig. The tunnel is open-jet, with Mach number range 0.2 to 1.1, and a special feature is that the Mach number and Reynolds number can be varied independently.

RP92
AD-144-214
N-52341

Data on Temperature Stabilization and Diffuser Performance of the 5 x 5 in. Pilot Blow-Down Wind Tunnel. N.B.TUCKER.
AGARD Rep. 92, 8 pp., 1956.
Describes briefly experiments on temperature control and diffuser performance made with a 5 x 5 in. pilot tunnel to provide data for a 5 x 5 ft blow-down tunnel to be constructed at the National Aeronautical Establishment of Canada. Temperature control is achieved by a closely-packed random arrangement of tin cans filling the reservoir volume. Performance results for variable throat diffuser are at Mach numbers from 2 to 4.

RP93
AD-150-313
N-57185

Cascade Flow Problems. H.SCHLICHTING.
AGARD Rep. 93, 14 pp., 6 refs., 1957.
A brief report of research work on cascades done recently at Braunschweig University. It includes calculations of loss coefficients on two-dimensional cascades in incompressible flow, and results of pressure distribution measurements on cascades at high subsonic Mach numbers.

RP94
AD-158-796
N-56082X

Titanium Production Developments Including Metallurgy and Alloying. R.I.JAFFEE.
AGARD Rep. 94, 89 pp., 26 refs., 1957.
The history and the future of the titanium industry are discussed in terms of costs and quantities of metal produced. Descriptions are given of various manufacturing techniques and metallurgical principles are also described.

RP95
AD-150-307
N-55022

Production Problems of Titanium and its Alloys. E.SWAINSON, R.L.P.BERRY.
AGARD Rep. 95, 29 pp., 1957.
Discusses the state of knowledge in certain aspects (ore reduction, melting, alloying, reclamation from scrap) of titanium technology, and gives some indication of the possible pattern of future developments.

RP96
AD-154-760
N-55019X

Titanium Fabrication. L.P.SPALDING.
AGARD Rep. 96, 33 pp., 1957.
A description is given of the problems encountered and the techniques evolved for their solution during the manufacture of some two thousand aircraft incorporating about a million pounds of titanium in their designs. Primary emphasis is given to titanium alloy sheet application.

RP97
AD-159-951
N-60757

French Work Relating to the Production and Examination of Large Fittings in Titanium Alloys. El GAMMAL.
AGARD Rep. 97, (in French), 45 pp., 1957.
Production and design studies on "Piano" wing fittings for the SO.4050 Vautour II are described. From samples the following properties were determined: tensile properties, variation of these properties at low temperatures, fatigue strength, heat treatment effects, strength of notched pieces under constant load. It is concluded that titanium alloys can now be used on transonic aircraft and will soon be available for use in supersonic aircraft.

RP99
AD-154-679
N-58826

Cermets as Potential Materials for High-Temperature Service. O.A.SANDVEN.
AGARD Rep. 99, 24 pp., 9 refs., 1957.
A review is given of the chemical, physical and mechanical properties of the most important and promising Hard metals and Cermet systems, with special attention to the creep resistance and ductility. Some experimental results on the system NbC-TiC-Ni are reported.

RP100
AD-154-680
N-57732

The Mechanical and Engineering Properties of Commercially Available Titanium Alloys. H.V.KINSEY.
AGARD Rep. 100, 15 pp., 1 ref., 1957.
The titanium alloys being produced on a commercial basis up to early 1957 are listed, nominal chemical compositions and manufacturer's designations for these alloys are given. An attempt has been made to collect all the published data on the physical, mechanical, and engineering properties of these alloys and to indicate those properties required by the aeronautical design engineer.

RP101 **A Survey of the Structural Properties of Some High Strength Sheet Steels.** M.A.MELCON.
AD-154-741 AGARD Rep. 101, 25 pp., 11 refs., 1957.
N-55027 Considers specifically the heat-treatable stainless steels 420, 422, 422M, AM350 and 17-7PH. Tri-cent, a low alloy steel and Thermold J, a tool steel are also discussed. Mechanical properties at room and elevated temperatures are discussed, also heat treatment, corrosion resistance, and formability. Fatigue, creep and stress-rupture data are presented. Tear-strength is evaluated for some materials. Fabrication problems are also considered.

RP102 **Aluminium Alloys for Aircraft Structures.** G.MEIKLE.
AD-154-742 AGARD Rep. 102, 10 pp., 6 refs., 1957.
N-55023 The compositions of three groups of alloys used in the U.K. are discussed in relation to alloys used in the U.S.A. Some of the difficulties experienced with stress-corrosion in using the high strength aluminium-zinc-magnesium alloys are mentioned and research at the Royal Aircraft Establishment on this problem, with particular reference to the effects of composition and heat treatment, is briefly mentioned. A possible alloy for use up to 200°C is noted.

RP103 **Sintered Aluminium S.A.P.** F.BOLLENRATH.
AD-157-281 AGARD Rep. 103, 18 pp., 7 refs., 1957.
N-58825 S.A.P. is made by compressing, sintering, and extruding aluminium powder. It has been developed by Aluminium-Industrie A.G., Neuhausen, Switzerland, and has outstanding mechanical properties at high temperatures.

RP104 **Selected Properties of Structural Materials at Elevated Temperatures.** D.A.SHINN.
AD-157-282 AGARD Rep. 104, 40 pp., 17 refs., 1957.
N-55018X A review of information required to permit detail design of elevated-temperature aircraft and missile structures. Because of the large quantity of data required proposals have been made for large-scale testing with semi-automatic facilities at several test centres. Stress, temperature, and time programmes, based on the flight path of a proposed aircraft, would be fed into equipment and cause simulation of service history in the test specimens. Such a plan has not yet been initiated but is being considered. Design criteria presented here would aid the formulation of requirements.

RP105 **Merit Indices for Structural Materials.** H.B.HOWARD.
AD-154-743 AGARD Rep. 105, 24 pp., 2 refs., 1957.
N-55025 Merit indices are derived for such properties as strength, stiffness, buckling of Euler and plate struts, wrinkling of tubes, thermal stress and deformation. These are applied to aluminium and titanium alloys and a stainless steel, up to 400°C. Analysis of a simple form of multi-web wing box is presented and an optimum strength curve derived for any material. The three alloys are compared for the same temperature range. Aluminium alloys appear suitable up to Mach 2.5; beyond that the choice of steel or titanium depends on whether torsional rigidity or bending strength is paramount.

RP106 **Some Aspects of Prediction of Load Spectrum for Airplanes.** C.E.BRÖNN.
AD-661-933 AGARD Rep. 106, 42 pp., 5 refs., 1957.
N-56680X The prediction of load spectra depends on regularity of (i) objective of operation, (ii) mission operational pattern of the aircraft. A detailed analysis of (ii) is necessary. Considerations for the selection of typical missions are reviewed for transport, combat-interception and combat-ground attack operations. Derivation of manoeuvring schedules are discussed together with the distribution of manoeuvring loads. Some important human engineering aspects and their influence on the load spectrum are discussed.

RP107 **Critical Flight Conditions and Loads Resulting from Inertia Cross-Coupling and Aerodynamic**
AD-134-742 **Stability Deficiencies.** W.J.G.PINSKER.
N-48821X AGARD Rep. 107, 32 pp., 4 refs., 1957.
Discusses the effects of gyroscopic forces on aircraft with large inertias during rolling and gives criteria for yaw divergence, pitch divergence and auto-rotational rolling. Critical loading cases in practical rolling manoeuvres are discussed and methods of deriving peak loads outlined. Aircraft responses in pitch-up are analyzed and data given for estimating peak loads in uncontrolled conditions and for pitch-up with pilot counteraction. Principal causes for loss of directional stability are indicated and some dangerous flight conditions outlined.

RP108 **Some Effects of Shed Vortices on the Flow Fields Around Stabilizing Tail Surfaces.** R.W.STONE, Jr.,
AD-157-283 E.C.POLHAMUS.
N-51605X AGARD Rep. 108, 25 pp., 20 refs., 1957.
This brief study shows that generally there is a large adverse effect of the flow fields on the tail loads and tail-load distribution. For some conditions an oscillatory characteristic of vortex flow exists and may cause tail buffeting.

RP109 **Flight Loads Measurements on NACA Research Airplanes.** De E.BEELER.
AD-159-948 AGARD Rep. 109, 35 pp., 15 refs., 1957.
N67-34612 Flight load measurements are made to confirm wind-tunnel model tests, to assess manoeuvring conditions required of the aircraft and the associated dynamic loading, and to reveal loading problems resulting from flight research. A summary is presented of some results for the X-1 rocket powered aircraft, the X-5 variable sweep aircraft, and the XF-92A delta-wing aircraft.

RP110 **The Practical Calculation of the Load Distribution on Aircraft.** G.SCHEPISI.
AD-206-064 AGARD Rep. 110, 21 pp., 11 refs., 1957.
N-56093X The necessary calculations are presented in convenient form. The mass forces are derived in terms of the rigid and elastic degrees of freedom, by use of dynamical equations. The equations are solved for symmetrical steady flight. A solution is attempted for unsteady flight.

RP111 **A Study of the Correlation Between Flight and Wind-Tunnel Buffet Loads.** W.B.HUSTON.
AD-157-284 AGARD Rep. 111, 17 pp., 11 refs., 1957.
N-51482 Methods used in the study of random processes are applied to the loads on an aircraft wing during buffeting. Results of power spectrum and load distribution measurements suggest that buffet loads can be regarded as the linear response to random input of a slightly-damped single-degree-of-freedom system. Dimensional analysis and beam theory are used to find a relationship between buffet loads in flight and on a wind-tunnel model. Flight and tunnel-test results are compared for several configurations.

RP112 **Near Field Jet Noise.** M.O.W.WOLFE.
AD-154-857 AGARD Rep. 112, 41 pp., 7 refs., 1957.
N-59736 The effect of jet engine noise on aircraft structures is considered. Near field noise measurements are reported for two representative turbojet engines, for a range of jet shear velocities. One engine operated with an after-burner. Isosonic contours are presented for overall noise pressure and pressures in $\frac{1}{3}$ octave frequency bands of the spectra. The increase in noise level due to reheat is less than expected.

RP113 **Strain Gage Calibrations and Flight Loads Testing Techniques.** N.A.KRAUSE.
AD-159-949 AGARD Rep. 113, 47 pp., 4 refs., 1957.
N-56216X Modern requirements for flight load measurements are discussed. Methods of installation and calibration of strain gage systems are described. Flight manoeuvres and methods of operation to obtain data are outlined and typical test data shown. Techniques for handling and analyzing data are discussed; examples of final results are presented, illustrating the concept of testing to 80% limit load and extrapolating to 100% limit load to determine critical conditions. Developments, including the use of electronic aids, in test programmes are discussed.

RP114 **Instrumentation and Data Handling Methods for Determining Load Distribution on Wind Tunnel**
AD-154-744 **Models by Pressure Distribution Measurements.** J.P.DOYLE, Jr.
N-55379X AGARD Rep. 114, 29 pp., 2 refs., 1957.
Two types of instrumentation are described: a serial scanning system, as used in testing the Convair B-58 $\frac{1}{17}$-scale pressure model, and a parallel system being installed in the Wright Air Development Center 10-ft transonic tunnel. Limitations on data collection due to tunnel operation and model geometry, and on the subsequent data reduction methods are considered.

RP115 **Atmospheric Turbulence Environment with Special Reference to Continuous Turbulence.**
AD-157-286 H.PRESS.
N-51483 AGARD Rep. 115, 29 pp., 31 refs., 1957.
Flight-test techniques for measuring the turbulence are briefly outlined and available measurements of the power spectrum reviewed. Measured results are examined in relation to the idealized models of a stationary Gaussian random process and of isotropic turbulence. Some recent results on the variation with altitude of the probability distribution of the root-mean-square gust velocity are presented and their application to operational response history calculations indicated.

RP116 **Aircraft Loads in Continuous Turbulence.** N.I.BULLEN.
AD-157-287 AGARD Rep. 116, 19 pp., 9 refs., 1957.
N-48593X Evidence suggests that the distribution of aircraft normal acceleration is not Gaussian, but follows the form of a modified Bessel function, with an exponential distribution of peak values. From this distribution the root-mean-square of the variable is determined. It tends to take one of two discrete values whose ratio is about 0.6. When duration of turbulence is known the number of zero crossings per second of the variable can be found. Two examples are given, each of two intensities of turbulence. It is probable that the shape of the power spectrum is independent of intensity, at least over a limited range.

RP117
AD-157-288
N-56099X

Response of Elastic Aircraft to Continuous Turbulence. R.L.BISPLINGHOFF, T.H.H.PIAN, K.A.FOSS.
AGARD Rep. 117, 20 pp., 13 refs., 1957.
A method for determining the disturbed motion and accompanying stresses of an elastic aircraft is reviewed. It is applied to find the response of the aircraft to continuous turbulence. Results are given of the stress amplification due to structural flexibility. Effects of the scale of turbulence and of spanwise variations of gust intensity on the responses are discussed.

RP118
AD-157-289
N-59734

A Review of Landing Gear and Ground Loads Problems. J.F.McBREARTY.
AGARD Rep. 118, 22 pp., 4 refs., 1957.
A brief assessment is given of the aircraft weight attributable to the landing gear and ground loads in general. Some of the less common ground loads phenomena are discussed, including skidding oscillations, brake chatter, shimmy, taxiing loads, and fatigue. Methods of solving these problems are discussed. It is concluded that yet more operational data are needed to refine the design targets for these phenomena.

RP119
AD-218-217
N-56081X

Development of a Method and Instrumentation for Evaluation of Runway Roughness Effects on Military Aircraft. C.K.GRIMES.
AGARD Rep. 119, 33 pp., 35 refs., 1957.
The techniques of generalized harmonic analysis are used to predict: (i) number of occurrences of loads exceeding a given magnitude, and (ii) probability of exceeding the given load. Reduction of data from instrumentation measuring runway profiles and recorded on magnetic tape is accomplished by a high speed digital computer. The methods and instrumentation can be applied to determine dynamic response of any surface vehicle.

RP120
AD-157-290
N-59735

High-Speed Stability and Control Problems as they Affect Flight Testing. M.J.ABZUG.
AGARD Rep. 120, 36 pp., 48 refs., 1957.
These testing problems are discussed in relation to the maximum envelopes of attainable Mach number and altitude, and load factor and Mach number. Techniques are described which have been used for special high-speed stability and control problems. The flight-testing of irreversible flight-control systems and automatic systems is briefly discussed. The necessity for relying on analytical methods is emphasized.

RP121
AD-154-745
N-53686X

A Contact Extensometer for the Recording of Flight-Load Spectra. O.SVENSON.
AGARD Rep. 121, 10 pp., 1957.
Describes an instrument developed in the Performance Testing Laboratory at Darmstadt, Germany. The varying stress cycles are registered on a film running at low speed. Any method can be used for the subsequent analysis. The instrument is to be installed in Lufthansa's aircraft.

RP122
AD-154-753
N-54139

The Influence of Drag Characteristics on the Choice of Landing Approach Speeds. D.LEAN, R.EATON.
AGARD Rep. 122, 24 pp., 3 refs., 1957.
Based on a study of lift-drag characteristics of 19 jet aircraft, which were considered to have satisfactory approach airspeeds, limiting values of speed stability are proposed for the three types of approach used for carrier, airfield and instrument landings. The values are in fair agreement with those actually used. It is considered that drag effects must be taken into account in estimating approach airspeeds and this improves the prediction of speeds for the latest types of aircraft.

RP123
AD-154-746
N-48410X

A Flight Technique for the Measurement of Thrust Boundaries and of Drag due to Lift. H.D.RYLANDS.
AGARD Rep. 123, 14 pp., 3 refs., 1957.
Existing methods are considered unsuitable for high performance aircraft. The proposed technique is acceptable for supersonic aircraft and is very suitable for subsonic aircraft. Preliminary flight trials have been made on a subsonic aircraft. Some data on drag due to lift can be obtained without the need for thrust measurement.

RP124
AD-158-795
N-60279

Flight Testing for Inertial Coupling Characteristics. C.H.MEYER.
AGARD Rep. 124, 6 pp., 1 ref., 1957.
The development of low-drag aircraft configurations has led to concentration of mass in the fuselage. This increases the yawing and pitching moments of inertia and reduces rolling moments of inertia, resulting in increased roll instability and finally in roll divergence. Causes and effects of roll divergence are discussed and possible solutions of the problem in the design of aircraft for specific rôles are considered.

RP125
AD-159-947
N-60455

Aircraft Handling Qualities and Pilot Response Characteristics. C.B.WESTBROOK, D.T.McRUER.
AGARD Rep. 125, 21 pp., 10 refs., 1957.
Examples show how the "pilot-opinion" judgement of handling characteristics is a subjective expression of the pilot-airframe system suitability. Research by the U.S. Air Force to determine the dynamic characteristics of the human pilot is reviewed and its aim to accomplish the design of overall systems including airframe, controls, pilot displays is described. Some of the recent results of correlation work to the two approaches to handling qualities – pilot opinion method and servo technique – are given.

RP127
AD-154-747
N-58827

Measuring Climb Performance of a Propeller Engined Transport Aeroplane Using the Accelerometer Technique. J.P.K.VLEGHERT.
AGARD Rep. 127, 10 pp., 4 refs., 1957.
Accurate assessment of performance is required when the aircraft is subject to climb requirements limiting weight. With the accelerometer technique described it is feasible to analyze the total aeroplane drag into its components. Some attainable accuracies and some problems in instrumentation are presented. Detailed knowledge of aeroplane drag data makes possible the assessment of optimum performance and evaluation of detail improvements.

RP128
AD-157-483
N-58824

Endurance Tests on Irreversible Servo-Controls. L.VANDENBERGHE.
AGARD Rep. 128, (in French), 6 pp., 3 refs., 1957.
A series of tests on a mechanical-input jack, from manufacture to batch installation on aircraft, is described, including bench-tests of performance, stability and life with numerous periodical dimensional checks. Flight tests check functioning under full operational conditions and determine the limits of operation. During flight test period the jack is dismounted at intervals for inspection.

RP129
AD-154-754
N-58000

A Classification System for Unprepared Landing Areas. D.P.SAMSON, Jr.
AGARD Rep. 129, 11 pp., 1957.
An unprepared landing area can be classified by the headings (i) area, (ii) terrain configuration, (iii) surface roughness, and (iv) soil description and bearing capacity. A numerical "terrain designator" is derived and can be used when stating design requirements for new aircraft.

RP130
AD-154-748
N-58828

High Speed Computers in the Aircraft Industry. F.P.COZZONE.
AGARD Rep. 130, 13 pp., 1957.
The growth in the use of high speed digital computers is discussed and a capability comparison made between the progressive computers used to date. The comparison is extrapolated to computers soon to be available. The types of problems capable of solution by computers are discussed.

RP131
AD-157-311
N-52868X

Some Possible Implications of Minimum Drag Speed at Altitude. R.P.DICKINSON.
AGARD Rep. 131, 8 pp., 1957.
Indicates the spheres in which minimum drag speed should be considered in flight testing at the higher altitudes.

RP132
AD-157-312
N63-15528

Introductory Remarks Concerning Some Aspects of Hypersonic Research and Research Facility Requirements. E.O.PEARSON, Jr.
AGARD Rep. 132, 27 pp., 25 refs., 1957.
After a brief résumé of the history of research in, and the characteristics of hypersonic flow, skin friction, heat transfer coefficients, the problems of boundary layer and shock wave interaction are discussed. The possibility of different types of hypersonic flight vehicles is introduced. A survey of research problems and experimental facilities up to Mach 15 is given.

RP133
AD-138-317
N-50038X

Dynamics of a Dissociating Gas. Pt. 3. Non-Equilibrium Theory. N.C.FREEMAN.
AGARD Rep. 133, 21 pp., 7 refs., 1957.
Lighthill's equilibrium theory is extended to non-equilibrium thermodynamic conditions by postulating a rate equation for the dissociation process. The behaviour of the gas in flow through strong normal shock waves and past bluff bodies is studied under non-equilibrium conditions.

RP134
AD-157-313
N63-84731

Molecular Approach to Problems of High-Altitude, High-Speed Flight. G.N.PATTERSON.
AGARD Rep. 134, 58 pp., 61 refs., 1957.
The zones of the upper atmosphere, the régimes of fluid mechanics, based on considerations of rarefaction and temperature, and the modern experimental methods for investigations in some of these régimes are discussed. Rarefaction effects are then discussed in terms of gas-surface interactions, free molecule flow and slip flow, and Newtonian flow is considered as an extension of free molecule motion. Effects of high temperature are indicated for undissociated air and air in dissociation equilibrium and important effects of relaxation outlined.

RP135
AD-150-318
N-55131X

Design and Operation of Hypersonic Wind Tunnels. R.SMELT, J.C.SIVELLS.
AGARD Rep. 135, 37 pp., 72 refs., 1957.
Problems of operation, including air supply, diffuser efficiency, heater design and operation, nozzle design and calibration and instrumentation are discussed. Real gas effects and the application of hypersonic-wind-tunnel results to flight problems are also discussed. Some solutions are given, based on experience of the design and operation of the Gas Dynamics Facility at the Arnold Engineering Development Center, U.S.A.

RP136
AD-150-317
N-54976

The Hypersonic Facility of the Polytechnic Institute of Brooklyn and its Application to Problems of Hypersonic Flight. A.FERRI, P.A.LIBBY.
AGARD Rep. 136, 39 pp., 16 refs., 1957.
The engineering problems of hypersonic flight are reviewed. The use of a hypersonic tunnel with stagnation temperatures of 3000 to 5000 deg.R for the solution of these problems is discussed. The hypersonic facility of the Polytechnic Institute of Brooklyn is discussed, together with design considerations of the heating system. Some of the testing techniques developed for conventional testing at Mach 6 and for shrouded model testing are reviewed.

RP137
AD-150-316
N-55117

Research in the U.S. Naval Ordnance Laboratory Ballistics Ranges. P.A.THURSTON.
AGARD Rep. 137, 28 pp., 5 refs., 1957.
The possibilities of ballistic ranges are explained. The complementary rôles of wind-tunnels and ballistic ranges for aerodynamic research are described. A general description is given of the ranges in use at the Naval Ordnance Laboratory and examples given to illustrate the research programme at these ranges.

RP138
AD-150-315
N-53979X

The Use of Gun-Launched Models for Experimental Research at Hypersonic Speeds. A.SEIFF.
AGARD Rep. 138, 19 pp., 7 refs., 1957.
Two methods for improving performance of gun-launched models studied at the Ames Laboratory of the N.A.C.A. are described. One is to use a counter-current supersonic air stream flowing opposite to the free-flying model, to attain Mach 13. The other approach is to replace powder gas as a propellant in guns by compression-heated helium. Short, light-weight projectiles have thus been propelled at speeds above 17,000 f.p.s. By combining both methods a Mach number of 25 can be attained.

RP139
AD-154-749
N-50053X

The Light Gas Hypersonic Gun Tunnel at A.R.D.E., Fort Halstead, Kent. R.N.COX, D.F.T.WINTER.
AGARD Rep. 139, 24 pp., 7 refs., 1957.
This intermittent tunnel, which has a running time of hundreds of milliseconds, uses a light piston driven at supersonic speed in a closed barrel. Multiple shock reflections between piston and end of barrel provide a high temperature, high pressure stagnation region of gas, which expands through a convergent-divergent nozzle. The theory of the process is given. If a light gas is used, perfect gas stagnation temperatures up to 10,000 deg.K are possible. Instrumentation and flow measurements are discussed.

RP140
AD-154-750
N-53175

NACA Hypersonic Rocket and High-Temperature Jet Facilities. P.E.PURSER, A.C.BOND.
AGARD Rep. 140, 13 pp., 8 refs., 1957.
Of the jets described, one is essentially the exhaust from a ramjet engine, providing stagnation temperatures up to 3000°F, one is a rocket engine (for 4,200°F), one a 4,000°F air jet with a ceramic heat exchanger, and one is an electric-arc-heated jet with stagnation temperatures of over 15,000°F.

RP141
AD-202-584
N-55128

Hypersonic Flow About a Thin Body of Revolution. R.TIMMAN.
AGARD Rep. 141, 10 pp., 1957.
The boundary layer equations are derived, taking into account the curvature of the body. A "similar" solution is found and the application of a Pohlhausen method with a suitable velocity profile gives the effect of radius of curvature in general terms. The research is continuing.

RP142
AD-206-237
N-63640

Exploratory Studies of Hypersonic Fluid Mechanics. S.M.BOGDONOFF.
AGARD Rep. 142, 29 pp., 22 refs., 1957.
Using a helium hypersonic tunnel studies were made of flow over simple 2- and 3-dimensional bodies at Mach numbers from 11 to 19. Detailed studies are reviewed for a flat plate. Preliminary results are given for plates with flaps, delta wings, base pressure models, blunt models and cones. Some preliminary results of boundary layer studies and dissolving models are given. The value of the helium tunnel facility is emphasized.

RP143 **Tube Wind Tunnel: A Special Type of Blowdown Tunnel.** H.LUDWIEG.
AD-154-755 AGARD Rep. 143, 11 pp., 4 refs., 1957.
N-55127 In this tunnel, the air container is a long cylindrical tube in which the air is pre-accelerated by an expansion wave before entering the nozzle of the tunnel. A constant stagnation pressure and temperature are thus attained without a control valve or heat accumulator. The influence of wall friction in the test section is discussed and experiments described. Means to reduce or compensate for the wall friction effects are considered. Possible applications of the tube tunnel are mentioned.

RP144 **The Shock Tunnel and its Applications to Hypersonic Flight.** A.HERTZBERG.
AD-154-751 AGARD Rep. 144, 32 pp., 45 refs., 1957.
N-52588X Modification of the conventional shock tube for the study of hypersonic flows is described and problems of operation and technique discussed. Instrumentation techniques for short-duration tests are outlined, particularly that for measuring heat transfer. Preliminary investigations are reported on the effects of shock attenuation on tunnel operation. A design of tunnel to increase testing time twenty five-fold is being studied. A technique for generating strong shock waves is described.

RP145 **Physical Gas Dynamics Research at the AVCO Research Laboratory.** P.H.ROSE.
AD-157-314 AGARD Rep. 145, 43 pp., 23 refs., 1957.
N-52150 In this résumé of the first years work at AVCO the advantages of the straight shock tube are discussed. Several investigations, using shock tubes, into critical gas dynamic problems, associated with the high temperatures of hypersonic flight are described and some preliminary studies of magnetohydrodynamics are summarized.

RP146 **Hypersonic Facilities in the Aerodynamics Department Royal Aircraft Establishment.** P.A.HUFTON.
AD-159-950 AGARD Rep. 146, 6 pp., 21 refs., 1957.
N-60733 The facilities are described and some development problems discussed. Appendices give notes on multiple diaphragm shock tubes, combustion-driven shock tubes, methods of evaluating imperfect gas effects in aerodynamic problems, and the development of the R.A.E. 6 in. diameter shock tube.

RP147 **Hypersonic Shock Tube Equipment at the National Physical Laboratory, U.K.** D.L.SCHULTZ,
AD-154-756 B.D.HENSHALL.
N-50048X AGARD Rep. 147, 23 pp., 3 refs., 1957.
Describes an existing shock tube fitted with a flow expansion nozzle, giving Mach 9, and a proposed larger tube. Performance charts illustrate the conditions for simulating full-scale flight. A unified electronic timing and recording system is described.

RP148 **Measurement of Pilot Mental Effort.** S.I.COHEN, A.J.SILVERMAN.
AD-200-672 AGARD Rep. 148, 23 pp., 1957.
N-62842 Describes methods of measuring total psychophysiologic response and discusses factors affecting a pilot's ability to cope with situations demanding effort. Some methods and results obtained in research at the Aeromedical Laboratory of the Wright-Patterson Air Force Base are described.

RP149 **Structures and Heat at Supersonic and Hypersonic Speeds.** B.DORLEAC.
AD-204-309 AGARD Rep. 149, (in French), 78 pp., 1957.
N-65088 Typical studies carried out in France are examined and the future problems arising from them considered. A working programme is proposed for the development of materials and structures suitable for future applications.

RP150 **The Problem of Structural Safety with Particular Reference to Safety Requirements.** H.EBNER.
AD-661-989 AGARD Rep.150, 23 pp., 33 refs., 1957.
N-72500 The historical development of the safety concept in aircraft design is described and the methods by which criteria have been derived in various national regulations are discussed. Comparisons are made of safety factors required in American, British, French and German regulations. A new statistical concept of safety, gust loads, fatigue and cumulative damage in fatigue are also discussed.

RP151 **General Considerations on Safety in Materials and Structures.** E.M.PROT.
AD-661-934 AGARD Rep. 151, (in French), 11 pp., 1957.
N-61750 The concept of safety is defined by reference to the concepts of frequency and probability and by consideration of the nature of the accidents which are to be obviated. Economic considerations must also come into the choice of safety factor. A sufficient number of tests should be established and evaluated statistically to give valid figures for mean valve and divergence for models or materials. The practical application of these recommendations is discussed.

RP152 **French and International Standards on Quality Control.** A.PALLEZ.
AD-159-946 AGARD Rep. 152, (in French), 8 pp., 1957.
N-60661 Quality control is defined and the necessity for measurable quantities and the setting of upper and lower limits of these demonstrated. French standards are reviewed for (i) statistical terminology, probability calculations, errors in measurement and measuring instruments, (ii) standards for quality control. Some work being carried out on an international basis is described.

RP153 **Safety and Safety Factors for Airframes.** A.M.FREUDENTHAL.
AD-221-406 AGARD Rep. 153, 21 pp., 13 refs., 1957.
N-74048 The concept of structural safety of airframes is analyzed on the basis of its relation to probability of failure in order to establish procedures of quantitativ· evaluation of safety factors for a predetermined acceptable risk of failure. The concepts of safety for ultimate strength and for fatigue are discussed in the light of recent developments in fatigue research, especially for random loading. Methods of safety analysis for both conditions are proposed.

RP154 **The Aircraft Structural Factor of Safety.** G.N.MANGURIAN.
AD-206-232 AGARD Rep. 154, 24 pp., 1957.
N64-83558 Discusses the question of reviewing the Aircraft Structural Factor of Safety with consideration of advances in structural and aerodynamic knowledge. A reduction in the factors seems realistic for some design aspects, not so for others.

RP155 **Some Remarks on the Fundamentals of Structural Safety.** A. van der NEUT.
AD-206-234 AGARD Rep. 155, 16 pp., 1957.
N-65090 The usual factor of safety is needed to account for exceptionally large loads. Present strength requirements result in more structural weight than necessary for the failure rate obtained. It is advocated that the ultimate load be established as the product of a safety factor little above unity and the "standard" load, which is very large. The suggested concept is particularly applicable for high-speed aircraft. Recommendations are made for determining "standard" loads and distribution of failure probability.

RP156 **Fatigue of Structural Materials at High Temperature.** B.J.LAZAN.
AD-202-582 AGARD Rep. 156, 27 pp., 28 refs., 1957.
N-64382 The general nature of the fatigue process, especially the progressive and statistical aspects are reviewed. Engineering factors important in high temperature fatigue are tabulated and effects of environmental conditions generalized. Effects of mean-stress, alternating stress, temperature, and stress concentration are discussed, also the creep phenomena occurring under combinations of cyclic and mean stresses. The rôle of resonant vibrations in fatigue is explained and criteria derived for judging resonance fatigue strength. Examples are given for different types of materials and engineering parts.

RP157 **Fatigue and Ageing.** F.BOLLENRATH.
AD-206-065 AGARD Rep. 157, 18 pp., 14 refs., 1957.
N-66131 Reasons for ageing are briefly discussed and results of different degrees of ageing given for some aluminium alloys and mild steel. The influence of vibration on the course of ageing is investigated. The interaction of diffusion and strain rates is mentioned and the resonance frequencies derived corresponding to the temperatures present during vibrational strain.

RP158 **Some Fundamental Features of Mechano-Chemical Attack on Metals.** T.P.HOAR.
AD-211-873 AGARD Rep. 158, 5 pp., 6 refs., 1957.
N-69063 The behaviour of oxide films under conditions leading to their chemical failure, and under fretting, fatigue and static stress conditions, is discussed. Recent experimental work is mentioned which indicates that metal that is yielding under mechanical stress is in an especially active chemical state. The implications of this work on the mechanism of stress-corrosion cracking are considered.

RP159 **Dry Corrosion and Protection of the Refractory Alloys Ni-Cr 80/20.** M.MATHIEU.
AD-204-305 AGARD Rep. 159, (in French), 21 pp., 30 refs., 1957.
N-66238 An investigation into the failure of blades made from forged alloys; the cause of failure is thought to be in the alloy itself. The following points are considered: (i) development of the internal structure under service conditions; (ii) incidence of corrosion from air and combustion gases; (iii) effect of work-hardening on structure development and corrosion. Surface treatment and crystallization are also considered.

RP160 **Transparent Materials for Aircraft: A Review.** E.W.RUSSELL.
AD-200-671 AGARD Rep. 160, 14 pp., 15 refs., 1957.
N-53927X Extensive work has been carried out on the organic plastics, and improved performance and reliability have been obtained, but with only limited advances in high temperature characteristics. As alternative materials, the inorganic glasses compel attention, but are shown to suffer from several limitations both for wind-screens and canopies. Possible lines for future development are indicated.

RP161 **Inorganic Transparencies for Aircraft Enclosures.** C.H.HAHNER, M.J.KERPER.
AD-206-239 AGARD Rep. 161, 23 pp., 24 refs., 1957.
N-56538X Reviews available information on glass, and contains a description of work now being done under the sponsorship of the Wright Air Development Center to obtain additional data on a few selected glasses that are believed to be suitable for use in aircraft (i.e. glasses that can be made in the form of polished plate glass of the required sizes).

RP162 **Structural Plastics for Airframe Construction.** N.J.L.MEGSON.
AD-157-315 AGARD Rep. 162, 16 pp., 15 refs., 1957.
N-59733 A general account of the development and methods of fabrication of reinforced plastics which can be moulded at low pressures. Applications discussed include wings, radomes, fuselages, drop tanks, and the use of plastics in the Fokker "Friendship". Future trends are outlined.

RP163 **Short Notes Contributed to the Pressure Measurements Meeting, Sponsored by the AGARD Wind**
AD-220-674 **Tunnel and Model Testing Panel.**
N63-15670 AGARD Rep. 163, 203 pp., 1958.
A collection of 31 papers dealing with pressure measurement, contributed by authorities from various NATO countries. Abstracts of the individual papers are given in the succeeding items.

RP163/1 **The Measurement of Static Pressure.** R.SHAW.
AGARD Rep. 163, 1-12, 5 refs., 1958.
Previous work by A.Myadzu and A.K.Ray suggested that the dimensions of a static-pressure hole in the side wall of a pipe through which fluid is flowing influenced the observed reading. The flow near the wall is disturbed by the hole, the error increasing as the size of the hole increases. Ray correlated his results by employing the principle of dimensional similarity, and expressed the error as a function of the Reynolds number, based on the hole diameter and the length/diameter ratio of the hole. The present investigations are being carried out to obtain results over an extended range of Reynolds number.

RP163/2 **Yawmeter for Low-Speed Flow with a Velocity Gradient.** O. de VRIES.
AGARD Rep. 163, 13-18, 1958.
Reports investigations on twenty different probes. Measurements were made at five different speeds between 16 and 70 m/sec.

RP163/3 **L.R.S.L. Inclination-Measuring Sonde of 2mm. Diameter.** LABORATOIRE DE RECHERCHES TECHNIQUES DE SAINT-LOUIS.
AGARD Rep. 163, (in French), 19-21, 1958.
This sonde, developed by Laboratoire de Recherches Techniques de Saint-Louis, enables measurements of the angles of incidence and of side-slip to be made. The sonde has a spherical-ended probe and is of the classical type.

RP163/4 **Transient Heating Effects on a Capacitance-Type Pressure Transducer.** P.FETHNEY.
AGARD Rep. 163, 23-26, 1958
The steps taken to minimize the transient heating effects incurred by capacitance-type transducers used for measuring pressure in combustion chambers are discussed; the conclusions indicate the conditions under which these transducers may be assumed to provide a true assessment of pressure.

RP163/5 **A Small Strain-Gauge Type Pressure Cell for use Inside Wind Tunnel Models.** W. van GENDEREN.
AGARD Rep. 163, 27-30, 1958.
Describes a pressure cell that has been developed with dimensions of about 1 in. diameter and ¼ in. thickness. The pressure cell is of the type in which strain gauges are cemented to a diaphragm. A special version of this cell has been developed for dynamic measurements.

RP163/6 **A Sensitive Strain-Gauge Pressure-Measuring Instrument.** W. van GENDEREN.
AGARD Rep. 163, 31-33, 1958.
Describes a sensitive but very robust instrument developed for measuring pressure; the instrument has the disadvantage of large external dimensions.

RP163/7 **Automatic Strain Gauge Bridges.** BOULTON PAUL AIRCRAFT, LTD.
AGARD Rep. 163, 35-36, 1958.
Describes briefly the multi-channel automatic strain-gauge bridge equipment supplied to the Aircraft Research Association for use with their transonic wind tunnel. Permits a large number of readings to be made in a short time.

RP163/8 **The Pirani Pressure Gage.** E.L.DAVIS.
AGARD Rep. 163, 37, 1958.
Describes a small Pirani gage (0.0005 cu. in. internal volume, and made of surgical grain-of-wheat lamps), and the operating equipment for recording 12 channels of low pressures in the range 0.1 to 10 mm. Hg abs. Also describes calibration techniques, and the operation of this apparatus.

RP163/9 **Automatic Manometers.** BOULTON PAUL AIRCRAFT, LTD.
AGARD Rep. 163, 39-42, 1958.
The Boulton Paul Aircraft Ltd. "Midwood-R.A.E." automatic manometers for use in wind tunnel pressure plotting and as primary elements in a Mach number monitor are briefly described.

RP163/10 **Accurate Measurement of Stagnation Pressure (50 Atmospheres) In the R.A.E. Hypersonic Tunnel.** T.A.HOLBECHE, L.R.VANDOME.
AGARD Rep. 163, 43-48, 1 ref., 1958.
Presents a brief description of the system being developed for the accurate measurement and recording of the stagnation pressure in the 7 in. x 7 in. hypersonic tunnel at R.A.E. Farnborough.

RP163/11 **Diaphragm Strain-Gauge Pressure Transducers.** BOULTON PAUL AIRCRAFT, LTD.
AGARD Rep. 163, 49-50, 1958.
Pressure transducers, developed by Boulton Paul Aircraft, Ltd, to meet the need for measurement of static and dynamic pressure in the range 0 to 5,000 lb/sq. in. are described.

RP163/12 **Recording Manometer with Photo-Electric Sensing of a Liquid Column.** W.WUEST.
AGARD Rep. 163, 51-58, 1958.
The pressure distribution in a boundary layer or a wake may be recorded by a probe (moving through the flow field) coupled to a suitable manometer. Here, a suitable recording manometer (with photo-electric sensing of a liquid column) which has been developed by K.Schiebe and the author (from a suggestion of Prof. A.Betz) is described.

RP163/13 **The Recording of Readings of the L.R.B.A. Multitube Manometers.** LABORATOIRE DE RECHERCHES BALISTIQUES ET AERODYNAMIQUES DE VERNON.
AGARD Rep. 163, (in French), 59-60, 1958.
The interest of this method, in use at the Laboratoire de Recherches Balistiques et Aérodynamiques, lies in the fact that it permits recording on perforated cards of the pressures indicated by several tubes (maximum 42), dispensing with the intermediate steps normally required. Its use is limited to the cases where the response-time of the liquid manometers does not constitute a difficulty.

RP163/14 **A Multitube Liquid Manometer Pressure Measuring System**
AGARD Rep. 163, 61-68, 1958.
Describes a standardized design of multitube liquid manometer (fitted with 25 or 40 tubes) in use at the Langley Aeronautical Laboratory. The multitube manometer boards are photographed with aerial cameras having high quality mapping lenses; these cameras use 250 ft rolls of film and have a 9 in. x 9 in. negative size.

RP163/15 **A Butylphthalate Manometer for Low Pressures.** E.L.DAVIS.
AGARD Rep. 163, 69-75, 1958.
In the butylphthalate manometer described, an absolute pressure of less than one micron is applied to one tube of a U-tube manometer with a good mechanical pump, and the pressure to be measured is applied to the other tube. A three-way valve in this manometer allows the reference pressure from the mechanical pump to be applied to both tubes until the pressure to be measured is within the full scale of the manometer. This manometer is made in several ranges up to 100 mm. Hg absolute.

RP163/16 **A Simple Method of Tube Adjustment for Multi-Tube Tilting Manometers.** D.W.BRYER.
AGARD Rep. 163, 77-78, 1958.
The individual adjustment of the manometer tubes mounted on the tilting table is obtained by grub screws which bear on flat metal strips which back the manometer tubes; thin spring strips arranged across the table retain the tubes against the metal strips. Manometers with this type of adjustment have proved satisfactory down to angles of 4°.

RP163/17 **Micro-Manometers for Low-Speed Work at the N.L.L.** W. van GENDEREN.
AGARD Rep. 163, 79-83, 1958.
A modified Fuess type alcohol manometer with inclined tube which is used for pressures up to 400 mm. water is described. A simple quick-acting balance which has been developed for routine calibration is also described. This balance can be calibrated by means of an Askania-built water micro-manometer.

RP163/18 **Averaging Multimanometer.** O.N.E.R.A.
AGARD Rep. 163, (in French), 85-87, 1958.
This apparatus enables one to obtain by a single measurement, the arithmetic mean of N pressures; the use of such a multimanometer thus results in a considerable saving of time.

RP163/19 **Short Note on Some Recent Calibrations of R.A.E. Automatic Self-Balancing Capsule Manometers.** J.R.ANDERSON.
AGARD Rep. 163, 89-97, 1958.
This instrument consists of two opposed pressure-sensitive capsule stacks or bellows connected to a weigh-beam which is arranged to balance the moment applied by the pressure difference in the capsules by means of a travelling jockey weight. Several of these instruments have shown large errors in calibration; these errors are apparently attributable to hysteris of the capsules, and water vapour or moisture in the manometer system. A résumé of investigations into these effects is presented; the use of a drying agent in the manometer system is advocated.

RP163/20 **Semi-Automatic Precision Pressure Cell Calibration System.** R.K.HALLETT, Jr.
AGARD Rep. 163, 99-102, 1958.
The semi-automatic pressure calibration system developed at the Ames Laboratory of NACA is described. This system is primarily intended to calibrate pressure transducers of the strain gauge type. The system uses as a primary standard an automatic mercury manometer.

RP163/21 **Fluctuating Pressure Measurements on the Surface of a Model in Low Speed Air Flow.** J.H.GERRARD.
AGARD Rep. 163, 103, 1 ref., 1958.
The use of a condenser microphone, with solid dielectric having a sensitive area of ¼ in. diameter, for measuring fluctuating pressures on the surface of circular cylinders in the range of Reynolds numbers in which vortices are shed, is described. This gauge is very simple to construct, and it can be made flush with the curved surface of a model.

RP163/22 **An Investigation of the Frequency Response of Pitot Probes and Preliminary Measurements of the Pitot Pressure Fluctuations in the N.A.E. 5 inch Pilot Supersonic Wind Tunnel.** R.WESTLEY.
AGARD Rep. 163, 105-130, 1958.
In order to determine the frequency response, the end of the pitot tube was inserted into the sound field of a calibration cavity. The cavity was driven by a University P.A. 30 horn unit which was fed from a Bruel and Kjaer, type 104, beat frequency oscillator. A standard microphone was connected to the cavity and its output or that from the pressure transducer of the pitot tube was measured on a frequency analyzer. The effects of probe length, and of damping material within the probe tube were investigated.

RP163/23 **Turbulence Investigation by Dynamic Total-Head Measurement.** R.E. de HAAN.
AGARD Rep. 163, 131-134, 1958.
Examines theoretical and practical considerations that affect the measurement of pressure fluctuations using a total-head instrument. The fluctuations may have an acoustic or turbulent origin, and a simple analysis shows that the acoustic pressure fluctuations on a total-head can easily attain the same value as the turbulent pressure-fluctuations.

RP163/24 **Condenser-Type Manometer for the Measurement of Rapidly Varying Pressures.** LABORATOIRE DE RECHERCHES TECHNIQUES DE SAINT-LOUIS.
AGARD Rep. 163, (in French), 135-136, 1958.
Describes the mechanical construction and electrical circuit of this condenser-type manometer which was developed for the L.R.B.A. supersonic wind tunnel.

RP163/25 **Integrating Pressure-Balance for Hinge Moment Measurements.** E.DOBBINGA.
AGARD Rep. 163, 137-153, 1958.
The basic theory and the construction and operation of a pressure balance for measuring the hinge moments acting on a control surface are described. A balance beam, supported on knife edges carries a number of "pressure bells" which are partially immersed in mercury. Each pressure orifice in the control surface has one bell on the beam, the interior of the bell being connected with the appropriate pressure lead by means of a thin stainless steel tube fastened to the bottom of the mercury reservoir.

RP163/26 **Integrating Multiple-Liquid Manometer for Low-Speed Drag Measurements.** E.DOBBINGA.
AGARD Rep. 163, 155-169, 1958.
The application of an integrating manometer for low-speed drag measurements is described. The treatment is restricted to quasi-two-dimensional aerofoils; in principle the method can also be used for determining the drag of a fuselage.

RP163/27 **Two-Way Switch and Isolating Valve for Multi-Tube Manometers.** D.W.BRYER.
AGARD Rep. 163, 171-174, 1958.
The conventional method of "freezing" the liquid levels of multi-tube manometers while readings are made, is to apply clamps to short lengths of rubber tubing in the pressure leads. Here, an improvement used at the N.P.L., Teddington, England, is described; it constitutes a simple form of slide valve which combines a sealing device with a two-way switch.

RP163/28 **Quick-Release Pressure Connectors Used in the 3 Foot R.A.E. Tunnel at Bedford.**
D.I.T.P.LLEWELYN-DAVIES, N.T.CAIGER.
AGARD Rep. 163, 175-179, 1958.
Describes an improved type of plug-and-socket multiple-tube connector which has given several years of satisfactory service in the 3 ft supersonic wind tunnel at R.A.E., Bedford.

RP163/29 **A Two-Way Distributor for Apparatus for the Measurement of Pressure.** O.N.E.R.A.
AGARD Rep. 163, (in French), 181-183, 1958.
The purpose of this device is to allow two separate pressures to be connected alternately to a liquid manometer, at the same time ensuring a perfect seal. The device can only be used conveniently when the difference between the pressures to be measured is less than about 100 mm. Hg.

RP163/30 **Digital Systems for Precision Multi-Point Pressure Recording.** M.B.WOOD.
AGARD Rep. 163, 185-199, 6 refs., 1958.
Topics considered include: survey of development; the scanivalve system; experimental digital system; a multi-channel punched tape system; and future development.

RP163/31 **The Mach Number Gauges used on the High-Speed Wind Tunnels at the National Physical Laboratory.** D.W.HOLDER.
AGARD Rep. 163, 201-203, 2 refs., 1958.
The Mach number in the working section of a wind tunnel can be derived from the ratio p/H (where p is the static pressure of the undisturbed stream in the working section and H is the total pressure). A simple mechanical system for measuring this ratio is described; the pressures p and H are communicated to bellows which are opposed by evacuated bellows; forces proportional to the pressure are communicated to a balance arm; a direct reading of Mach number is obtained.

RP164
AD-490-736
N-60372 **Notes on Wind Tunnel Pressure Measurements from the Operator's Point of View.** J.S.THOMPSON, D.W.HOLDER.
AGARD Rep. 164, 10 pp., 40 refs., 1958.
A brief description of the objects of the various pressure measurements in wind tunnels, explaining the purposes for which they are needed and the special requirements of each. Appendices give an assessment of the accuracy desirable for various applications.

RP165
AD-206-233
N-65089 **Development of Pressure Measuring Devices for a Blow-Down Wind Tunnel at the D.V.L.** A.HEYSER.
AGARD Rep. 165, 25 pp., 1958.
Measuring devices discussed include electronic multimanometers and a miniature differential pressure transducer, as well as instrumentation for measuring stagnation pressure. Consideration is also given to the response times that can be realized under normal operating conditions.

RP166
AD-206-066
N-56883 **A Survey of New Developments in Pressure Measuring Techniques in the N.A.C.A.** J.DIMEFF.
AGARD Rep. 166, 25 pp., 5 refs., 1958.
Describes the following transducers designed to meet the needs of research within the N.A.C.A.: an inexpensive strain gauge transducer with an accuracy of 0.05% of its full differential range; a deflecting diaphragm capacitance-type transducer for the range below several mm. of Hg; a transducer $\frac{1}{8}$ in. in diameter; an experimental transducer the deforming member of which is a thin layer of dielectric compressed under the action of the unknown pressure.

RP167
AD-204-308
N-66135 **The Automatic Handling of Pressure Measurements in Wind Tunnels.** R.MOREAU.
AGARD Rep. 167, (in French), 16 pp., 1958.
The chain of operations described consists of (i) photographing the meniscus levels in a bank of manometers, (ii) projecting the images against a graduated scale, (iii) converting the image readings

to numerical, tabulated values, (iv) a controlled checking operation, (v) transfer of results to perforated cards, (vi) verification of the perforations. The results are then ready for computation purposes.

RP168 **Propulsion Wind Tunnel Digital Pressure System.** R.W.KAISNER.
AD-206-231 AGARD Rep. 168, 26 pp., 1 ref., 1958.
N-65091 Describes the digital pressure system of the Propulsion Wind Tunnel, Arnold Engineering Development Center. This system is capable of measuring four reference pressures and 250 model pressures at a rate of 20 per sec. Operating modes and the reliability of the system are discussed.

RP169 **The Measurement of Unsteady Pressures in Wind Tunnels.** E.L.DAVIS, Jr.
AD-262-484 AGARD Rep. 169, 26 pp., 21 refs., 1958.
N-57669 Practical solutions to the problem of accurately measuring unsteady pressures in wind tunnels are described; emphasis is on the response of pressure systems, calibration techniques and equipment, and wind-tunnel instrumentation. A guide is given to the selection of a pressure gauge volume-connecting tubing system. A cam-type pulsator calibrator with a sinusoidal pressure variation up to ± 3 lb/sq. in. and a frequency range up to 5,000 c.p.s. is described.

RP170 **Wide Frequency Band Manometer and Application to the Measurement of Rapidly Varying Pressures.** P.LIENARD.
AD-204-310 AGARD Rep. 170, (in French), 15 pp., 8 refs., 1958.
N-65087 Describes the use, for aeronautical research, of manometers based on microphones such as are used for acoustic measurements. Characteristics required, methods of construction and possibilities for dynamic calibration are described.

RP171 **Capacity Manometer for the Measurement of Rapidly Varying Pressures.** A.MOUTET.
AD-661-935 AGARD Rep. 171, (in French), 43 pp., 7 refs., 1958.
N-73186 Describes equipment developed by O.N.E.R.A. for investigating instability phenomena in ramjets and rockets. A range of pick-ups was used, including types with interchangeable diaphragms. Component parts of the electronic equipment are described and their performance reported. Calibration problems are discussed, and the results of applications to both internal and external aerodynamic flows are given.

RP172 **Techniques of Pressure-Fluctuation Measurements Employed in the R.A.E. Low-Speed Wind-Tunnels.**
AD-211-874 T.B.OWEN.
N-69036 AGARD Rep. 172, 59 pp., 5 refs., 1958.
A technique was developed for examining, at model scale and in a low-speed wind-tunnel, the aerodynamic excitation responsible for aircraft vibration at flight speeds where Mach number does not have an important effect. The basic measurements are of the total intensity and spectrum function of the pressure fluctuations, and a description is given of the capacity-type transducers and the associated electronic equipment used.

RP173 **Pressure Sondes and Miniature Manometers for use in Wind Tunnels and in Flight.** M.BASSIERE.
AD-204-306 AGARD Rep. 173, (in French), 18 pp., 1958.
N-66212 Instruments designed by O.N.E.R.A. for specific purposes are described. In particular the miniature strain-gauge manometers à H60, 20H61, the optical manometer 20H20, telemetric manometers 20H34 and 20H32 are discussed. Useful ranges, accuracy and methods of construction are described.

RP174 **Optimized Design of Systems for Measuring Low Pressures in Supersonic Wind Tunnels.**
AD-661-937 J.M.KENDALL.
N-72454 AGARD Rep. 174, 26 pp., 8 refs., 1958.
Derives an expression for the lag-time in a pressure-measuring system for use with supersonic tunnels, and gives a procedure for determining optimized dimensions of tubing. For the measurement of pressures varying with time, the determination of maximum permissible time-rate of variation for a given accuracy is included. The effects of gas evolution from the walls of plastic tubes are evaluated; this evolution of gas may result in errors of up to 50%.

RP175 **Some Problems Associated with the Measurement of Very Low Pressures.** G.J.MASLACH.
AD-218-220 AGARD Rep. 175, 30 pp., 40 refs., 1958.
N-69950 Describes several types of pressure-sensitive elements used for measuring very low pressures, and presents a method of design for the connecting line joining an orifice to a pressure-sensitive element. Shows that the time-response is affected by out-gassing effects and variable temperatures, and indicates corrections. Measurements are presented to illustrate external flow effects at low densities.

RP176
AD-661-936
N63-15670
Pressure Measurements in an Arc-Discharge Wind Tunnel. M.R.MULKEY, W.T.EARHEART, Jr., E.E.McADAMS, Jr.
AGARD Rep.177, 26 pp., 2 refs., 1958.
Topics discussed are: types of transducers, electrical interference, low-impedance transducers, and data-recording systems. Solutions to pressure-measuring problems are given, based on experience at the Arnold Engineering Development Center.

RP177
AD-200-673
N-62843
Pressure Measurement in Armament Research. A.J.CABLE.
AGARD Rep. 177, 10 pp., 1 ref., 1958.
Describes typical pressure transducers (copper-crusher gauges, piezo-electric transducers and strain-gauge transducers) developed at A.R.D.E. for internal ballistics research. A quartz piezo-electric transducer and a modified piston-type strain gauge transducer are being used for pressure measurements in the A.R.D.E. Hypersonic Wind Tunnels.

RP178
AD-206-068
N-66133
Elastomers for High Temperature Applications. E.R.BARTHOLOMEW.
AGARD Rep. 178, 23 pp., 1958.
A review is given of the source and nature of high-temperature elastomer problems, and the limitations of the more conventional elastomer problems are discussed. Recent data on properties of special high-temperature polymers and their compounds are included.

RP179
AD-218-218
N-70211X
Ceramics and Glass and their Application in Modern Aeronautics. L.ZAGAR.
AGARD Rep. 179, 15 pp., 10 refs., 1958.
The development of silicates, and their application in aeronautical engineering, are discussed. Glass, ceramics and oxy-ceramic materials are dealt with, and the properties of these materials are described in some detail.

RP180
AD-661-938
N-73187
Resistance to Fatigue of Metal-Metal Glued Joints. L.LOCATI.
AGARD Rep. 180, (in French), 22 pp., 1958.
Considers the behaviour of glued steel sheets under alternating stress and gives results of fatigue tests on Redux glued joints having an overlap of 22 mm. The occurrence of fatigue rupture in metal-metal glued joints and the effect on fatigue strength of various ageing treatments used for some of the test pieces are discussed, and the fatigue strength values for glued joints are compared with those for riveted joints.

RP181
AD-206-067
N-66132
Application of Structural Adhesives in Air Vehicles. D.L.GRIMES.
AGARD Rep. 181, 28 pp., 1958.
The use of adhesives as structural joint media, for both aircraft and missiles, is considered. A systematic and detailed discussion is presented of the advantages and disadvantages of adhesives.

RP182
AD-661-987
N-68555X
Some Instabilities Arising from the Interactions between Shock Waves and Boundary Layers. N.C.LAMBOURNE.
AGARD Rep. 182, 40 pp., 40 refs., 1958.
Information available concerning flow fluctuations and instabilities arising from shock induced separation in the flow over aerofoil surfaces is reviewed. The effect this pheomenon has on the oscillatory behaviour of aerofoils and control surfaces is examined briefly. A more detailed consideration concerns work done at the N.P.L. on the part played by shock-induced separation in control-surface instability.

RP183
AD-206-235
N-65086
Effect of Boundary Layer Thickness on Flutter of Control Surfaces: A Brief Survey of Relevant Reports. N.C.LAMBOURNE.
AGARD Rep. 183, 2 pp., 11 refs., 1958.
Reports containing information relating to an assessment of the effect of the boundary layer on control-surface flutter are listed. All the reports except one deal with aerodynamic hinge moments or pressure distributions for oscillating control surfaces. The exception contains measurements of flutter characteristics in addition to hinge-moments. With the exception of one report conditions are restricted to incompressible flow.

RP184
AD-661-939
N-61829X
An Outline of the Theoretical Basis of Ground Tests of Vibration. R.MAZET.
AGARD Rep. 184, (in French), 18 pp., 33 refs., 1958.
The structure considered, assumed to be linear, is defined on the basis of an "associated conservative structure" (AS) and the natural AS modes are taken as reference modes, the object of the ground test being to ascertain these modes and the overall characteristics associated with them, viz., natural frequencies, generalized masses, and generalized viscosities of the real structure. The response of the structures to harmonic excitation and to percussive or plucking excitation is examined. A theoretical justification of certain ground measurement methods suitable for use with small models is also presented.

RP185
AD-206-236
N-60362

A Review of the Development of Cermets. G.C.DEUTSCH, A.J.MEYER, Jr., G.M.AULT.
AGARD Rep. 185, 20 pp., 25 refs., 1958.
Cermet materials are defined, and the development of different varieties is discussed. The physical and mechanical properties of cermets are dealt with, with special reference to their poor impact strength and ductility; possible ways in which these two properties might be improved are also considered.

RP189
AD-661-940
N-64132

An Example of the Determination of the Principal Aerodynamic Coefficients from Flight Tests.
G. Le BLANC.
AGARD Rep. 189, (in French), 23 pp., 1958.
It is shown that the principal coefficients can be obtained from a few simple flight tests to enable performance and handling qualities to be assessed at the prototype stage of development. Only small movements of the aircraft and control surfaces are necessary so that the coefficients are functions of the Mach number only. Determination of coefficients of an aircraft with conventional controls is discussed as an example.

RP190
AD-218-805
N-61547

On the Extraction of Stability Derivatives from Full-Scale Flight Data. J.K.ZBROZEK.
AGARD Rep. 190, 20 pp., 7 refs., 1958.
From longitudinal response measurements only the lift-curve slope can be obtained; measurement of the basic derivatives is limited to zero frequency. In theory the basic lateral derivatives can be obtained from measured transient responses to control inputs. The control derivatives can also be obtained. It is concluded that, for recording aircraft responses accurately, the basic aircraft instruments now available are below the standard required for dynamic measurements of stability of present and future aircraft.

RP191
AD-211-872
N-62667

Application of Dynamic Testing Procedures to Stability and Control Flight Test Programs.
W.W.HUFF, Jr.
AGARD Rep. 191, 16 pp., 4 refs., 1958.
Transient response testing is discussed from the viewpoints of aiding in the rapid extension of the flight envelope of a new model aircraft, and introducing new test pilots to the subject of dynamic testing for stability and control characteristics. Specific attention is devoted to instrumentation and data-reduction procedures, and test procedures used in investigating stability margins in roll manoeuvres and high dynamic pressure flight conditions.

RP192
AD-218-281
N-61607

Flight Testing of Automatic Stabilisation and Control Systems in Manned Aircraft. H.W.TURNER.
AGARD Rep. 192, 23 pp., 1958.
Procedures which have been developed at A.A.E.A., Boscombe Down, England, for flight-testing such systems are summarized. Two types of system are discussed: auto-stabilization with limited control authority, and auto-pilot systems with considerable control authority. Test instrumentation for these two types is discussed, and methods used for evaluating the aircraft/automatic control system combination for a particular task are described.

RP193
AD-206-070
N-62666X

Control and Stabilization System Reliability. W.I.STIEGLITZ.
AGARD Rep. 193, 22 pp., 25 refs., 1958.
Discusses the design, ground testing and flight testing of control and stabilization systems. Reviews the need for power controls and stability augmentation systems, and discusses methods of testing and analysis used in evaluating reliability.

RP194
AD-218-219
N-69951

On the Structural Stability of a Certain Class of Linear Motions. S.LEHNIGK.
AGARD Rep. 194, 15 pp., 9 refs., 1958.
The problem is a mathematical one; its main theorem is given and proved. To show the application, two examples of flight mechanics are given. The first deals with the automatically controlled longitudinal motion of an aeroplane with variable centre-of-gravity location. The second considers the structural longitudinal stability of an aeroplane with regard to the stationary flight-path velocity.

RP195
AD-218-806
N-63833X

Application of Direct Engine Thrust Measurements in Supersonic and Hypersonic Flight Régimes.
H.R.DETTWYLER.
AGARD Rep. 195, 19 pp., 1958.
Design philosophy and actual flight experience of a direct thrust-measuring device (a thrust beam between airframe and engine fitted with strain gauges) applied to a supersonic test vehicle is described. The test vehicle is used for the development of ramjets. Characteristic outputs of the device are discussed in relation to true performance of air-breathing engines for the supersonic and hypersonic ranges.

RP196 **Flight Measurements of Ramjet and Rocket Thrust.** C.BOURGAREL, J.BESLON.
AD-661-941 AGARD Rep. 196, (in French), 83 pp., 1958.
N-64135 Some simplifying assumptions are made, such as (i) flow is one-dimensional, (ii) specific heats are constant both before and after combustion, (iii) flow is adiabatic before combustion, (iv) air-intake zones are shock-free and the flow is isentropic. Techniques based on the use of strain gauges, thermodynamics and aerodynamics are examined. Effects of mixture richness, altitude and Mach number are also considered. Graphs of results are given. An appendix gives an English version of the main points of the text.

RP197 **Measuring In-Flight Thrust of a Turbojet-Powered Aircraft.** W.J.COLEMAN, D.F.DeSANTO.
AD-202-583 AGARD Rep. 197, 38 pp., 40 refs., 1958.
N-64381 Describes the theoretical formulation of a practical method for measuring the in-flight net thrust of a turbo-jet aircraft. Discusses basic principles of thrust determination, current definitions and instrumentation techniques, including details of a traversing tailpipe rake.

RP199 **Simulator Study of G.C.A. Approach in the Second Flight Régime.** M.BISMUT, J.BOUTTES.
AD-661-942 AGARD Rep. 199, (in French), 10 pp., 1958.
CN-63616X Piloting difficulties encountered in the second régime with aircraft of low aspect ratio wings were analyzed on a simplified simulator, using an analogue computer and a fixed pilot's cabin. In an attempt to improve the behaviour of the aircraft, the speed was stabilized by means of automatic control applied to the jet thrust.

RP200 **All-Weather Testing in the United States Air Force.** L.G.GAMBLE.
AD-206-069 AGARD Rep. 200, 8 pp., 1958.
N-66136 The procedures adopted for the all-weather testing of U.S.A.F. aircraft, known as Phase V testing, are described. The tests are divided into (i) extreme temperature testing in which tests are carried out at various temperatures ranging from −65 to 165°F, and (ii) the weather flight phase in which the aircraft is tested in the worst weather conditions that can be found, and in which hooded and night-flying are included. Emphasis is given to icing tests.

RP202 **Some Results of Fight Tests with the Tu-104.** G.BOCK.
AD-218-807 AGARD Rep. 202, 7 pp., 3 refs., 1958.
N-73185 A summary of some of the facts reported in the Soviet periodical "Civil Aviation". Curves show the variation of angle of attack with lift coefficient for various values of flight Mach number. The wing profile is designed for high critical Mach numbers, but this results in a tendency to buffeting at cruising speed. A curve shows the lift coefficients at which this occurs for various Mach numbers. Stability, control, rate of climb on one engine, and rate of climb during landing with retracted landing gear are discussed. The author considers that the Tu-104 could take off safely with a gross weight of 72.5 tons, even if one engine cut out after take off.

RP203 **Ozone as a Hazard in High Altitude Flying.** E.W.C.WILKINS.
AD-211-562 AGARD Rep. 203, 22 pp., 29 refs., 1958.
N-67462 In a zone extending from 50,000 ft to 150,000 ft above the Earth's surface the ozone content is considered to be a biological hazard, to be taken into account in the design of cabins using outside air for pressurization. High ozone concentration can also affect the functioning of some aircraft components. Possible means of circumventing the hazard are discussed.

RP205 **High Temperature Testing of Aircraft Structures.** R.R.HELDENFELS.
AD-227-398 AGARD Rep. 205, 33 pp., 32 refs., 1958.
N-64167 Some of the equipment and techniques used at the NASA Langley Aeronautical Laboratory are described. These include quartz-tube lamps and arc-image furnaces for heating at rates of 100 Btu/sq. ft-sec. and 1,000 Btu/sq. ft-sec. respectively. Three aerodynamic heating facilities are: a Mach 3 blowdown tunnel, a ceramic-heated air jet and an electric-arc air jet. These cover a stagnation temperature range up to 10,000°R. Their capabilities are reviewed in relation to expected flight characteristics of future vehicles. Some research products and results are presented.

RP206 **General Introduction to Thermal Structures.** J.TAYLOR.
AD-661-955 AGARD Rep. 206, 15 pp., 13 refs., 1958.
N-77026 Basic aerodynamics and material data are reviewed, also the basic structural theory which has been developed. Their application to the design of the general form of any particular structure is discussed. The concept of combining strains due to both loads and temperature is particularly discussed, and its effect on design requirements emphasized.

RP207 **The Influence of Aerodynamic Heating on the Structural Design of Aircraft.** M.W.RUBESIN.
AD-233-119 AGARD Rep. 207, 22 pp., 20 refs., 1958.
N63-83568 Expressions are given for determining the heat transfer to several aircraft shapes at hypersonic speeds. These are used to examine the basis for selecting a structure to withstand aerodynamic heating. Structures considered are those which can accept the heating by re-radiation, absorption through temperature rise of a mass, or absorption by phase change of a structure. Examples illustrate these possibilities with reference to recovery of a data capsule from a satellite which may have lifting or non-lifting surfaces.

RP208 **Some Effects of Internal Heat Sources on the Design of Flight Structures.** G.E.A.TROMANN, R.B.ERB.
AD-237-621 AGARD Rep. 208, 62 pp., 7 refs., 1958.
N-83560 The magnitude and accuracy of the heat sources and their effects on the structure are discussed. An assessment is given of the engine-bay problem, its heating, structural effects and design. In appendices the analytical treatments of steady and transient state temperature distributions are given, also an analysis of the thermal stresses in a typical jet engine-bay structure.

RP209 **Heat Conduction in Solids at Hypersonic Speeds.** L.BROGLIO.
AD-227-399 AGARD Rep. 209, 11 pp., 7 refs., 1958.
N-68137 Pt. 1 is an extension of a general approach to the heat conduction problems, previously reported (SIARgraph No. 4 by L.Broglio), to a body whose thermal properties are dependent on temperature. Pt. 2 applies this to problems in hypersonic flight. Pt. 3 gives a numerical application of Pts. 1 and 2 to a hollow hemisphere at hypersonic speed.

RP210 **Cooling of Structures in High-Speed Flight.** C.B.NEEL.
AD-233-120 AGARD Rep. 210, 21 pp., 15 refs., 1958.
N-64834 Discusses ways of cooling critical areas of structures, with emphasis on radiation, heat sink, and conduction cooling. The strong effect of conduction under both steady-state and transient conditions is shown. The electrical heat-flow analogue used at Ames Research Center is described. It gives a simplified method, useful in computing wing leading edge temperature, including the effects of radiation, heat capacity and heat conduction.

RP211 **Heat Transfer by Radiation.** H. de L'ESTOILE, L.ROSENTHAL.
AD-233-117 AGARD Rep. 211, (in French), 77 pp., 25 refs., 1958.
N63-21549 The first part discusses the radiation flux coming from the shock layer of a re-entering missile cone and compares it with the convection flux at the stagnation point and heat radiated from the walls, for three different cases in which the ogive shape varies. Numerical results are given. Then the method used at Etablissement Aéronautique de Toulouse for measuring emission factors for metals is described. Results are given for 18/8 steel, multimet and two titanium alloys.

RP212 **The Thermal Resistance of Joints.** J.-J.BERNARD.
AD-221-409 AGARD Rep. 212, (in French), 16 pp., 6 refs., 1958.
CN-74076X Describes apparatus devised at O.N.E.R.A. to study the contact heat resistance between conductors or conductors and insulators and the effect of pressure of joining on this. Because of the thinness of the materials measurements have to be made externally to the material; suitable techniques are described and results reported.

RP213 **A Design Philosophy for Repeated Thermal Loading.** E.W.PARKES.
AD-237-622 AGARD Rep. 213, 24 pp., 1958.
N-83564 The elastic and inelastic behaviour of simple structures subjected to cyclic thermal loading is discussed. The results are considered in relation to possible definitions of structural loading.

RP214 **Theory of Structural Design.** W.S.HEMP.
AD-233-121 AGARD Rep. 214, 38 pp., 7 refs., 1958.
N-66442 Minimum weight design of a structure with balanced external loads and free from failure or undue deformation is the aim of aeronautical structural design. Classical results (based on the work of Maxwell, Mitchell and Cox) and their application are reviewed, mathematical theory developed for the two-dimensional case and some special solutions derived.

RP215 **Design Processes for High-Speed Flight.** B.O.HEATH.
AD-661-944 AGARD Rep. 215, 25 pp., 1958.
N-77027 Problems of aerodynamic heating are examined with reference to conclusions drawn from a review of earlier supersonic design problems. Current experience is discussed of temperature as a design parameter in relation to flight factors. New materials and methods of presenting their high temperature properties are discussed.

RP216
AD-221-407
N-74058

Sandwich Structure for High Temperature Vehicles. H.R.ASHLEY
AGARD Rep. 216, 32 pp., 6 refs., 1958.
Reviews sandwich structures from the viewpoints of theoretical efficiency, practical design, and manufacture, for the temperature range 150 to 1000 deg.C. Physical properties of alloys R.R.58, F.V.520 stainless steel, 6A1 4 Va titanium alloy, Nimonic 90 and 0.5 titanium molybdenum are summarized, and with core data, are incorporated into graphs of structural efficiency in sandwich and honeycomb form at high temperature. Thermal stress factors are given. The practical design and production aspects are also considered, including types of sandwich structure which may be used with insulation and cooling systems.

RP217
AD-254-481
N-95155

Fabrication and Application of Light Alloy Honeycomb Sandwich. C.THOMAS.
AGARD Rep. 217, (in French), 20 pp., 1958.
After a brief survey of the methods of fabrication some important aspects of the use of sandwich material are examined. These applications involve: (i) safety in service and means of effecting this; (ii) fatigue problems and the 'fail-safe' concept; (iii) sampling of structures to include the behaviour of the core in loading; (iv) future prospects for sandwich structures in relation to heat problems.

RP218
AD-237-623
N-83559

Missile Structures and Materials. E.Z.GRAY.
AGARD Rep. 218, 22 pp., 8 refs., 1958.
The state-of-the-art is reviewed and recommendations made for future research into material selection, design criteria, analysis, testing and reliability. Better definition of environment is emphasized and multi-environmental analyses and tests required for optimum design.

RP219
AD-227-400
N-64067

Interpretation and Applicability of Results of Wind-Tunnel Flutter and Control Surface Buzz Investigations. A.G.RAINEY.
AGARD Rep. 219, 13 pp., 1958.
Considers the aspects of using wind-tunnels, model simulation, suitability of tunnel, and application to flight. Types of flutter for this form of study, degree of simulation required, the value of small-scale aeroelastic component model, and the application of results to determine critical flutter ranges or margins of safety are described.

RP220
AD-228-639
N-77028

Models and Measuring Apparatus for the Wind-Tunnel Determination of Non-Stationary Aerodynamic Forces. R.DAT.
AGARD Rep. 220, (in French), 20 pp., 1958.
Aspects of mounting models and methods of excitation are discussed with reference to the technique used at O.N.E.R.A. whereby natural modes are chosen as degrees of freedom. This enables the same equations to be used as those for calculating flutter and to introduce measured data in the same way as in ground vibration testing of aircraft.

RP221
AD-236-018
N-66561

The Determination of the Flutter Speed of a T-Tail Unit by Calculations, Model Tests and Flight Flutter Tests. J.C.A.BALDOCK.
AGARD Rep. 221. 25 pp., 1958.
Tests on the Handley Page Victor are described. They included investigations of low speed wind flutter models and calculations were made from flight tests of the aircraft. Test flight results agreed with estimated values despite differences in the ground resonance modes and sub-critical response. The value of low speed tunnel test and safety aspects of flutter are discussed generally.

RP222
AD-233-122
N-66570

Flutter Investigations in High-Speed Wind Tunnels. C.SCRUTON, E.P.L.WINDSOR.
AGARD Rep. 222, 37 pp., 11 refs., 1958.
Pt.1 considers requirements of simulated flight by wind tunnel flutter models, especially for transonic and supersonic flight. Difficulties and aspects of model design and construction are discussed. Pt.2 includes the practical application of similarity conditions for studying transonic flutter of a specific tail unit. The subcritical response method of test is adequate for revealing reliable predictions of flutter.

RP223
AD-248-342
N-70708X

A Method for the Prediction of the Onset of Buffeting and Other Separation Effects from Wind Tunnel Tests on Rigid Models. H.H.PEARCEY.
AGARD Rep. 223, 76 pp., 27 refs., 1958.
The method is based on observation of the divergence in the variation of mean static pressure at the wing trailing edge at the critical stage in boundary layer separation. The significance of this variation and its connection with the effects of separation on the mean and steady loads is discussed for different types of separation. Predictions for low-speed separations and shock-induced ones are discussed, together with related divergences in flow characteristics. Special considerations apply to swept wings.

RP224
AD-661-990
N-65068

Stability-Derivative Determination from Flight Data. C.H.WOLOWICZ, E.C.HOLLEMAN.
AGARD Rep. 224, 45 pp., 14 refs., 1958.
Discusses such factors as, test techniques, determination of mass characteristics, instrumentation. Methods of analysis from flight data are presented. Simple equations using period and damping are

generally adequate for longitudinal stability and the graphical time-vector method for lateral derivative analysis. It is believed that primary stability and control derivatives are probably accurate to within 10 to 25%.

RP 225
AD-233-118

Improvement of the Approach and Landing Characteristics of Modern Fighters. J.CZINCZENHEIM, P.JAILLARD.
AGARD Rep. 225, (in French), 24 pp., 10 refs., 1958. (Also translated into the English language in AGARD Rep. 225-T).

RP225/T
AD-236-017
N63-81119

In connection with the necessary substitution of grassed landing areas instead of expensive concrete ones, the author examines the causes of deterioration in performance at low speed of high performance aircraft and some of the possibilities of improving performance.

RP226
AD-232-995
N-67729

Emergency Stopping of Aircraft Which Over-Run Airfield Runways. J.THOMLINSON.
AGARD Rep. 226, 45 pp., 9 refs., 1958.
Discusses, in a general way, such methods as the soft-ground over-run area, mechanical schemes with or without fitted arrester hooks, catching devices, such as nets, barriers, and their energy-absorbing systems. Some of the more important points in the mechanics of these systems are mentioned.

RP227
AD-227-468
N-67283

United States Air Force Development of Aircraft Arresting Gear. V.V.VARY.
AGARD Rep. 227, 18 pp., 1958.
Explains briefly the difference in overall requirements for arresting carrier-based and land-based aircraft. The U.S. Air Force Arresting Gear Programme is described and various devices for engagement and successful stopping discussed. Emergency stopping only is the aim at present.

RP228
AD-227-469
N-76334

Some Tests on Befab 'Safeland' Safety Barriers. G.SALIS.
AGARD Rep. 228, 23 pp., 1958.
The 'safeland' barrier (net type) was tested at the Italian Air Force Flight Test Centre, using DH.100, Fiat G.80, F.86E and F.84F jet aircraft on two types of barrier, the 4-3F and 6-3F. Arresting from take-off or landing was effective with almost constant deceleration of about 1g with only slight damage to the aircraft. The barriers were simple to set up and maintain; no preliminary ground preparation is necessary.

RP229
AD-661-943
N-77029

Study of the Use of Parachute-Brakes in Landing. J.GREMONT.
AGARD Rep. 229, 18 pp., 1958.
The problem of braking high-speed aircraft is discussed generally. The method of using a parachute-brake is then reviewed with reference to several sources of experience. Three aspects are reported: experimental study; development of theory; and discussion of different methods of employment.

RP230
AD-227-470
N-78778X

An Evaluation of the Factors Which Influence the Selection of Landing Approach Speeds.
F.J.DRINKWATER, 3rd, G.E.COOPER, M.D.WHITE.
AGARD Rep. 230, 8 pp., 1958.
An NACA study, intended to increase understanding of factors influencing pilots' choice of approach speeds, by an evaluation of landing techniques of a wide variety of aircraft, using the constant speed. constant angle, type of approach. It is suggested that reductions in minimum approach speed are possible if pilot control techniques are adapted to aircraft characteristics. The study is continuing.

RP231
AD-661-954
N-64797

Ground Deceleration and Stopping of Large Aircraft. J.A.ZALOVCIK.
AGARD Rep. 231, 32 pp., 7 refs., 1958.
Sources of deceleration such as wheel braking, aircraft drag, aerodynamic brakes, parachutes, reversed thrust, are considered. The effect of tyre friction, wheel load and brake capacity on wheel-braking, and the effect on stopping distance of the use of elevators, flaps, spoilers, and nose-up attitudes are considered in some details. A mathematical analysis of some relevant factors is given in an Appendix.

RP232
AD-227-501
N-76335

The Performance Testing of Military Aircraft-Carrier Aircraft. R.P.DICKINSON.
AGARD Rep. 232, 7 pp., 1958.
The operation of carrier-borne aircraft is described briefly and it is shown how this differs from that of other military aircraft for performance assessment. The determination of approach speeds and wind limitations for catapult take-off are discussed and the instrumentation required for trials described.

RP233
AD-233-123
N-61828

Development of the Spark-Heated, Hypervelocity, Blowdown Tunnel-Hotshot. R.W.PERRY, W.N.MacDERMOTT.
AGARD Rep. 233, 72 pp., 27 refs., 1958.
High stagnation temperatures are attained by heating a confined mass of air by electrical discharge from a condenser bank. The air is expanded in a Laval nozzle. The original 16-in. tunnel is in routine operation with instrumentation for pressure, heat transfer and force tests. Components of

missiles have been tested at Mach 11 to 20, at equivalent altitudes of 140,000 ft and 200,000 ft. A test period of 50 milliseconds is attained. A brief account is given of advanced developments based on the electric-discharge method of heating gases.

RP234 **Methods of Flight Testing in the Soviet Union.** H. SCHUMANN.
AD-254-482 AGARD Rep. 234, 10 pp., 1959.
N-95163 This review is based on data published in the Soviet Union. Manoeuvrability and handling qualities are mainly discussed. A table is given which summarizes the flight tests necessary to provide information necessary to determine characteristics of a new design of aircraft.

RP235 **Advanced Cockpit Instrumentation.** J.ANAST.
AD-236-019 AGARD Rep. 235., 21 pp., 1959.
N-82226 A description of post-World War 2 work, undertaken by the U.S. Government and Lear Inc., to develop an integrated system to meet demands of increased speed, increased mission complexity and all-weather operation.

RP236 **The USAF Vertical Instrument Program.** E.L.BROWN.
AD-237-624 AGARD Rep. 236, 31 pp., 1959.
N-83588 This programme was initiated to develop a control panel with an integrated, interrelated display presentation, instead of individual outputs from separate instruments.

RP238 **Consideration of Human Factors in Helicopter Design.** W.G.MATHENY.
AD-243-286 AGARD Rep. 238, 13 pp., 1 ref., 1959.
N-69705X Discusses mainly factors affecting operation and control. Two aspects are considered; one dealing with vehicle stability, the other with the display of instrument readings to the pilot. The second part is being investigated in the Army Navy Instrument Program.

RP239 **Medical and Human Engineering Aspects of Flight in Ryan VTOL and STOL Aircraft.** P.F.GIRARD.
AD-237-625 AGARD Rep. 239, 22 pp., 5 refs., 1959.
N-83587 After a brief historical note on these Ryan aircraft, the major aspects of the principal medical and human factors in hovering and transitional flight are discussed, especially from the human engineering aspect. The importance of these factors in early design stages for satisfactory handling qualities is emphasized.

RP240 **Physiological Instrumentation of Pilots for Test and Operational Flights in Navy High Performance Jet**
AD-248-343 **Aircraft: Phase 1 – Preliminary Investigations.** F.H.AUSTIN.
N-90870 AGARD Rep. 240, 3 pp., 1959.
Describes briefly projects of the Naval Air Test Center intended to provide criteria for developing new equipment so that the pilot can be fully instrumented for in-flight monitoring.

RP241 **Measurements on the Relation Between Magnitude and Duration and on the Rate of Application of**
AD-243-005 **the Control Forces Achieved by Pilots in Simulated Manoeuvres.** T.van OOSTEROM.
N-87154 AGARD Rep. 241, 28 pp., 7 refs., 1959.
Two series of measurements made at the N.L.L. to obtain data on desirable control characteristics of aircraft and to obtain basic information for establishing structural strength requirements. All tests were performed on test-rigs provided with spring-loaded pedal controls, control wheel, and stick.

RP242 **The Problem of Escape from Satellite Vehicles.** C.V.CARTER, W.W.HUFF, Jr.
AD-243-006 AGARD Rep. 242, 15 pp., 7 refs., 1959.
N-69729 Specific problem areas considered are: escape prior to take-off, during high-pressure boost, during exit from the atmosphere and entry into the atmosphere, and during orbit. Designs for systems are presented, feasible for lifting or non-lifting configurations. Compatibility of the system with the parent vehicle design and operation is essential; basic requirements of environment, stability and control, and means of initiating descent from orbit are also required.

RP243 **X-15 Research Aircraft Emergency Escape System.** J.F.HEGENWALD, Jr., J.F.MADDEN,
AD-243-007 P.R.PENROD.
N-87145 AGARD Rep. 243, 36 pp., 1959.
Requirements, component descriptions, performance characteristics, diagrams and photographs are given of a system compatible with the configuration and mission profiles of the aircraft.

RP244 **Some Human Engineering Aspects of Several Unconventional Aircraft.** V.K.PUTNAM.
AD-243-008 AGARD Rep. 244, 12 pp., 5 refs., 1959.
N-87158 Presentation of human engineering characteristics, such as control, noise, downwash effects of several types of VTOL aircraft.

RP245 **On Models for the Probability of Fatigue Failure of a Structure.** E.PARZEN.
AD-243-009 AGARD Rep. 245, 19 pp., 21 refs., 1959.
N-87146 Pt.1 presents a review of probabilistic considerations involved in evaluating the strength of materials and constructing S-N curves. In Pt.2 a probabilistic model is advanced for the life before fatigue failure of a structure.

RP246 **On the Nonlinear Approach to the Aeroelastic Stability Theory.** H.G.KUSSNER.
AD-243-010 AGARD Rep. 246, 15 pp., 6 refs., 1959.
N-87156 The causes of structural non-linearities in aircraft are discussed and a nonlinear force-deflection diagram given by complex Fourier analysis. An approximate method for solving nonlinear flutter equations is developed from systems of homogeneous linear equations. A special case of the method – the harmonic balance – is compared with more accurate solutions.

RP247 **Considerations on the Information Known About the Strength of Glass Fibre.** G.DIXMIER.
AD-243-011 AGARD Rep. 247, (in French), 11 pp., 16 refs., 1959.
N-87239 It has recently become possible to make mechanical components based on glass fibre of a strength and rigidity equal to those of components made from steel and light alloy, when compared on a weight-for-weight basis. This review of literature and reported investigations relates to the use of pure silica and glass filaments.

RP248 **Measurement of Aircraft Moments of Inertia.** N.L.WENER.
AD-243-012 AGARD Rep. 248, 24 pp., 4 refs., 1959.
N-87159 Describes experiments for deducing stability derivatives from flight test data, using measurements of inertia. The manpower required for this is examined and further tests recommended.

RP249 **Airspace Requirements for Flight Testing.** E.F.GODFREY.
AD-243-013 AGARD Rep.249, 7 pp., 1959.
N-81584 The need for airspace for supersonic testing is discussed and the organization and control facilities of two such zones in the U.S.A. are described. Proposals are made for a new zone. It is considered that the establishment of such zones in U.S.A. has greatly reduced the risk of collisions.

RP250 **Experience of Supersonic Flying Over Land in the United Kingdom.** T.H.KERR.
AD-243-014 AGARD Rep. 250, 16 pp., 4 refs., 1959.
N-78472X Supersonic flights over land must be authorized by Flying Administration, Ministry of Supply. Low-level flights and 180 flights at above 35,000 ft have been made by the Fairey Delta 2 aircraft from R.A.E., Bedford. Risk of damage increases with decreasing altitude; at 10,000 ft, and below, cracking of glass and plaster may occur.

RP251 **Some Aspects of Shock-Wave Generation By Supersonic Airplanes.** G.H.JORDAN.
AD-248-344 AGARD Rep. 251, 19 pp., 7 refs., 1959.
N-90853 Discusses some experimental in-flight pressure surveys of the near field of two test aircraft with reference to distance, configuration and Mach number. Far field pressures are discussed, variables affecting the flow field strength, and damage caused to ground structures. The effect of the flow field on other aircraft in the vicinity of the supersonic aircraft is also considered.

RP252 **Pilot's Rôle in Space Flight.** C.R.WESTBROOK.
AD-243-015 AGARD Rep. 252, 14 pp., 1959.
N64-84798 Capabilities and limitations of the human as an actuator, sensor, computer, and as part of a control system are discussed in relation to flight control in a space mission. The phases of a soft lunar landing are reviewed to see what degree of automation or human intervention is necessary. The presence of man as a flight control element is considered to be justified.

RP253 **A Background of the Problems of Boundary Layer Research.** H.SCHLICHTING.
AD-262-483 AGARD Rep. 253, 32 pp., 57 refs., 1960.
N-100-650 A progress review, including consideration of stability and transition, turbulent boundary layers, three-dimensional boundary layers, boundary layer control, and boundary layers in hypersonic flows. Unsolved boundary layer problems for incompressible flow are reviewed.

RP254 **Review of the Effect of Distributed Surface Roughness on Boundary-Layer Transition.** A.L.BRASLOW.
AD-262-487 AGARD Rep. 254, 13 pp., 20 refs., 1960.
N62-17260 This review includes a correlation of 3-dimensional roughness effects at subsonic and supersonic speeds, discusses the influence of heat, pressure on stability, and of boundary layer control on the sensitivity of laminar flow to distributed roughness. Considers the transition-triggering mechanism and the use of Reynolds number to predict roughness height to cause premature transition. Conditions promoting transition are discussed.

RP255
AD-262-485
N-91282X

Effect of Roughness on Transition in Supersonic Flow. E.R. van DRIEST, C.B.BLUMER.
AGARD Rep. 255, 19 pp., 4 refs., 1960.
Effects of roughness elements (spheres) on the transition on a 10 deg. cone were studied in the 12in. supersonic tunnel of the Jet Propulsion Laboratory of California Institute of Technology, at Mach 2.71. An expression is derived for the Mach number influence on effective tripping, in terms of Reynolds number.

RP256
AD-262-482
N-100-651

Effects of Unit Reynolds Number, Nose Bluntness, and Roughness on Boundary Layer Transition. J.L.POTTER, J.D.WHITFIELD.
AGARD Rep. 256, 68 pp., 37 refs., 1960.
Factors affecting transition and the effects of unit Reynolds number and very small degrees of leading edge bluntness are discussed in detail. A means of estimating the effect of roughness on boundary layer transition is suggested.

RP257
AD-262-486
N-83695

The Effect on Profile Drag of Randomly Distributed Low-Intensity Roughness. W.S.COLEMAN.
AGARD Rep. 257, 19 pp., 16 refs., 1960.
The effect is discussed in terms of the turbulent spots generated by excrescences. Functions defining the intermittency factor for turbulence at any cross-section of the boundary layer are obtained from the kinematical properties of spots and also from Emmon's transition theory. The influence of roughness on wing profile drag is then considered and the critical spacing of excrescences deduced.

RP258
AD-262-623
N64-84798

Experimental Investigation on Boundary Layer Suction by Series of Slits and Holes. W.WUEST.
AGARD Rep. 258, 24 pp., 7 refs., 1960.
The development of boundary layers with pressure gradient on filter paper, slits, holes, perforations has been studied in the A.V.A. low-turbulence wind-tunnel. The behaviour of wall-stress, dissipation and boundary-layer parameters is deduced.

RP259
AD-263-705
N-86311

Calculation of the Turbulent Boundary Layer with Continuously Distributed Suction. W.PECHAU.
AGARD Rep. 259, 14 pp., 16 refs., 1960. (Formerly Report No.60/6).
The method of calculation, based on an approximate solution of the momentum- and energy-integral equations of the boundary-layer, yields the momentum thickness and a shape factor which is a criterion for location of the separation point. Solutions in closed form are given for a flat plate at zero incidence with homogeneous suction and for boundary layer flows with similar velocity profiles. Numerical examples demonstrate the most economical application of suction.

RP260
AD-262-624
N-85352

Some Aspects of Free Shear-Layer Instability and Sound Emission. E.MOLLO-CHRISTENSEN.
AGARD Rep. 260, 9 pp., 8 refs., 1960.
Discusses the relative importance of instability fluctuations and turbulence as noise sources in a jet. Detection of sound emission from instability waves is described. Some problems associated with supersonic disturbances in shear layers are also discussed.

RP261
AD-652-920
N62-15908

Characteristics of Separated Cylindrical Boundary Layers. O.WEINMANN.
AGARD Rep. 261, 2 pp., 3 refs., 1960.
Discusses the frequency laws for velocity fluctuations in the jet transition region. An analysis of the natural frequency shows that frequency of the maximum amplitude coincides with the mean value of the natural frequency. The group velocity is calculated, the frequency of the vortex formation being stabilized by sound energy, and it is shown that the group velocity has a maximum in the region of the natural frequency, i.e. a maximum energy transport for this frequency.

RP262
AD-266-057
N-103-364

Recent Developments in the Field of Low Drag Boundary Layer Suction Research. W.PFENNINGER.
AGARD Rep. 262, 24 pp., 22 refs., 1960.
Describes experiments to determine the behaviour of laminar suction wings at a reduced turbulence level corresponding to flight conditions. Results confirm that high Re numbers can be achieved with full-chord laminar flow if external disturbances are minimized. Practical methods of accomplishing this are discussed.

RP263
AD-279-803
N62-14016

Experimental Research on the Mechanism of Transition. E.MATTIOLI, G.ZITO.
AGARD Rep. 263, 35 pp., 13 refs., 1960.
Experiments on transition in a smooth straight pipe. The occurrence of so-called turbulence spots preceded and followed by laminar flow is described and their characteristics discussed. Methods of assisting or preventing transition are described. The sinusoidal speed waves caused by screens and the acoustic signals produced by a hot-wire are also dealt with. An Appendix describes an electronic instrument for measuring the intermittence factor and a proposed method of control for obtaining standard measurements.

RP264
AD-265-908
N-103-360

Flow Stability in the Presence of Finite Initial Disturbances. P.BRADSHAW, J.T.STUART, J.WATSON.
AGARD Rep. 264, 37 pp., 29 refs., 1960.
Theoretical and experimental studies of finite amplitude disturbances in viscous flow when they are (i) oscillatory and grow with streamwise distance between parallel planes until equilibrium is reached, or (ii) depart from an unstable equilibrium with streamwise distance. Results of experiments on disturbances in a straight pipe and the theoretical associated concepts are also described. 'Breaking patterns' are shown to be horseshoe vortices.

RP265
AD-266-058
N-103-362

On the Stability of Couette Flow. F.SCHULTZ-GRUNOW.
AGARD Rep. 265, 7 pp., 1960.
Couette flow between concentric cylinders in relative rotation is regarded as a critical experiment in laminar boundary layer stability. It is shown that an exact solution can be obtained for the stability problem. The solution is developed.

RP266
AD-265-909
N65-84243

Three-Dimensional Laminar Instability. W.O.CRIMINALE, Jr.
AGARD Rep.266, 65 pp., 21 refs., 1960.
By linear theory, a localized disturbance in a boundary layer with a Blasius velocity profile is examined. The initial disturbance is synthesized from all possible waves whose propagation velocities and amplification rates follow from classical two-dimensional theory by Squire's generalization. Growth and diffraction of the spot is described and its ultimate fate predicted, showing the variation of maximum growth rate as a function of time. Approach to the Tollmien-Schlichting wave train is demonstrated.

RP267
AD-294-735
N64-82671

Stagnation Point Fluctuations and Boundary Layer Stability for Bodies of Revolution with Hemispherical Noses. A.M.KUETHE, W.W.WILLMARTH, G.H.CROCKER.
AGARD Rep. 267, 35 pp., 17 refs., 1960.
Measurements made in the nose region of the bodies indicate the presence of relatively high-amplitude low-frequency fluctuations in the vicinity of the nose. Correlation measurements indicate that the fluctuations are coupled with random motion of the stagnation point. Measurements were also made of the response of the boundary layer on the nose to small and large disturbances.

RP268
AD-266-056
N-84050

Stability of the Compressible Laminar Boundary Layer. L.LEES, E.RESHOTKO.
AGARD Rep. 268, 25 pp., 7 refs., 1960.
Previous theoretical treatments have ignored or only partially accounted for the effect of temperature fluctuations on the 'viscous' disturbance. It is shown that the fluctuations have a strong influence on both inviscid and viscous disturbances above Mach 2.0. The analysis also includes the effects on viscosity and thermal conductivity and introduces the viscous dissipation term dropped in earlier theoretical treatments.

RP269
AD-262-625
N-81889

Boundary Layer Development in Supersonic Shear Flow. R.H.ROGERS.
AGARD Rep. 269, 32 pp., 7 refs., 1960.
Boundary layer development on a blunt cone was investigated; experimental results are given for a 15 deg. angle and tip radius varying from less than 1/1000th in. to 0.5 in. at M 3.12 and 3.81. The location of the transition region is discussed and the factors determining its movement. Preliminary theoretical results confirm these results qualitatively but the assumptions made are not justified.

RP270
AD-279-829
N-108-667

A Method of Solving the Orr-Sommerfeld Equation Governing the Onset of the Transition in a Boundary Layer. A. von BARANOFF.
AGARD Rep. 270, (in French), 20 pp., 6 refs., 1960.
Theoretical methods serving as a basis for discussion of the problem of transition includes one which consists of calculating the effect of the non-linear terms in the Navier equation on the behaviour of disturbances of the Tollmien-Schlichting type. This report gives a method of calculation based on an integral equation specially adapted for this application.

RP271
AD-279-820
N-108-669

Localization of Transition by Perturbation of the Boundary Layer in Supersonic Flow. R.MICHEL.
AGARD Rep. 271, (in French), 27 pp., 3 refs., 1960.
Some preliminary results of a routine experimental study to determine the main factors in transition phenomena. An experimental technique developed consists in artificially disturbing the boundary layer and assessing the resulting deformation by strioscopic examination of the flow. The method has been applied to bodies of revolution, using different types of disturbances; annular steps and steps of limited height. The length of separated flow is a characteristic parameter, from which position and extent of the transition region can be determined. Effect of pressure gradient and body shape on transition has been studied by this technique.

RP272
AD-265-899
N-85344

The Existence of Three-Dimensional Perturbations in the Reattachment of a Two-Dimensional Supersonic Boundary Layer After Separation. J.J.GINOUX.
AGARD Rep. 272, 18 pp., 7 refs., 1960.
The reattachment region was investigated at M 2.16, using two-dimensional compression corners and step models. Interaction between shock and boundary layer was also considered. Strong, regular, repeatable spanwise perturbations were observed in the boundary layer which could not be explained by irregularities in upstream flow or in the models. In all cases, street-like perturbations existed up to the transition point. The effects of step-height and boundary-layer thickness on the wave length of the flow perturbations were investigated.

RP273
AD-263-706
N-81888X

Boundary Layers in Three Dimensions. J.C.COOKE, M.G.HALL.
AGARD Rep. 273, 52 pp., 48 refs., 1960.
A discussion of recent advances:– general considerations; momentum integral equations; streamline and geodesic coordinates; cross-flows; exact solutions of Yohner and Hansen, and of Sedney; momentum integral methods using streamline coordinates; work of Timmon and Hall, Pohlhausen, Thwaites; methods of Zaat and Cooke for laminar boundary layers with small cross-flow; methods for turbulent boundary layers.

RP274
AD-266-059
N-103-361

Approximate Methods of Solving the Laminary Boundary Layer Equations on Wings with Regions of Crossflow. A.W.LINDFIELD.
AGARD Rep. 274, 26 pp., 18 refs., 1960.
A comprehensive method is suggested for obtaining any of the equations used in the solution of boundary layer flow, without need for any further assumptions regarding the magnitudes of terms other than the initial boundary layer assumptions. The method is applied to two-dimensional boundary layers to illustrate the underlying principle involved in solving three-dimensional boundary layers. Brief mention is made of the application of these methods to compressible boundary layers on swept infinite wings.

RP275
AD-294-173
N63-11838

Interaction Between Separation at the Leading Edge and at the Trailing Edge in Three Dimensions. E.A.EICHELBRENNER.
AGARD Rep. 275, (in French), 10 pp., 7 refs., 1960.
Describes work at O.N.E.R.A. on the nature of flow formations arising on and around simple three-dimensional obstacles such as ring wings. The occurrence of breakaway and reattachment are related to the degree of angle of attack. The problem of preventing stall at high incidence can be solved by a suitable cambering of the three dimensional leading-edge. The camber can be determined by rheological analogy. For one specific case, wind tunnel tests confirmed the effectiveness of the method.

RP276
AD-263-707
N65-88618

On Surface Pressure Fluctuations in Turbulent Boundary Layers. G.M.LILLEY, T.H.HODGSON.
AGARD Rep. 276, 46 pp., 24 refs., 1960.
Existing work is reviewed especially with reference to wall turbulence. An approximate theory is given for the pressure fluctuations on the wall under both a turbulent boundary layer and a wall jet. The conclusions are confirmed experimentally. Results from the wall jet suggest that the intensity of pressure fluctuations in the regions of adverse pressure gradient, approaching and beyond separation, will be higher than in regions of zero pressure gradient.

RP277
AD-279-836
N-91811

Experimental Studies on the Interaction of Strong Sound Fields with Free Convection Boundary Layers. E.E.SOEHNGEN, J.P.HOLMAN.
AGARD Rep. 277, 54 pp., 122 refs., 1960.
A summary of data obtained from three independent studies on unsteady-state heat-transfer phenomena. Types of environment studied were; (i) standing sound wave fields; (ii) constant pressure or diffuse sound fields; (iii) travelling sound wave fields.

RP278
AD-294-784
N63-80154

Turbulence and Perturbations in the Boundary Layer of a Flat Plate. A.FAVRE, J.GAVIGLIO.
AGARD Rep. 278, (in French) 54 pp., 21 refs., 1960.
Perturbations affect width distribution of mean velocities, thickness, friction forces etc. These perturbations have been observed and studied. Time and breadth function equations have been set up using valid classical simplifications. Two momentum balances are presented and friction determined from them. An apparent over-estimation may be due to lateral escape of momentum. More precise measurements are obtained by hot-wire anemometers.

RP279
AD-279-835
N-85305

Effects of Heat Transfer on Laminar Boundary Layer Development under Pressure Gradients in Compressible Flow. R.J.MONAGHAN.
AGARD Rep. 279, 44 pp., 10 refs., 1960.
An approximate analysis shows that momentum thickness, skin friction and heat transfer of the compressible laminar boundary layer developing under pressure gradients may be given by formulae

which are formally the same as those obtained under zero pressure gradient conditions if an appropriate length transformation is applied to the x-co-ordinate. The formulae for skin friction and heat transfer include factors which are functions of a pressure gradient parameter.

RP280
AD-262-626
N-100-743

Boundary Layer Separation in the Presence of Heat Transfer. G.E.GADD.
AGARD Rep. 280, 13 pp., 11 refs., 1960.
The effects of heat transfer on the separation in laminar supersonic flow are considered theoretically and experimentally. Theoretically, cooling the walls reduces the extent of regions of separation and steepens the pressure gradients; heating the wall reverses this effect. Experiments partially confirm this.

RP281
AD-279-826
N-90922

Turbulent Boundary Layers with Heat Transfer in Compressible Flow. J.C.ROTTA.
AGARD Rep. 281, 39 pp., 18 refs., 1960.
The well-known concept of wall and defect law is extended to the turbulent boundary layer at supersonic Mach numbers. The effect of compressibility and heat transfer on the distribution of mean velocity and temperature is investigated on this basis, and a comprehensive analysis of available measurements is made. As an application, the relations to predict the local skin friction coefficient, recovery factor and heat transfer coefficient are given. Some results are discussed.

RP282
AD-279-824
N-85350

Real-Gas Laminar Boundary Layer Skin Friction and Heat Transfer. R.E.WILSON.
AGARD Rep. 282, 24 pp., 9 refs., 1960.
The laminar boundary layer equations were integrated for the case of a flat plate over a wide range of free-stream enthalpies and velocities, and over a wide range of enthalpies of the gas at the wall. The range of free-stream velocities extended up to 25,000 ft/sec. at low free-stream enthalpies, corresponding to local conditions on a slender body travelling at high speed.

RP283
AD-265-910
N-103-363

The Thermal Laminar Boundary Layer on a Rotating Sphere. J.SIEKMANN.
AGARD Rep. 283, 17 pp., 7 refs., 1960.
A method is developed, for incompressible fluid having uniform flow, which follows an idea due to N. Frössling, in which the temperature distribution is expressed as a power series expansion. Use is made of results previously obtained by N.E. Hoskin for the velocity distribution in the laminar boundary layer of a rotating sphere. Numerical results, obtained with an IBM 704 computer, are included.

RP284
AD-262-627
N-100-745

An Experimental Technique to Measure Heat Transfer Fluxes at High Speeds: Turbulent Heat Transfer Data on a Blunt Body at M = 3.98. L.BROGLIO, C.BUONGIORNO.
AGARD Rep. 284, 12 pp., 6 refs., 1960.
The technique described is for measuring the heat transfer rates on a model, and for fixing the temperature distribution at a given value. The application of the technique to a blunt body is described.

RP285
AD-263-708
N-102-003

Test and Evaluation of U.S. Navy Aircraft Weapon Systems. J.B.PARADIS.
AGARD Rep. 285, 12 pp., 1960.
Describes (i) the birth of a naval aircraft weapon system; (ii) concept of navy testing; (iii) testing organization; (iv) chronology of tests; (v) management of tests. Detailed test procedures are not discussed.

RP286
AD-265-911
N-103-359

United States Air Force Weapon System Testing. J.J.BERKOW, T.C.KENSLER, Jr.
AGARD Rep. 286, 16 pp., 1960.
A general outline of USAF test requirements for manned aircraft, from the contractors tests of prototypes to tests by the users of production aircraft. Examples are used to demonstrate the number of aircraft involved and the degree of integration of personnel and objectives. ARDC tests such as for climatic and adverse weather conditions, performance, weapon system evaluation, and fire control system efficiency are briefly described.

RP287
AD-262-628
N-100-744

The Flight Testing of Aircraft Weapon Systems. R.P.DICKINSON.
AGARD Rep. 287, 27 pp., 6 refs., 1960.
The flight-testing of elements of the weapon system (guns, guided weapons, guided and unguided rockets, guided and free-fall bombs) is dealt with in a broad survey, with some detailed test techniques. The assessment follows through the stages of cockpit engineering, aerodynamic and auto control, armament loading and carriage, navigation to the zone of operation, to the attack phase, and impact accuracy.

RP288
AD-279-830
N-108-668

Design and Operation of the X-15 Hypersonic Research Airplane. G.R.MELLINGER.
AGARD Rep. 288, 31 pp., 1960.
The following aspects of the X-15 rocket aircraft are discussed: description of vehicle, description of systems, materials and fabrication, use of XLR 11 engine, pilot evaluations, flight demonstration, value of air-launching capability, and programme status.

RP289
AD-262-629
N-87588

The X-15 Research Program. De E.BEELER.
AGARD Rep. 289, 17 pp., 1960.
A brief account of the programme including some of the early flight-test results and demonstrating the present status of the project.

RP290
AD-263-709
N-87484

Remarks on the Status of Project Mercury. A.C.BOND, A.B.KEHLET.
AGARD Rep. 290, 11 pp., 7 refs., 1960.
A broad overall review of the initial programme of the U.S. for manned orbital flight, Project Mercury, is presented in the light of experience gained in the two years since its initiation. The space capsule and some of its primary systems are described in conjunction with the mission and its requirements. The status of the flight-test programme is also covered.

RP291
AD-262-630
N62-15907

Dyna Soar Research Objectives. F.R.ANDERTON, Jr.
AGARD Rep. 291, 6 pp., 1960.
Research objectives of this hypersonic glider are reviewed and its flight regime compared with those of current manned space projects. Ground testing and areas in which technical advances are expected are discussed. The flight test programme is described generally with reference made to specific test objectives.

RP292
AD-265-912
N-70223

A Background to the Problems of Wind-Tunnel Interference. E.W.E.ROGERS.
AGARD Rep. 292, 22 pp., 59 refs., 1959.
Progress in the field of interference is briefly surveyed, some of the present-day difficulties pointed out and an attempt made to assess the direction required for future work.

RP293
AD-279-832
N-70424

Some Applications of Transonic Flow Theory to Problems of Wind Tunnel Interference. W.A.PAGE, J.R.SPREITER.
AGARD Rep. 293, 22 pp., 22 refs., 1959.
By application of approximate methods of solution to the small-disturbance equations of transonic flow, insight is gained into the nature of wind-tunnel wall interference about two-dimensional aerofoils and axisymmetric bodies in the transonic speed range and particularly at Mach 1. The available methods for predicting interference are reviewed and comparisons with theory and experiment are made in various cases that illustrate different aspects of wall-induced interference in wind tunnels with solid-wall and ventilated test section.

RP294
AD-279-821
N-108-654

The Effectiveness of the Transonic Wind-Tunnel as a Device for Minimizing Tunnel-Boundary Interference for Model Tests at Transonic Speeds. R.H.WRIGHT.
AGARD Rep. 294, 68 pp., 43 refs., 1959.
The nature of subsonic tunnel-boundary interference is briefly discussed. First-order theory of subsonic interference is slotted and in porous-wall or perforated tunnels is reviewed, and certain results of slotted-tunnel theory are compared with experimental data. The slotted tunnel is found to be extremely effective in minimizing subsonic interference, the porous-wall or perforated tunnel less effective. The boundary interference in transonic tunnels near Mach 1 is much smaller than would be suggested by the subsonic linearized theory. Testing of models of small size relative to the tunnel is, therefore, possible near M.1. Supersonic interference can be reduced, but it cannot be practically removed, and for testing at low supersonic speeds, the models must again be kept small relative to tunnel size. These conclusions are supported by several experimental examples and comparisons.

RP296
AD-661-956
N62-15909

Some Effects of Wind Tunnel Interference Observed in Tests on Two-Dimensional Aerofoils at High Subsonic and Transonic Speeds. H.H.PEARCEY, C.S.SINNOTT, J.OSBORNE.
AGARD Rep. 296, 61 pp., 20 refs., 1959.
The necessity for using models of a suitably large size is pointed out. Interference effects of the slotted working section used at N.P.L. are discussed and the magnitudes of blockage and lift effect corrections deduced. A simple adaptation of the open area of the walls would reduce the corrections to insignificant proportions but would give a reduced choking Mach number and introduce wake interference effects for strongly separated flows. The results are not valid for all ratios of model chord to tunnel height, only for those normally used at N.P.L.

RP297
AD-661-953
N62-15910

An Investigation of Interference Effects on Similar Models of Different Size in Various Transonic Tunnels in the U.K. F.O'HARA, L.C.SQUIRE, A.B.HAINES.
AGARD Rep. 297, 90 pp., 18 refs., 1959.
Details are given of the results of tests in the RAE, 3ft x 3ft slotted tunnel and the ARA 9ft x 8ft perforated tunnel. The tests were made on swept wing models at subsonic speeds and speeds just above M = 1.

RP298
AD-266-060
N-72720

Notes on Half-Model Testing in Wind Tunnels. J.A. van der BLIEK.
AGARD Rep. 298, 29 pp., 39 refs., 1959.
A short review of the effects associated with the half-model technique which include tunnel wall boundary layer and gap between model and tunnel wall. Reflection plane configurations are considered. Some experimental data are given, comparing full and half-model tests.

RP299
AD-263-710
N-71201

Corner Interference Effects. K.GERSTEN.
AGARD Rep. 299, 15 pp., 13 refs., 1959.
Discusses the problem of three-dimensional incompressible flow in the corner of two semi-infinite plates at right angles, with special reference to interference between the boundary layers of the plates. The effect of interference on the transition from laminar to turbulent flow is discussed.

RP300
AD-279-834
N-108-670

Support Interference at Supersonic Speeds. J.D.WHITFIELD.
AGARD Rep. 300, 26 pp., 14 refs., 1959.
Effects of Mach number, length Reynolds number, and unit Reynolds number on support interference are discussed. Results of experimental studies at Arnold Engineering Development Center are presented. The effects of sting-length interference are shown to be strongly dependent on the transition location as well as the length Reynolds number for the case with transitional wake flow. The effects of sting-length interference on the base and afterbody drag of m dels with cylindrical and boat-tailed afterbodies are discussed. Results of tests with bluff-shape models supported by fine wires are presented and compared with results obtained with conventional sting-type supports.

RP301
AD-279-833
N-108-646

Large Angle of Attack Model-Sting Interference Effects at Transonic Speeds. D.ZONARS.
AGARD Rep. 301, 41 pp., 6 refs., 1959.
An experimental investigation has been conducted in the WADC 10-ft. Transonic Wind Tunnel for the purpose of determining sting interference characteristics of a cylindrical body of revolution with an ogive nose. The sting-support system consisted of three different sting sizes which were attachable to either the body base, nose, or model side. This model-support system provided a method for obtaining angle of attack data through a range 0 to 180 deg. with resulting sting effects throughout the angle range. Six-component internal strain gauge balance tests were conducted throughout the Mach number range 0.6 to 1.2. The majority of the test was conducted at a stagnation pressure of 1200 lb/ft^2 abs. with resulting Reynolds number variations from 0.225 x 10^6 to 0.297 x 10^6 based on the mo · ' body diameter.

RP302
AD-661-952
N-80530

Effects of Supports on the Flow Behind a Body. P.REBUFFET.
AGARD Rep. 302, (in French), 33 pp., 5 refs., 1959.
With a view to determining the effects of supports on models with flat bases in supersonic flow and with turbulent boundary layer, two cases are examined: (i) the effect of obstacles upstream of the two-dimensional base, and (ii) a body of revolution passing through the throat of the jet from upstream to downstream.

RP303
AD-661-951
N62-15912

Tunnel-Wall Effects Associated with VTOL-STOL Model Testing. R.E.KUHN, R.L.NAESETH.
AGARD Rep. 303, 25 pp., 6 refs., 1959.
The tunnel wall effect in VTOL-STOL testing is similar to that associated with conventional model testing but differs greatly in degree due to jets such as jet flaps. In addition flow separation can also be induced by the tunnel walls. NASA experiences of these problems in closed-throat tunnels are reviewed.

RP304
AD-279-827
N-79256

Further Comments on High-Lift Testing in Wind Tunnels with Particular Reference to Jet Blowing Models. S.F.J.BUTLER, J.WILLIAMS.
AGARD Rep. 304, 33 pp., 12 refs., 1959.
Discusses some of the special problems of wind-tunnel testing which arise with high-lift jet-blowing models, supplementing AGARD Report 63. Further detailed comments are made on tunnel-wall interference, test rigs and methods of minimising constraints from air-feeds to models, and on general test and model design techniques.

RP305 **Effects of a Wall on a Blown Wing.** R.DUQUENNE, H.WERLE.
AD-661-949 AGARD Rep. 305, (in French), 27 pp., 8 refs., 1959.
N62-15889 This study relates to trailing edge blowing in the presence of a wall. The possibilities of calculating the potential flow are examined and two examples given in which profile and jet are replaced by a line of velocity discontinuity. Calculation is by rheoelectric analogue. Visualization tests using water for low speed flow are described. These permit the mechanism of flow and the effect of the principal parameters to be observed.

RP306 **Industrial Uses of Wind Tunnels with Particular Reference to Wind Machines.** K.EMSLIE.
AD-279-837 AGARD Rep. 306, 10 pp., 4 refs., 1960.
N-108-674 A description of equipment and test techniques at the English Electric Co.'s facilities at Warton Aerodrome. Tests have been made on radar aerials and wind machines.

RP307 **Aerodynamic Problems of Motor Cars.** H.SCHLICHTING.
AD-279-825 AGARD Rep. 307, 17 pp., 2 refs., 1960.
N-108-648 Describes wind-tunnel tests made at the Institute of Fluid Mechanics, Technical University of Braunschweig to examine ways of reducing drag. Vehicles tested were a Volkswagen lorry, a Volkswagen private car and motorcycles.

RP308 **A Type of Wind Tunnel for Simulating Phenomena in the Natural Wind.** H.PETERSON.
AD-279-831 AGARD Rep. 308, 7 pp., 1960.
N-108-673 A description is given of a type of wind tunnel specially suited for measuring wind pressure on buildings, shelter effects and smoke concentration from power plant stacks or the diffusion of radioactivity from an atomic power plant.

RP309 **The Use of Wind Tunnels in Industrial Aerodynamic Research.** C.SCRUTON.
AD-279-822 AGARD Rep. 309, 49 pp., 31 refs., 1960.
N-109-672 The use of wind tunnels for this purpose is reviewed with particular reference to the work at the Aerodynamics Division of the National Physical Laboratory. Problems are classified under: (i) study of flow problems; (ii) assessment of steady wind forces on vehicles, buildings and structure; (iii) oscillatory effects. Experimental techniques are similar to those used for aeronautical research.

RP310 **Wind Tunnel Tests to Determine the Efficiency of a Proposed Extension to a Welding Shed in**
AD-279-828 **Suppressing Draughts.** L.E.LEAVY.
N-108-642 AGARD Rep. 310, 13 pp., 1960.
Tests are described in a 9ft x 7ft subsonic tunnel on a model shed and the adjacent building to determine if a modification to the shed would reduce draught and the ingress of rain and snow through the open ends. Results were satisfactory.

RP311 **Examples of Aerodynamic Tests Made Outside the Realm of Classical Aerodynamics.**
AD-652-995 A.MARTINOT-LAGARDE, A.FAUQUET.
N-103-358 AGARD Rep. 311, 12 pp., 1960.
Of the several topics considered (e.g. drag of a fishing net, resistance of terrestrial structures to the wind, motion of the smoke from a ship, etc.) only one section is related to aircraft, and this considers investigations of the motion of jettisoned cockpit covers and fuel tanks.

RP312 **Surface Warp and Aerodynamic Heating.** W.B.HUSTON.
AD-652-925 AGARD Rep. 312, 22 pp., 43 refs., 1960.
N62-15913 A brief review of the state-of-the-art of relating temperatures, structural deformations and aerodynamic loads. Some representative structural problems are first considered, then the interrelation between structural deformation and aerodynamic load.

RP313 **Non-Aeronautical Applications of Low-Speed Wind-Tunnel Techniques.** P.J.POCOCK.
AD-248-522 AGARD Rep. 313, 95 pp., 385 refs., 1960.
N62-15911 Reviews numerous articles describing the implications and problems of general industrial uses for low speed tunnels.

RP314 **Industrial Applications of Wind Tunnel Investigations.** F.K.BOUTWELL, R.C.PORTER.
AD-490-420 AGARD Rep. 314, 13 pp., 7 refs., 1960.
N62-14505 Notes briefly the differences between aeronautical and industrial test applications. Tests on smoke stacks and their behaviour were made at the University of Michigan. Results and pictorial examples from the study are presented.

RP315 **Flight Testing of the Fiat G91.** G.CIAMPOLINI.
AD-661-950 AGARD Rep. 315, 22 pp., 1961.
N62-14803 A summary description with special reference to test methods, flying technique, recording devices and data processing. The correlation between flight, wind tunnel and design results is emphasized as a guidance to some flight mechanics problems. The international cooperation of NATO countries in the programme is noted.

RP316 **Aliasing Errors in Sampled Data Systems.** A.J.MALLINCKRODT.
AD-294-172 AGARD Rep. 316, 21 pp., 4 refs., 1961.
N63-80509 The term 'aliasing errors' is first defined, and then the principles of analysis of random time series are applied to the problem of quantitative estimation and minimization of such errors. It is shown that errors in practical systems can be such as to largely invalidate the resulting data. The possibility of large sampling apertures is considered briefly and found to be a practical means of highly efficient pre-sampling filtering. The practical procedures for design of pre-sampling filters and measurement of the signal parameters required to set the sampling rate are discussed.

RP317 **Flight Test Instrumentation for V/STOL Aircraft.** G.BRUNING.
AD-652-926 AGARD Rep. 317, 58 pp., 11 refs., 1961.
N62-14804 A summary of results of visits to organizations with experience of testing V/STOL aircraft. General aspects of instrumentation are considered and examples given; the physical quantities of interest are discussed and recording methods described. An attempt is made to suggest an optimum instrumentation. Most quantities can be measured conventionally but those such as low horizontal speed, altitude, rate of climb and descent present difficulties. Lighter airborne equipment is described.

RP318 **Some Notes on U.K. Experience in the Testing of VTOL Aircraft.** R.T.SHIELDS.
AD-652-927 AGARD Rep. 318, 11 pp., 1961.
N62-14805 Considers the methods of testing the Rolls-Royce 'Flying Bedstead', Short SC.1, and the Hawker P.1127. Ground facilities (in particular gantries and perforated platforms) and instrumentation are discussed, and recommendations are made for future testing.

RP319 **Flight Test Techniques and Instrumentation for VTOL Aircraft.** R.J.TAPSCOTT.
AD-444-705 AGARD Rep. 319, 56 pp., 5 refs., 1961.
N62-14432 A discussion is presented of the basic measurements made in flight with VTOL aircraft, to explore the new régimes of flight involved, and to develop design criteria and operating techniques in the new régimes. The importance of pilot orientation in order that he may provide accurate observations and opinions to the engineer is considered particularly in regard to the many qualitative aspects of the VTOL flight programmes conducted to date.

RP320 **Gas-Plasma Research at the Institute for Thermodynamics in Braunschweig.** F.BOSNJAKOVIC, W.SPRINGE, K.F.KNOCHE.
AD-294-733
N63-80147 AGARD Rep. 320, 13 pp., 11 refs., 1959.
Discusses problems of thermal equilibrium of a plasma gas, for temperatures up to 100,000 deg.K. The effects of enclosed radiation at temperatures beyond 20,000 deg.K, which can be very significant, are considered. Plasma heat-transfer problems are dealt with in the second part of the Report.

RP321 **Research at the National Physical Laboratory on the Ionization Properties of Gases at High**
AD-294-741 **Temperatures.** D.L.SCHULTZ.
N63-80155 AGARD Rep. 321, 16 pp., 16 refs., 1959. (Formerly NPL/Aero/378).
A description is given of techniques which enable the electron density and collision frequency of ionized air to be measured. Results show general agreement with simple equilibrium theory, and it is suggested that the complication of species in ionized air may be reduced without serious error by considering only nitrogen molecules, oxygen atoms, nitric oxide, ions and electrons.

RP322 **Research at the National Physical Laboratory on the Properties of Gases at High Temperatures.**
AD-294-736 K.C.LAPWORTH.
N63-80156 AGARD Rep. 322, 30 pp., 29 refs., 1959. (Formerly NPL/Aero/380).
Possible methods of temperature measurement by spectrographic means are reviewed and some preliminary shock tube results are presented. It has been necessary to use shocks reflected from the closed end of the tube in order to obtain adequate light for spectrographic work. It is shown that with this technique it is necessary to resolve the spectra in time in order to separate phenomena occurring at different times in the shock tube. Apparatus for achieving this is described and a time resolved spectrum is presented.

RP323 **Thermodynamic and Transport Properties of High Temperature Air.** C.F.HANSEN.
AD-294-739 AGARD Rep. 323, 26 pp., 30 refs., 1959.
N63-80151 Vehicles travelling at high speed excite the air to high temperatures resulting in dissociation and ionization, so that the air properties deviate considerably from those of a simple gas. Some effects of these reactions are considered in relation to the thermodynamic properties of the air, the transport coefficients and the diffusion of heat. Methods are presented for calculating the thermodynamic properties of air with good accuracy up to 15,000 deg.K and for pressures from 10^{-6} to 10^{2} atm.

RP324 **The Properties of Nitrogen up to 15,000 deg.K.** H.MAECKER.
AD-652-929 AGARD Rep. 324, 7 pp., 1959.
N62-14521 With a newly developed cylindrical cascade arc for high power input, and with the development of the theory of the arc, it has been possible to determine the electrical conductivity, the heat conductivity and the heat flux potential of nitrogen up to 15,000 deg.K by means of electrical and spectroscopic measurements.

RP325 **Characteristics of Cylindrical Arcs at High Temperatures.** T.PETERS.
AD-652-930 AGARD Rep. 325, 13 pp., 12 refs., 1959.
N62-14520 The properties of stationary cylindrical arcs at very high temperatures are studied on the basis of a fully ionized hydrogen-like plasma. The fundamental equations of this problem, the energy balance, the current-voltage equation and the condition for the equilibrium between magnetic pressure and gas pressure are not integrated exactly but solved with the aid of Steenbeck's principle of minimal electric field strength. Comparison with experimental data in the temperature range up to 50,000 deg.K, and with results of the nearly exact method of approximation given by Maecker, it is shown that the application of this principle leads to proper approximate solutions in a rather simple way.

RP326 **Chemistry, Ionization and Radiation in the Non-Equilibrium Front of Normal Shocks in Air.** B.KIVEL.
AD-294-737 AGARD Rep. 326, 22 pp., 12 refs., 1959.
N63-80150 The Avco-Everett research programme on non-equilibrium phenomena in normal shocks is summarized. Three classes of experiments are described: (i) absorption of ultra-violet radiation (ii) emission of optical radiation, and (iii) microwave absorption and reflection. The use of these measurement techniques in unravelling the complex phenomena that occur in the non-equilibrium region of normal shocks is outlined.

RP327 **Experimental Measurements of Temperature and Relaxation Times Behind Shock Waves.**
AD-294-131 A.C.GAYDON, I.HURLE.
N63-80508 AGARD Rep. 327, 12 pp., 8 refs., 1959.
By using a photomultiplier and cathode-ray oscillograph responsive only to changes in light signals, the sodium-line reversal technique has been adapted for time-resolved studies of temperature behind shock waves produced by a bursting diaphragm. A double-beam system has also been developed, which eliminates changes due to varying concentration of added metal, and interference filters can be used instead of a spectrograph.

RP328 **Interferometric Measurement in a Shock Tube of Dissociation Rates for Air and its Component Gases.**
AD-294-743 S.BYRON.
N63-80152 AGARD Rep. 328, 13 pp., 6 refs., 1959.
Fundamental chemical kinetic measurements in air and its component gases are being made in a shock tube. A Mach-Zender interferometer is used to measure the density of a dissociating gas as a function of time behind a shock wave. Results to-date are presented and future work is discussed.

RP329 **A Study of Strong Shock Waves Produced in a Magnetogasdynamic Shock Tube.** A.I ATE.
AD-294-740 AGARD Rep. 329, 12 pp., 7 refs., 1959.
N63-80149 A magnetogasdynamic shock tube is briefly described. Experiments have been performed at A.R.D.E. with air and helium in the tube, and the shock wave pattern was recorded using a streak camera over a range of initial pressures. The shock tube attenuation is compared with that predicted by the one-dimensional similarity solution for an intense blast wave.

RP330 **Methods for the Calculation of High Temperature Gas Transport Properties.** E.A.MASON.
AD-294-742 AGARD Rep. 330, 16 pp., 39 refs., 1959.
N63-80157 Available methods for calculating the transport properties of multi-component, dissociating gas mixtures are reviewed and discussed. It is assumed that the composition of the mixture and the forces among the various atomic and molecular species present are known. There are two distinct aspects of the problem: the development and use of the proper kinetic theory formulae, and the numerical computation of a large number of difficult cross-sections ('collision integrals') from the given force laws. Various useful approximation methods for both aspects of the problem are also discussed.

RP331 **Determination of Short-Range Intermolecular Forces.** J.T.VANDERSLICE.
AD-294-734 AGARD Rep. 331, 15 pp., 17 refs., 1959.
N63-80146 Knowledge of the forces between atoms, molecules, and ions at close distances of approach is necessary for the calculation of the properties of gases at very high temperatures. Available methods for determining reliable force laws at close distances are reviewed and discussed.

RP332 **Recombination of Oxygen Atoms at Surface.** J.C.GREAVES, J.W.LINNETT.
AD-294-738 AGARD Rep. 332, 9 pp., 19 refs., 1959.
N63-80148 The recombination coefficient, γ, for oxygen atoms at various oxide surfaces at room temperature was measured using the method due to Smith. It was found that the acidic oxides have a low activity. High activity seems to be associated with either incomplete d-shells (oxides of Mn, Fe, Co, Ni, Cu) or with alkalinity (MgO and CaO). Other features of the results are also discussed.

RP333 **A Method of Forming Continuous Empirical Equations for the Thermodynamic Properties of Air from**
AD-294-171 **Ambient Temperatures to 15,000 deg.K with Applications.** M.GRABAU.
N63-80510 AGARD Rep. 333, 31 pp., 7 refs., 1959.
Relates generally to automatic data reduction for arc-driven hotshot wind-tunnels which operate at high stagnation temperatures. Pressure and density are used as the simplest independent variables. The thermodynamic functions $H\rho/p$, S/R, and $1/Z$ for air, plotted at constant density as a function of the logarithm of the pressure, were found to exhibit basically similar graphical type-forms throughout the thermodynamic domain between 200 and 15,000 deg.K and densities between 10^{-6} and 10^{2} relative atmospheres.

RP334 **The Aeroplane Designer's Approach to Stability and Control.** G.H.LEE.
AD-275-406 AGARD Rep. 334, 19 pp., 2 refs., 1961.
N62-12254 Attempts to explain to the missile specialist the way in which the aeroplane designer looks at stability and control. It is shown that the traditional approach has now reached the limits of complexity, leading to the new concept of fully integrated power control autopilot, autostabilization, electrical signalling system, known as 'fly by wire'. The modern aeroplane designer's approach to stability and control is thus closer to that of the missile designer than previously.

RP335 **The Missile Designer's Approach to Stability and Control Problems.** M.W.HUNTER, J.W.HINDES.
AD-272-590 AGARD Rep. 335, 11 pp., 1961.
N62-10109 This discussion is divided into three major categories which deal, respectively, with missile configurations in contradistinction to aircraft configurations, the rôle of natural co-ordinates as they relate to stability and control concepts, and the different positions of aircraft and missiles with respect to the technological 'state of the art'.

RP336 **Flying Qualities Requirements for United States Navy and Air Force Aircraft: Pt.1 and 2.** W.KOVEN,
AD-272-921 R.WASICKO.
N62-10108 AGARD Rep. 336, 44 pp., 31 refs., 1961.
The history of the flying quality requirements is briefly reviewed and significant aspects of their establishment and use discussed. Major features of current specifications are detailed and reasons for specific requirements outlined. Recent research on flying qualities and its relation to current specifications is noted.

RP337 **Design Aims for Stability and Control of Piloted Aircraft.** H.J.ALLWRIGHT.
AD-272-591 AGARD Rep. 337, 32 pp., 2 refs., 1961.
N62-10110 Reviews the present situation on stability and control requirements for military aircraft as seen by an evaluation authority. The need to modify the approach to these problems to take account of basic changes in aircraft design, performance, pilot guidance and operating conditions is stressed. Discussion.

RP338 **Design for Missiles.** L.G.EVANS.
AD-275-407 AGARD Rep. 338, 14 pp., 1961.
N62-12255 The requirements of missile control system design are compared with those of manned aircraft, showing where advantage can be taken of the absence of aircrew or passengers. Safety requirements are less severe, and a satisfactory mission may be achieved in spite of localized instability problems. The basic problems which beset the missile designer and the steps which he must take to ensure that all have been satisfactorily solved, are reviewed.

RP339 **State of the Art of Derivatives.** H.H.B.M.THOMAS.
AD-275-408 AGARD Rep. 339, 53 pp., 158 refs., 1961.
N62-12256 The methods at present available for the estimation of the usual longitudinal and lateral stability derivatives of an aircraft are briefly discussed for each derivative in turn. This is preceded by an introductory section dealing with trends in aircraft geometry and their implications regarding the stability derivatives. To illustrate this further, the general discussion of methods is followed by a rather more

detailed consideration of the estimation of these derivatives for a slender-wing type of aircraft, mainly at low speeds, when incidence effects are shown to be important. Possible alternative formulation of the aerodynamics is briefly considered.

RP340
AD-275-409
N62-12257

The Estimation of Oscillatory Wing and Control Derivatives. W.E.A.ACUM, H.C.GARNER.
AGARD Rep. 340, 41 pp., 26 refs., 1961.
Reviews the accuracy of theoretical predictions of derivatives for wing and control oscillations and illustrates this by recent experimental work at Mach numbers between 0 and 2.5. The main area of uncertainty is in the transonic flow régime, but further development is also required for slender wings and oscillatory interference in slotted-wall tunnels.

RP341
AD-275-410
N62-12258

Current Progress in the Estimation of Stability Derivatives. L.V.MALTHAN, D.E.HOAK.
AGARD Rep. 341, 24 pp., 1 ref., 1961.
A recent programme dealing with the formulation of concise methods for predicting stability derivatives throughout the subsonic, transonic, supersonic and hypersonic speed régimes is described. Future plans for continuing and extending the work are outlined. A specific example is given to illustrate in detail the type of results which have so far been obtained. Emphasis is placed on original methods for predicting lift and pitching-moment characteristics of low-aspect-ratio wings at high angles of attack, and accuracy of the methods is indicated by extensive correlation with wind tunnel and flight test data.

RP342
AD-275-411
N62-12259

Calculation of Non-linear Aerodynamic Stability Derivatives of Aeroplanes. K.GERSTEN.
AGARD Rep. 342, 26 pp., 55 refs., 1961.
Non-linear dependence of lift and pitching moment on the angle of attack occurs especially with slender bodies, for example aerofoils of small AR and slender bodies of revolution. A survey is presented of existing methods for calculating non-linear effects and the various methods with their different vortex patterns are compared. A new method for calculating the lift distribution for wings with sharp leading edges in incompressible flow is also presented. It can be considered as an extension of the linear lifting-surface theory of E. Truckenbrodt (WGL-Jahrbuch, 1953). It is valid for arbitrary planforms and aspect ratios. There is good agreement of this new theory with experiments on rectangular, swept and delta wings.

RP343
AD-275-412
N62-12260

Estimation of Rotary Stability Derivatives at Subsonic and Transonic Speeds. M.TOBAK, H.C.LESSING.
AGARD Rep. 343, 24 pp., 12 refs., 1961.
Considers the estimation of subsonic rotary stability derivatives of wings. The unsteady potentional flow problem is solved by a superposition of steady-flow solutions. Numerical results for the damping coefficients of triangular wings are presented as functions of aspect ratio and Mach number, and are compared with experimental results over the Mach range 0 to 1. Experimental results are used to point out a close correlation between the non-linear variations with angle of attack of the static pitching-moment curve slope and the damping-in-pitch coefficient. The underlying basis for the correlation is found as a result of an analysis in which the indicial function concept and the principle of superposition are adapted to apply to the non-linear problem. The form of the result suggests a method of estimating non-linear damping coefficients from results of static wind tunnel measurements.

RP344
AD-288-055
N62-17195

Calculation by Rheoelectric Analogy of Aerodynamic Derivatives of a Wing of Finite Span. M.ENSELME, M.O.AGUESSE.
AGARD Rep. 344, (in French), 14 pp., 7 refs., 1961.
Two types of problems are involved in the calculation of the derivatives; that for steady flow and that for unsteady flow. The former was solved some years ago by Malavard who gave position derivatives and derivatives related to constant angular velocity in pitch or roll. This method is briefly reviewed. The rheoelectric solution for unsteady flow was obtained by R. Duquenne. The basic principles are outlined and results for harmonic conditions on wings of various planforms are presented and compared with the numerical values of Lawrence and Gerber.

RP345
AD-447-783
N62-14806

A Method of Accurately Measuring Dynamic Stability Derivatives in Transonic and Supersonic Wind Tunnels. H.G.WILEY, A.L.BRASLOW.
AGARD Rep. 345, 13 pp., 4 refs., 1961.
A sting-mounted model performs a single-degree-of-freedom sinusoidal oscillation while measurements are made of the displacement and of the moment required to sustain the oscillation. The method is particularly well adapted to the testing of unorthodox aerodynamic bodies whose stability is unpredictable. The frequency and amplitude of the oscillation are controlled by the operator and not dictated by the characteristics of the body. Airstream turbulence and buffeting do not affect the results. Unstable bodies do not cause the mechanism to diverge and configurations with negative damping can be tested.

RP346 **Wind Tunnel and Flight Measurements of Aerodynamic Derivatives.** M.SCHERER, P.MATHE.
AD-661-948 AGARD Rep. 346, (in French), 38 pp., 1961.
N62-14807 The first part of the report, researches in wind tunnels, complements preceding studies by critical
N68-19350 examination of methods and means of measurement used at present. The second part describes the flight measurements carried out by a French manufacturer in producing a prototype aircraft.

RP347 **Static and Dynamic Stability of Blunt Bodies.** H.C.DuBOSE.
AD-446-169 AGARD Rep. 347, 27 pp., 2 refs., 1961.
N62-14396 Describes relationships between the flow fields and the static and dynamic stability of blunted-cone-cylinder-flare type re-entry bodies at Mach numbers from 0.7 to 5.0. Effects of variations in some of the shape parameters on the dynamic stability are presented. It is shown that certain combinations of cone and flare angles results in instability in the transonic range. Also, comparison is made between free and forced oscillation data.

RP348 **Effects of Aeroelasticity on the Stability and Control Characteristics of Airplanes.** H.L.RUNYAN,
AD-446-167 K.G.PRATT, F.V.BENNETT.
N62-14409 AGARD Rep. 348, 29 pp., 12 refs., 1961.
The effects of aeroelasticity on stability and control are discussed under the two general categories of longitudinal and lateral motion. In each case the effects of wing, fuselage, and tail flexibility on stability of motion and effectiveness of control are discussed for various flight conditions including dynamic pressure and Mach number.

RP349 **The Influence of Structural Elasticity on the Stability of Airplanes and Multi-Stage Missiles.**
AD-446-168 L.T.PRINCE.
N62-15096 AGARD Rep. 349, 50 pp., 3 refs., 1961.
A root locus method for examining the influence of structural coupling on the stability of uncontrolled aeroplanes is presented. This graphical technique permits a rapid but accurate quantitative evaluation of the effects of changes in aeroelastic and aerodynamic characteristics on stability. Specific examples illustrate the utility of the method. Problems involved in integrating a flexible vehicle into an automatic flight control system are also discussed. The similarity of the problem as it exists in manned aeroplanes and multi-stage missiles is presented. Examples are shown which illustrate the conventional (linear control) design approach to this problem. An approach utilizing adaptive (non-linear control) techniques is also presented.

RP350 **Discussion of Two Methods of Studying the Motion of a Flexible Missile.** M.BISMUT, C.BEATRIX.
AD-288-056 AGARD Rep. 350, (in French), 17 pp., 1961.
N62-17202 Discusses two methods of calculation for studying the effects of aeroelasticity on the dynamic behaviour of missiles in flight. The linearized equations of motion (first method) are first established, and their application to the study of divergence is shown. The equivalence of the elastic deformation and of a modification of the aerodynamic coefficients (second method) is then demonstrated in support of a simplifying hypothesis.

RP351 **The Influence of Aeroelasticity on the Longitudinal Stability of a Swept Wing Subsonic Transport**
AD-448-909 **Aircraft.** C.M.KALKMAN.
N62-14808 AGARD Rep. 351, 36 pp., 7 refs., 1961.
A simplified numerical treatment of the influence of the aeroelastic deformations on the longitudinal stability and control characteristics of an aircraft with a swept-back wing of large aspect ratio is carried out for the sub-critical speed range. Only the deformation of the wing and the bending of the fuselage have been taken into consideration. As a result of the study it was found that the stability and control of the aircraft are only slightly affected by the aeroelastic deformation.

RP352 **Some Static Aeroelastic Considerations of Slender Aircraft.** G.J.HANCOCK.
AD-448-910 AGARD Rep. 352, 17 pp., 1961.
N62-14502 A series of simple theoretical models are discussed, representing the essential features of flexible aircraft both of the classical and integrated varieties, in trimmed level flight. Assuming linear aerodynamics it is shown that the maximum speed for trimmed flight for the classical aircraft is determined primarily by the tail-plane flexibility. For the integrated aircraft this maximum speed occurs when both the overall aeroelastic distortion and the control forces become very large, the effectiveness of the control to trim is related to the similarity of the weight and aerodynamic lifting distributions. Detailed calculations on trimmed plate wings of varying plan form further illustrate these general points.

RP353 **Pitch-Yaw-Roll Coupling.** L.L.CRONVICH, B.E.AMSLER.
AD-448-911 AGARD Rep. 353, 15 pp., 1961.
N62-14503 One of the most significant coupling problems in missile experience is that which results from interaction between the pitch, yaw and roll modes of motion. This paper discusses the geometric,

aerodynamic and control system couplings and their mutual interactions which give rise to overall system stability problems. The supersonic aerodynamic static stability and control characteristics of a typical configuration which experiences aerodynamic coupling both in attitude and in control are discussed, together with the selection of both control system and aerodynamic parameters to provide maximum system stability margins.

RP354
AD-652-996
N62-15480

Application of the Analogue Computer to the Study of the Coupling of Longitudinal and Transverse Motions of an Aircraft. F.C.HAUG.
AGARD Rep. 354, (in French), 73 pp., 18 refs., 1961.
The object of the calculations carried out is to make a contribution to the study of aircraft motion during complex manoeuvres. The procedure used consists of integrating the system of equations defining this motion and then analyzing the solutions obtained. The aircraft motion is represented by the classical equations including non-linearities due to the inertia terms, and also certain aerodynamic non-linearities. The classical equations have been simplified to demonstrate the inertia coupling.

RP355
AD-276-612
N62-12813

Influence of Deflection of the Control Surfaces on the Free-Flight behaviour of an Aeroplane. X.HAFER.
AGARD Rep. 355, 22 pp., 9 refs., 1961.
The influence of the non-linear effects on the flight behaviour of modern high-performance aircraft under control inputs is demonstrated with a number of systematic calculations. These illustrate the coupling effects with various symmetrical and unsymmetrical control inputs at different Mach number and altitudes. The effects of changing the aerodynamic derivatives, of the engine gyroscopic couple, and of the ratio of moments of inertia are also demonstrated.

RP356
AD-276-614
N62-12814

Low-Speed Stalling Characteristics. J.C.WIMPENNY.
AGARD Rep. 356, 14 pp., 3 refs., 1961.
Low-speed stalling requirements, and methods of design to comply with them, are reviewed. It is concluded that the design process is very ad hoc and some suggestions for further work in this field are made.

RP357
AD-276-615
N62-12815

Some Low-Speed Problems of High-Speed Aircraft. A.SPENCE, D.LEAN.
AGARD Rep.357, 37 pp., 20 refs., 1961.
Deals with the low-speed aerodynamics of aircraft shapes suitable for achieving a required range at supersonic speeds. No attention is given to 'slewed' wings, nor to possible application of powered lift or variable geometry. Wind tunnel tests are described on a simplified model with boundary layer control methods applied. Mention is also made of the possibility of adverse ground effect on maximum lift. Considers also work aimed at clarifying some of the requirements for handling qualities of future aircraft. Flight tests on an Avro 707A aircraft, with artificially worsened characteristics, are described, and it is shown that substantially constant performance in the piloting task can be achieved at the expense of increased pilot effort. Some tentative conclusions on desirable levels of speed stability and phugoid damping are drawn.

RP358
AD-276-616
N62-12816

Factors Limiting the Landing Approach Speed of Airplanes from the Viewpoint of a Pilot. R.C.INNIS.
AGARD Rep. 358, 14 pp., 1961.
The results of two specific aircraft were considered; one a swept-wing jet fighter employing blowing-type boundary-layer control (BLC) on highly deflected leading and trailing-edge flaps, and the other a straight-wing, twin-engine cargo aircraft using propeller slipstream in conjunction with an area suction BLC system on the flaps and drooped ailerons to develop high lift. From these studies an attempt is made to provide a better understanding of the effect of various stability and control characteristics on the pilot's selection of approach speeds. It is shown that in the presence of poor handling qualities, the pilot demands an excess margin of speed which he uses to compensate for the attention required by the undesirable characteristics.

RP359
AD-276-617
N62-12817

Post-Stall Gyrations and their Study on a Digital Computer. S.H.SCHER.
AGARD Rep. 359, 17 pp., 7 refs., 1961.
Research employing a digital computer is being conducted on large-angle motions, including post-stall gyrations, which occur on operational aircraft and which will probably continue to occur on some of the aircraft of the future. Illustrations of post-stall gyrations which have occurred on aircraft are given and analytical methods being used at the Langley Research Center in pertinent studies are described. Results obtained are correlated with small dynamic model test results, and then may be extrapolated to account for effects of full-scale Reynolds number, altitudes and Mach number. Attempts are made to accumulate basic information that will be of aid to designers. Some typical results are presented which illustrate use of the analytical methods.

RP360 **The Place of Servo-Mechanisms in the Design of Aircraft with Good Flight Characteristics.**
AD-277-147 K.H.DOETSCH.
N62-13429 AGARD Rep. 360, 13 pp., 7 refs., 1961.
Discusses the fundamental consideration of the place for 'black boxes' in the design of good stability and handling characteristics. The shortcomings of the human operator's perception and response which can be safely overcome by the use of servo-mechanisms are dealt with, and suggestions made for less safe tasks for automatic aids. The arguments for and against artificial static stability are also discussed.

RP361 **Effects of Servo-Mechanism Characteristics on Aircraft Stability and Control.** F.A.GAYNOR.
AD-277-146 AGARD Rep. 361, 26 pp., 7 refs., 1961.
N62-13568 Past, present, and future trends in the application of servo-mechanisms to aircraft are briefly outlined. The rôle of servo-controls is reviewed in progression from early 'relief-type' automatic controls through present-day stability-augmented aircraft with fully-powered flight control systems. The servo or automatic control designer's approach to stability and control and the theoretical and practical considerations involved in integrating an automatic control system with an aircraft flight control system are described using as an example the design of a self-adaptive stability augmentation and flight control system for a supersonic aircraft.

RP362 **Flight Controls Considered as Forming a Servo-System.** J.GREMONT.
AD-652-997 AGARD Rep. 362, (in French), 19 pp., 41 refs., 1961.
N62-14015 The flight control system is discussed as a servo system in which the input is the pilot's commands and the output the movements of the controls. The servo consists of components such as stabilizers, autopilots, artificial force intensifiers, etc. Ground and Flight test methods are examined in relation to this concept and also the aspects of safety and flight quality.

RP363 **Determination of Suitable Aircraft Response as Produced by Automatic Control.** E.MEWES.
AD-661-945 AGARD Rep. 363, 20 pp., 13 refs., 1961.
N62-12818 The effects of the adjustment of control mechanisms (coupling factor variations of certain autopilots) on the characteristics of the motion of an aircraft, omitting flexibility and compressibility effects, were investigated. The investigations were based on the simple equations of motion of an aircraft. Variations of the motion due to applying more complex equations were also investigated. The motions were calculated as responses to a unit step impulse of a yawing moment (due to variation in thrust of a side engine or to the occurrence of a crosswind field which decreases a little later, as e.g., in the case of a horizontal side gust).

RP364 **An Approach to the Control of Statically unstable Manned Flight Vehicles.** M.DUBLIN.
AD-447-784 AGARD Rep. 364, 18 pp., 3 refs., 1961.
N62-14017 A design objective of high Mach number performance manned flight vehicles is concerned with flight operations such that minimum longitudinal trim drag is achieved. The utilization of longitudinal statically unstable vehicles is one means of obtaining this desired objective. Taking a delta wing canard controlled aircraft as an example, this report presents a control concept based on three redundant systems of compensating for static instability. These systems consist of a mechanical stability augmentation system, a conventional autopilot system, and a fuel transfer system. Each system by itself is capable of permitting adequate control of the aircraft, so that loss of any one system still permits a high degree of flight safety and reliability.

RP365 **The Use of Piloted Flight Simulators in General Research.** G.A.RATHERT, Jr., B.Y.CREER, M.SADOFF.
AD-404-196 AGARD Rep. 365, 19 pp., 14 refs., 1961.
N62-13882 Recent research on a number of general flying-qualities problems is reviewed in order to discuss the use of piloted simulators and their validity. Direct comparisons between different types of simulators and actual flight tests are used to show which information cues to the pilot are required in each of several basic problem areas, of advanced transports and spacecraft, where the use of simulators might be particularly desirable.

RP366 **Simulation in Modern Aero-Space Vehicle Design.** C.B.WESTBROOK.
AD-445-596 AGARD Rep. 366, 21 pp., 1961.
N62-15465 Discusses the simulation facilities used in the United States, and an attempt is made to classify them. Use of flight control system simulators in the design of a vehicle is described.

RP367 **Mathematical Models for Missiles: A Simulator Study of the Effects of Aerodynamic Non-Linearities**
AD-445-594 **and Cross-Couplings on the Performance of a Guided Missile.** W.S.BROWN, D.I.PADDISON.
N62-15164 AGARD Rep. 367, 28 pp., 2 refs., 1961.
Describes the use of a large analogue computer, supplemented by digital computations, to study the effects of high-incidence aerodynamic non-linearities and cross-couplings on the performance of a

hypothetical cruciform missile. Aerodynamic data, obtained from wind tunnel tests of a suitable model, were simulated in detail, and linear aerodynamic characteristics were subsequently substituted for purposes of comparison. The effects of the aerodynamics on response and on homing performance against targets turning at a constant rate are displayed as graphs. The accuracy and limitations of the analogue method are indicated by comparisons of the simulator results obtained digitally.

RP368
AD-446-170
N62-15124
In Flight Simulation – Theory and Application. E.A.KIDD, G.BULL, R.P.HARPER, Jr.
AGARD Rep. 368, 32 pp., 20 refs., 1961.
Analogue computers, fixed base simulators, and other ground machines are discussed. In particular, the theory and actual techniques of in-flight simulators of the variable stability type are dealt with. The conclusion is drawn that the solution of the various problems of handling qualities requirements and of control system development requires the use of ground-based simulators and in-flight simulators as complementary tools.

RP369
AD-445-595
N62-15095
Application of Analytical Techniques to Flight Evaluations in Critical Control Areas. J.WEIL.
AGARD Rep. 369, 27 pp., 49 refs., 1961.
Discusses test results pertinent to a variety of typical flight-control problem areas of the current generation of aeroplanes. The results presented were obtained from flight investigations on many research and operational aircraft at the NASA Flight Research Center over the past 10 years. Basic stability problems are considered such as pitch-up, roll coupling, and marginal directional stability. Development of augmentation systems and control system evaluations are also discussed.

RP370
AD-652-931
N62-15162
Investigation on the Improvement of Longitudinal Stability of a Jet Aircraft by the use of a Pitch-Damper. R.MAUTINO.
AGARD Rep. 370, 30 pp., 1961.
Describes the results of preliminary calculations and subsequent flight tests conducted in order to determine possible improvements in longitudinal stability of the G91 jet aircraft due to the installation of a pitch-damper. The calculated and flight test results were compared and agreement was found to be quite good. The conclusion is drawn that the results achieved from the preliminary calculations were suitable for the evaluation of the efficiency and stability of a servo system of the type described.

RP371
AD-652-998
N62-15540
Methods Used for Developing the Breguet 940 Blown Wing Aircraft. G. de RICHEMONT.
AGARD Rep. 371, (in French), 12 pp., 1961.
Development testing included the use of a stationary model, wind tunnel tests on a flight model to accustom the pilot to STOL configurations and to study the lateral controls, electronic simulation, to study second phase flight, use of controls and autopilots and finally, tests on the actual aircraft, closely linked to the model tests.

RP372
AD-445-597
N62-15524
Theory of the Flight of Airplanes in Isotropic Turbulence – Review and Extension. B.ETKIN.
AGARD Rep. 372, 46 pp., 1961.
A brief review of the structure of atmospheric turbulence is followed by two basic methods of analysis (the impulse method, and the Fourier component method including the power series approximation). An extension of the power series approximation is given to cover the case of three gust components. Finally some information is presented on the flight path of a vehicle in isotropic turbulence.

RP373
AD-445-599
N62-15526
Theoretical Study of the Rolling Response of Aircraft to Turbulent Air. J.K.ZBROZEK
AGARD Rep. 373, 41 pp., 8 refs., 1961.
A method is presented for assessing the lateral responses of aircraft to continuous turbulence. The method is applied to the study of rolling behaviour in turbulent air of a range of aircraft configurations. Pilot control is shown to be an essential variable in the study.

RP374
AD-688-677
N62-15163
Statistical Optimization of Guidance by Alignment of a Self-Propelled Missile in the Presence of Noise.
P.LEFEVRE.
AGARD Rep. 374, (in French), 55 pp., 8 refs., 1961.
Advances in servo system synthesis have modified Wiener's theory of linear filters. The statistical method of Newton can be usefully applied in adapting alignment guidance systems to self-propelled missiles. The guidance chain has been optimized using a statistical method to fix the probability of saturation, assuming that the target is capable of steady random and ergodic manoeuvres and that the glint noise is similar to white noise.

RP375
AD-445-598
N62-15477
Techniques and Instrumentation Associated with Rocket Model Heat-Transfer Investigations.
C.B.RUMSEY.
AGARD Rep. 375, 20 pp., 5 refs., 1961.
A discussion of some of the techniques used by NASA associated with model configuration, trajectory planning, model instrumentation, and interpretation of basic heat transfer data and methods of thermal protection. It includes research on the effectiveness of transpiration cooling and instrumentation for the continuous reading of the ablation of Teflon.

RP376
AD-287-535
N62-17201

Techniques for the Investigation of Aerodynamic Heating Effects in Free Flight. J.PICKEN, D.WALKER.
AGARD Rep. 376, 58 pp., 14 refs., 1961.
Describes the methods currently in use for the investigation of acrodynamic-heating phenomena using rocket-propelled free-flight test vehicles. The main object is the measurement of heat transfer, but there are brief comments on some simple methods of assessing ablation effects.

RP377
AD-661-946
N62-15525

Measuring Techniques for Kinetic Heating using the Missile 'Antares'. H.J. Le BOITEUX
AGARD Rep. 377, (in French), 11 pp., 1961.
Describes the techniques employed by O.N.E.R.A. to study kinetic heating phenomena of high-speed re-entry (Mach = 8) into the at mosphere. The Antares 4-stage vehicle was developed for this purpose. Measuring methods especially those for thermal flux are described and discussed. Theoretical and experimental results are compared.

RP378
AD-287-536
N62-17200

Measurements of Dynamic Stability from Three Simplified Free-Flight Models of a Supersonic Research Aircraft (Bristol ER.134) over the Mach number Range 1.2-2.6. K.J.TURNER.
AGARD Rep. 378, 49 pp., 9 refs., 1961.
Values of the lateral stability derivatives were measured on free-flight models of the Bristol E.R.134 for Mach 1.2 to 2.6. These show that the aircraft should be laterally stable up to Mach 2.6 at least, although the free-flight results indicate a some-what smaller stability margin than estimates or wind-tunnel measurements. Additional data were derived from the longitudinal motion.

RP379
AD-285-788
N62-17191

Aerodynamic Stability and Performance Characteristics obtained from Autopilot-Controlled Supersonic Test Vehicles. E.T.MARLEY.
AGARD Rep. 379, 14 pp., 1961.
Supersonic flight test vehicles were used in the early stage of a missile development programme in order to obtain flight aerodynamic information and to confirm estimates from wind tunnel data and theoretical calculations. The flight vehicle discussed is a rocket-propelled high-fineness-ratio body of revolution having four long, very low AR wings in cruciform arrangement placed in line with all-moveable tail control surfaces. The proper deflection of these surfaces controls the vehicle in pitch, yaw and roll.

RP380
AD-285-789
N62-17192

Measurement of Aerodynamic Characteristics of Re-entry Configurations in Free Flight at Hypersonic and Near-Orbital Speeds. R.L.NELSON.
AGARD Rep. 380, 29 pp., 15 refs., 1961.
Presents extensions of techniques developed for aircraft and low-speed missiles made possible by recent theoretical studies of re-entry mechanics and dynamics and their application to flight measurements. Emphasis is placed on the reduction of oscillation data to obtain static pitching moment and damping data. Highly non-linear characteristics are assumed. The technique is shown to be adequate for re-entry configurations trimmed about zero angle-of-attack.

RP381
AD-288-057
N62-17199

Use of Missiles for Vibration Tests in Free Flight. R.DAT.
AGARD Rep. 381, (in French), 22 pp., 1961.
The following topics are considered:– tests in wind tunnels or in free flight, programme for forecasting flutter, design of wing models, different types of rockets used in free flight, measurement of flight parameters, ground measurements, comparison of three types of rocket vehicles, summary of tests carried out.

RP382
AD-285-790
N62-17194

Sounding Rocket Experiments For Meteorological Measurements. W.NORDBERG.
AGARD Rep. 382, 20 pp., 14 refs., 1961.
Rocket flights using Aerobee, Nike-Cajun and similar launch vehicles have been made during the last ten years to measure temperature, pressure, density, wind and atmospheric composition at various altitudes. Sufficient results have been obtained at altitudes below 100 Km at a number of launch sites to indicate that variations of pressure, density, temperature and winds at these altitudes are truly meteorological. The techniques and measurements which led to these results are outlined.

RP383
AD-287-537
N62-17193

Rockets For Use in Upper Atmosphere Research. W.W.BERNING.
AGARD Rep. 383, 28 pp., 14 refs., 1961.
The atmospheric and geophysical properties of the atmosphere above 100 Km and their methods of measurement are discussed, with particular emphasis on the interaction of the sounding vehicle with the properties being measured. The economics of rocket-sounding, including considerations of trajectories, altitudes, vehicle speed and geographical location are also considered.

RP384 **Survey of Activities on Space Research By The Netherlands P.T.S.** L.D. de FEITER.
AD-291-745 AGARD Rep. 384, 9 pp., 1961.
N63-80618 A review of experiments made by the Ionosphere and Radio-Astronomy Section of the Netherlands Postal and Telecommunication Systems. These relate to studies of the ionosphere and also on communication satellites.

RP385 **Some Particular Aspects of the Use of Free-Flight Models in the Netherlands.** G.Y.FOKKINGA.
AD-287-538 AGARD Rep. 385, 23 pp., 1961.
N62-17198 A survey is given of the facilities of the N.L.R. in the field of free-flight models. Ground and airborne measuring equipments are described and particulars of launching, stabilization, control and recovery of the models are discussed. Attention is also given to data processing and a few results of actual flights are included.

RP386 **Functional and Environmental Testing of Spacecraft.** H.I.MAXWELL.
AD-287-539 AGARD Rep. 386, 8 pp., 1961.
N62-17197 The reasons for and the need for such testing are discussed, and the importance of reliability is stressed. Testing is divided into three phases:– development tests, prototype tests, and flight acceptance tests. Some development tests carried out as part of Project Echo are illustrated and described; also included are specifications and descriptions of tests on the S-55 Micrometeoroid satellite.

RP387 **Notes on the Design and Performance of a Three-Stage Rocket Test Vehicle for Aerodynamic Research**
AD-287-540 **at Hypersonic Speeds.** J.A.HAMILTON.
N62-17206 AGARD Rep. 387, 27 pp., 4 refs., 1961.
WRE, Australia and RAE England have jointly sponsored and developed a three-stage rocket test vehicle having as its primary function the extension of free-flight aerodynamic researches up to speeds of 10,000 ft/sec. Two vehicles have been flown successfully. This report gives details of some of the design problems encountered, and describes the engineering and operational aspects of the project.

RP388 **A Study of Sounding Rocket Systems.** K.M.RUSS.
AD-287-541 AGARD Rep. 388, 73 pp., 1961.
N62-17205 Presents for each of 18 existing systems, a short description, a sketch with overall dimensions, weight and maximum acceleration data, and two performance charts – apogee altitude versus payload for various launch angles, and altitude versus time for various payloads at a launch angle of 88 degrees. The aim is to aid in the preliminary selection of a vehicle for a specific payload mission.

RP389 **The Design and Operation of Multi-Stage Rocket Vehicles.** H.F.HALSTED.
AD-287-542 AGARD Rep. 389, 17 pp., 1961.
N62-17203 Reviews certain major interrelationships existing between the various branches of engineering concerned with the design and operation of unguided multi-stage rocket vehicle systems.

RP390 **Aeroelastic Analyses of Multistage Rocket Systems.** J.S.KEITH, J.W.LINCOLN, G.TARNOWER.
AD-287-926 AGARD Rep. 390, 48 pp., 12 refs., 1961.
N62-17864 Outlines the methods that may be used to perform load and stability analyses for multi-stage rocket systems. Design criteria and time domain and frequency domain studies are discussed. Two appendices deal with the derivation of the time domain equations of motion and the method of obtaining the transfer functions of a damped aeroelastic system.

RP391 **Ascent Problems of Sounding Rockets.** N.L.CRABILL.
AD-287-543 AGARD Rep. 391, 13 pp., 10 refs., 1961.
N62-17204 The dynamic stability and wind weighting problems of a spinning sounding rocket are investigated by numerical solution of the six equations of rigid body motion. Transition through the roll resonance régime is discussed, and first stage trajectory dispersions are compared with those actually measured on five vehicles.

RP392 **Efficacy of Different Procedures for Reducing the Dispersion of Experimental Missiles.** M.BISMUT.
AD-288-058 AGARD Rep. 392, (in French), 18 pp., 1961.
AD-442-629 The risks attendant on dispersion increase as the performance of the missile increases. Means to mini-
N62-17865 mize may be based on (i) careful choice of missile characteristics, but the inert missile may still be
N64-28657 capable of inadmissible variation; (ii) impulse-actuated spin may permit of obtaining an accuracy of 1 deg. on the slope of the initial trajectory; (iii) a better precision can be attained by the use of an automatic attitude control by the use of auxiliary jets and a simple servo.

RP393 **Rocket Model Research Instrumentation.** F.B.SMITH.
AD-287-927 AGARD Rep. 393, 22 pp., 1961.
N62-17866 Describes some of the instrumentation which is required, both in the vehicle and on the ground, for aerodynamic experiments using rocket-propelled vehicles. Covers tracking and Doppler radars, airborne telemetry systems, and radiosonde equipment.

RP394 **Data Handling and Processing of Rocket Model Research Data.** P.F.FUHRMEISTER.
AD-287-956 AGARD Rep. 394, 17 pp., 1 ref., 1961.
N62-17919 Discusses techniques and procedures for handling and processing research data received for NASA rocket-propelled model flights. Data handling equipment and techniques used to prepare telemetry, radar theodolite, Doppler radar, and atmospheric survey data for entry into a digital computer are described. Models for digitizing analogue signals recorded on oscillographs and magnetic tape are discussed along with the handling of digital magnetic tape recordings. Equipment and procedures used for computation and machine preparation of graphs and tabulated results for direct insertion into research reports are described.

RP395 **Pressure Probes in Free Molecule Flow.** K.R.ENKENHUS, E.L.HARRIS, G.N.PATTERSON.
AD-287-928 AGARD Rep. 395, 25 pp., 12 refs., 1961.
N62-17920 When the mean free path becomes a significant fraction of a characteristic dimension of a pressure probe, the usual continum formulae relating the measured pressure to the free stream pressure and Mach numbers are no longer valid. This paper treats the case where the mean free path is so large compared with the probe diameter that intermolecular collisions may be neglected. Theoretical expressions are given for the pressure measured in a flowing gas with an orifice probe and a long tube pressure probe. Experimental investigations have been conducted using a low-density wind tunnel and a rotating arm apparatus. Agreement between theory and experiment was quite satisfactory.

RP396 **Special Rockets and Pyrotechnics Problems.** J.G.THIBODAUX.
AD-287-544 AGARD Rep. 396, 17 pp., 1961.
N62-17196 The design, operation and application of various pyrotechnic and auxiliary devices for use on rocket test vehicles, including considerations of safety, failure modes and circuit design, are discussed. The conclusion reached is that the use of small pyrotechnic devices, and auxiliary rocket systems makes possible the programming of nearly all desired functions in a free-flight research model.

RP397 **The Recovery of Flight Test Payloads.** A.M.SMITH, R.F.PECK.
AD-287-929 AGARD Rep. 397, 20 pp., 1961.
N62-17921 A general discussion of recovery system design for ballistic re-entry missiles. System integration is emphasized. Pre-flight development testing and evaluation of the recovery system is described as an important design consideration. The NERV (Nuclear Emulsion Recovery Vehicle) is presented as a typical example of an application of these concepts.

RP398 **Examples of Application of Optical Measuring Methods to Fundamental Aerodynamic Researches.**
AD-415-702 J.L.SOLIGNAC.
N63-18720 AGARD Rep. 398, (in French), 39 pp., 9 refs., 1960.
This report presents the essential features of this work both from the point of view of the apparatus used (the design and development of which are described) and from that of applied research. Some typical results indicate the advantage and the limitations of this particular measuring technique.

RP399 **Methods of Study, By Hydraulic Analogy of Subsonic, Supersonic and Hypersonic Flows.** H.WERLE.
AD-661-947 AGARD Rep. 399, (in French), 45 pp., 42 refs., 1960.
N63-17764 Reviews the characteristics and uses of a number of hydraulic devices, in particular of those used in the Hydraulic Analogy Laboratory of O.N.E.R.A.: hydrodynamic tunnel, supersonic tank ($\gamma = 2$), hypersonic analogy assembly, etc. These items of equipment are used for visualization of the flow around models by means of suitable methods. They have made it possible, in a large number of cases, as shown by the results quoted by way of example, to make a qualitative, or even quantitative contribution to aerodynamic research work carried out by other means.

RP400 **The Experimental and Theoretical Determination of the Elastic Characteristics of Modern Airframes.**
AD-426-282 R.H.GALLAGHER, I.RATTINGER.
N63-86348 AGARD Rep. 400, 64 pp., 1962.
Develops analytical and experimental procedures for structural response in flight régimes from subsonic to hypersonic. The results of model and prototype wing tests are summarized and compared with predictions based on available methods of low aspect ratio wing analysis. Tests were performed in both unheated and heated environments to provide data over a range of geometric parameters. Recent tests relating to a hypersonic wing-body combination are described. A survey is given of promising techniques and future requirements.

RP401 **The Influence of Aerodynamics in Wind Power Development.** E.W.GOLDING.
AD-294-168 AGARD Rep. 401, 45 pp., 47 refs., 1961.
N63-80507 Deals with the characteristics of the wind as a source of power and outlines the methods of obtaining and analyzing wind data. The selection of favourable sites for wind power installations is discussed and followed by notes on the design and performance of windmills. The cost of generating electricity by this means is compared with alternative power sources.

RP402 **The Model-Controlled Method for the Development of Variable-Stability Aircraft.** D.G.GOULD.
AD-411-599 AGARD Rep. 402, 31 pp., 9 refs., 1962.
N63-19110 The application of a technique described as the model-controlled method (termed adaptive or semi-adaptive when applied to autopilots) for providing aircraft with variable stability and control characteristics is described. The development of a variable-stability helicopter using this method is treated in some detail to illustrate the significant design parameters and to demonstrate the advantages of the method over the more customary approach.

RP403 **A Review of In-Flight Simulation Pertinent to Piloted Space Vehicles.** N.A.ARMSTRONG,
AD-410-499 E.C.HOLLEMAN.
N63-18840 AGARD Rep. 403, 19 pp., 14 refs., 1962.
This survey shows how the environment of actual flight may be used to simulate many phases of manned space exploration. A number of simulations using conventional, modified, and specially built aircraft are discussed in relation to the portion of space flight to which they are generally applicable, that is the launch, orbital, entry, or the landing-approach phase. Only the scope of the investigations is indicated; no detailed descriptions of, or conclusions from, the research programme are given. Quantative results may be extracted from the papers mentioned in the references.

RP404 **Vertical Instruments.** J.H.KEARNS, E.WARREN.
AD-410-322 AGARD Rep. 404, 25 pp., 58 refs., 1962.
N63-19500 A discussion of Vertical Scale Instruments covering the historical facts which lead to their design through to their application. The point is made that Vertical Instruments represent the foundation of a new approach to the creation, design and development of displays.

RP405 **Recent Developments in the U.K. in Flight Instruments.** K.R.HONICK.
AD-411-600 AGARD Rep. 405, 27 pp., 2 refs.. 962.
N63-19111 Developments in panel mounted ('head down') flight instruments are described. The achievement of increased integration of instrument indications together with the use of a flight-director indicating demand action by the pilot by instrumental techniques which separate the functions of sensing, computation and display are discussed. Simplifications of the pilot's task by super-position of essential elements of the instrument field on the external field, using optical projection of collimated information onto a reflector plate or the windscreen ('head up' display), is also described.

RP406 **The Case for Adaptive Controls.** M.A.OSTGAARD, E.B.STEAR, P.C.GREGORY.
AD-410-500 AGARD Rep. 406, 25 pp., 22 refs., 1962.
N63-19036 Attempts to show that adaptive control systems are practical, that they have lived up to expectations, and that they represent a significant advance over the conventional linear control systems. To do this, the original problems which led to the initiation of applied research effort on adaptive flight control systems and the expected solutions from this research are reviewed along with certain pertinent historical aspects of linear feedback control theory. A typical flight control problem for re-entry vehicles is described, the conventional linear and the adaptive solutions to this problem are discussed in detail, and a practical mechanization of an adaptive flight control system for this application is described in some detail. Also some other promising adaptive techniques and their expected potential are discussed.

RP407 **Locating and Synchronizing Flight Research Tracking Stations.** E.DURBIN.
AD-434-010 AGARD Rep. 407, 56 pp., 18 refs., 1962.
N64-10073 Mobile tracking ships are being used to an increasing extent in support of astronautical operations. Here, the accuracies of several basic systems for determining ship's position and local time are presented. Positioning systems analyzed are: (i) inertial, (ii) astronautical (radio-optical), (iii) radio, (iv) sonar bench marks, (v) satellite (Transit); the timing systems analyzed are (i) timing signals from station WWV, (ii) VLF time system, (iii) Loran-C, (iv) WOSAC (World-wide Synchronization of Atomic Clocks), (v) Transit. Ship velocity determination is also considered.

RP408 **Recommendations for V/STOL Handling Qualities.**
(See also AGARD Rep. 408, 34 pp., 1962.
RP577) Presents the recommendations of a Working Group sponsored by the AGARD Flight Mechanics Panel, on desirable handling qualities for military V/STOL aircraft. The recommendations, which are necessarily tentative, particularly as regards their application to large aircraft, are based in some respects on requirements for U.S. military helicopters, but considerable use has been made of the results of flight assessments of handling qualities of a number of V/STOL research aircraft.

RP408A
AD-661-748
N65-28861
(See also RP577)

Recommendations for V/STOL Handling Qualities (with an Addendum Containing Comments on the Recommendations).
AGARD Rep. 408A, 64 pp., 1964.
This report presents the recommendations of a Working Group sponsored by the AGARD Flight Mechanics Panel on desirable handling qualities for military V/STOL aircraft (previously published in Report 408), together with an addendum giving comments made by the V/STOL Handling Qualities Technical Assistance Panel. Five appendices, also included for the first time, give further comments from various sources.

RP409
AD-422-560
N64-10133

Ground Proximity and the VTOL Aircraft. P.E.COLIN.
AGARD Rep. 409, 33 pp., 59 refs., s.d.
This report reviews experimental work, both model and full-scale, carried out or currently in progress in the NATO countries, to determine the ground effects associated with VTOL aircraft operating close to the ground. It also contains comments on areas where further research and development would be valuable. The survey includes problems of ground erosion, re-circulation and the aerodynamic pressure distribution on the aircraft in the presence of the ground. The VTOL aircraft considered are those using free-propeller or ducted-fan systems or hot-jet lifting engines.

RP410
AD-410-498
N63-18723

Cyclic Temperature Effects on Materials and Structures. J.A.DUNSBY.
AGARD Rep. 410, 23 pp., 56 refs., 1962.
A review is made of the present state of knowledge on cyclic temperature effects on materials and structures. Suggestions are made for further research.

RP411
AD-438-907
N64-19922

Medical Indoctrination for Flyers – An Aeromedical Handbook for Aircrews.
AGARD Rep. 411, 111 pp., 1963.
This handbook is designed to provide aircrews with a more complete understanding of the biological sciences affecting present-day flying. It is not an exhaustive treatment of all the aeromedical factors and aircrews should discuss any questions arising with their own flight surgeons. The material is taken almost verbatim from Royal Canadian Air Force Pamphlet 69, 'Fit to Fly'.

RP412
AD-422-499
N64-10258

Critical Study on Fatigue Crack Propagation. W. BARROIS.
AGARD Rep. 412, 50 pp., 36 refs., 1962.
Stress pattern around a crack (solution for an infinite plate, solution for a finite plate); the physical process of fatigue and crack propagation; crack propagation (the Weibull and Heywood tests, form of correlation of K and dl/dn, relation of l to dl/dn, dispersion-tests by Sud-Aviation, the influence of alternating stresses and of the material, influence of overloading/preloading, influence of test frequency, scale effect).

RP413
AD-426-374
N64-13151

The Problems of Designing for the Take-Off and Landing of High-Speed Aircraft. A.N.CLIFTON.
AGARD Rep. 413, 14 pp., 1963.
An introduction to the series of papers given at the 9th Meeting of the Flight Mechanics Panel discussing generally a number of take-off and landing problems.

RP414
AD-426-377
N64-11907

Aerodynamic Aspects of Boundary Layer Control for High Lift at Low Speeds. J.WILLIAMS, S.F.J.BUTLER.
AGARD Rep. 414, 69 pp., 32 refs., 1963.
Usefulness of boundary-layer control (BLC) at the knee of a trailing-edge flap, over the wing nose close to the leading edge or at the knee of a leading-edge flap. Methods of providing BLC (slot blowing, slot suction, area suction, inclined air-jets, and specially-designed aerofoil shapes). The aerodynamic aspects of slot blowing over trailing-edge flaps and the wing nose are examined in detail; slot suction and area suction are also considered. The associated practical design features required for good performance are discussed and flight-handling implications are mentioned.

RP415
AD-426-375
N64-11908

Thrust Reverser Performance and the Ingestion Problem. D.M.BROWN.
AGARD Rep. 415, 30 pp., 1963.
The ingestion of gas or stones may severely limit thrust reverser effectiveness and also prove extremely expensive to the airline operator in engine repairs if it is not dealt with during power plant design. A method of simulating the problem at model scale has been established and confirmed by full-scale results on several transports powered by Rolls-Royce engines.

RP416
AD-426-376
N64-13172

Implications of Recent Investigations on Runway Roughness Criteria. T.L.COLEMAN, A.W.HALL.
AGARD Rep. 416, 20 pp., 7 refs., 1963.
Results obtained from recent National Aeronautics and Space Administration investigations of runway roughness are discussed. These results are used to assess the adequacy of runway roughness criteria based on power spectral density techniques. In addition, an analytical method for studying repairs to unsatisfactory runways is described.

RP417
AD-426-283
N64-11806
The Problems of Exact Calculation of Take-Off and Landing Characteristics of Conventional Transport Aircraft. E.OVERESCH.
AGARD Rep. 417, 18 pp., 1963.
The ground roll, transition, and steady-climb phases of conventional take-off calculations often ignore certain factors which are of relatively little importance for small aircraft and long take-off runs, but which may be significantly important for large aircraft and short take-off runs. These factors, and the effect of taking account of them in the take-off and landing calculations, are discussed.

RP418
AD-427-675
N64-13877
A Method of Evaluating Runway Friction for the Prediction of Actual Take-Off Runs. G.CIAMPOLINI.
AGARD Rep. 418, 10 pp., 1963.
Describes a method of obtaining practical values of the rolling coefficient of friction immediately before take-off, and allows preliminary calculations to be made, using simple nomograms, of the actual ground-run distances for the atmospheric and ground conditions prevailing at the time.

RP419
AD-426-284
N64-11950
The Provision of Adequate Lateral Control Power for Landing Approach Conditions. G.A.PATTERSON, W.SPANGENBERG.
AGARD Rep. 419, 12 pp., 1963.
An investigation at the Naval Air Test Center has attempted to correlate the measured rolling performance of both large and small aircraft in the landing approach conditions with pilot opinion regarding adequacy of lateral control power to pick up a wing or to maintain the desired flight path in the presence of turbulence or crosswinds. This paper describes the NATC investigation and tentative flight test results obtained, in relation to current flying qualities specification requirements. Bank angle changes at the end of one second of 20 deg. for carrier-based aircraft and 8 deg. for land-based aircraft are suggested as criteria for lateral control power in the landing approach condition.

RP420
AD-426-378
N64-11991
Flight Measurements of the Influence of Speed Stability on the Landing Approach. K.J.STAPLES.
AGARD Rep. 420, 24 pp., 5 refs., 1963.
A small delta aircraft was used to study the effects of speed instability on the pilot workload and accuracy in the approach task. Speed instability was produced by the use of a reversed autothrottle which varied thrust with airspeed and/or incidence. Glide path control was by radio talkdown, based on information from either a tracking theodolite or normal airfield radar. It was concluded that mean square throttle movement is a useful guide to the effect of speed stability on the difficulty of the approach, and corresponds with pilot ratings; there are indications that throttle movements are unaffected by the type of talkdown control, whereas elevator, speed, and glide path measurements are altered appreciably.

RP421
AD-427-670
N64-13878
Features of Large Transport Aircraft Affecting Control During Approach and Landing.
W.J.G.PINSKER.
AGARD Rep. 421, 33 pp., 10 refs., 1963.
These features are shown to be largely associated with growth in size and with the trend to configurations extending predominantly in the fore and aft direction. These 'inertially' or 'dynamically' slender aircraft, tend to combine slow response in pitch with lively behaviour in roll. In the longitudinal plane there appears to be increased demands on the pilot's judgement in the approach, and accuracy might be maintained by the use of a simple director aid. Satisfactory lateral control in crosswinds depends on $(-l_v)$ being kept small and on the provision of powerful and fast-responding ailerons; and possibly roll-stabilization. Many of the phenomena discussed cannot be resolved by theoretical analysis alone and simulator investigations are planned.

RP422
AD-428-750
N64-13879
Ground Run Prediction. D.A.RUSH.
AGARD Rep. 422, 14 pp., 1963.
The problem of monitoring aircraft performance during take-off ground run and indicating whether or not the take-off can be made safely is considered in relation to the take-off procedure commonly employed by the operators of transport aircraft. Equipment is described which has been developed around the operational concepts outlined. The equations of prediction, the component parts of the predictor and the methods that can be employed to measure aircraft motion are described. Applications of the equipment to emergency stop, taxi and landing are also considered.

RP423
AD-426-286
N64-11909
United States Navy Pilot Controlled Landing Procedure and Associated Equipment. J.H.NELSON, G.M.GRIFFIN.
AGARD Rep. 423, 15 pp., 1963.
The constant glide slope power approach to landing is defined as establishing the aircraft in the desired landing condition early in the landing manoeuvre and maintaining this condition to touchdown. Reasons for the U.S. Navy adopting this procedure are advanced. The applicability of the procedure to non-carrier-based fixed-wing aircraft is discussed. Various optical and electronic devices, including an approach power compensator, which can aid the pilot in executing the discussed procedure are fully described. The effectiveness of each device, is delineated.

RP424 **Some Aspects of Automatic Flareout Performance.** J.E.NETHAWAY.
AD-428-751 AGARD Rep. 424, 20 pp., 6 refs., 1963.
N64-13880 The principles of the B.L.E.U. flareout system are explained and some typical flight and analogue computer records of autoflares are presented. The effect of wind variation is discussed. Difficulties which may be experienced include unfavourable ground effect, loss of lift from the throttling of large propeller engines and excessive nose-down attitude during approach. Examples are shown which indicate their effect on the automatic flare.

RP425 **APN-114 Manual and Automatic Landing System: Terminal Control Theory, System Integration**
AD-427-674 **Concepts, Flight Test Results, and Future Developments.** D.D.FARNUM. J.W.MONTOOTH.
N64-13447 AGARD Rep. 425, 34 pp., 8 refs., 1963.
Describes the theory and operation of the APN-114 Automatic and Manual All-Weather Landing System. Results of flight test programme, utilising the Convair TF-102A and the Boeing 707-80, are presented. Possible system building blocks, including advantages and disadvantages, are noted. Also, areas which require additional research and development are briefly discussed.

RP427 **The Landing of Advanced Flight Vehicles.** D.B.SEAGER.
AD-428-752 AGARD Rep. 427, 13 pp., 1963.
N64-13881 Summarizes the results of a study by the Lockheed Co. of some problems associated with the landing of manned advanced flight vehicles (i.e. re-entry and hypersonic cruise vehicles). Means of defining satisfactory configurations developed during the investigation are discussed.

RP428 **Horizontal Landing Techniques for Hypersonic Vehicles.** R.G.HOEY.
AD-428-753 AGARD Rep. 428, 11 pp., 1963.
N64-13882 The terminal approach and landing techniques being used for the X-15 hypersonic research vehicle are described. The development of these techniques and some flight test results are discussed. The effects of wing loading, lift-drag ratio, visibility, handling qualities, speed brakes, and trim changes are analyzed as they pertain to low L/D landings of the X-15 and other hypersonic configurations. The use of an in-flight landing simulator to provide pilot training and maintain pilot proficiency is emphasized.

RP429 **Investigations on the Ground Performance of Aircraft Relating to Wet Runway Braking and Slush Drag.**
AD-427-669 U.T.JOYNER, W.B.HORNE, T.J.W.LELAND.
N64-13883 AGARD Rep. 429, 34 pp., 12 refs., 1963.
A review is made of recent U.S. research on the ground performance of aircraft. The NASA Landing Loads Track at the Langely Research Center is briefly described, together with its capabilities. Various factors affecting landing and take-off distances are discussed and performance calculations given for a typical jet transport showing the effect of runway slush. Areas of interest for future research are indicated.

RP430 **The Use of Piloted Flight Simulators in Take-Off and Landing Research.** G.E.COOPER.
AD-426-285 AGARD Rep. 430, 30 pp., 10 refs., 1963.
N64-11910 The use of such simulators is discussed from the research pilot's viewpoint. Examples taken from recent landing studies at the Ames Research Center are presented to illustrate and define the value and limitations found in various types of simulators. The simulators used are classed as either part-task or whole-task simulators, reflecting the simulator sophistication and purpose.

RP431 **A Flight Test Method for the Evaluation of Approach and Runway Lighting Effectiveness.**
AD-431-316 T. van OOSTEROM.
N64-16291 AGARD Rep. 431, 18 pp., 2 refs., 1963.
Describes a flight operational method for evaluating the effectiveness of visual approach and landing aids. The method is based on a quantitative appraisal of the guidance obtained from a given configuration of lights; tests are performed on a statistical basis.

RP432 **Simulator Assessments of Take-Off and Landing.** A.G.BARNES.
AD-427-667 AGARD Rep. 432, 16 pp., 1963.
N64-13884 The value of flight simulators in assessing take-off and landing characteristics of aircraft in the design stage is discussed. Problems associated with such simulation fall into two classes – computation and presentation. Possible solutions to some of these problems are presented, based on experience in a fixed-base simulator.

RP433 **Noise and Its Effect on Aircraft Operation.** G.M.COLES.
AD-427-666 AGARD Rep. 433, 18 pp., 1963.
N64-13942 Reviews the two main forms of engine noise: jet noise and compressor noise. In the inflight operation of a particular aircraft the three factors most significantly affecting community noise level are altitude, airspeed and power setting. As each of these factors affects each form of noise generation in a different way, a considerable investigation of possible take-off techniques must be carried out in order to achieve the maximum community benefit from special procedures.

RP434 **Note on the Evaluation of Runway Length Necessary for Take-Off and Landing.** J.GREMONT.
AD-428-754 AGARD Rep. 434, 8 pp., 1963.
N64-14215 For several years work has been carried out on the measurement and the calculation of wheel-braking distances of aircraft on wet runways. These results are summarized and the conclusions to be drawn from them are delineated.

RP435 **The Stopping of Aircraft on Landing.** E.RACCA.
AD-431-317 AGARD Rep. 435, (in French), 15 pp., 1963.
N64-17540 The use of stop-barriers for arresting aircraft during landing when the aircraft braking system has failed or proved inadequate is considered. The characteristics (general, mechanical, and geometrical) required of such barriers are first examined, and then problems related to their use are discussed.

RP436 **Lowering of Minimum Weather Conditions for the Landing of Transport Aircraft.** R.LARRIEU.
AD-428-755 AGARD Rep. 436, (in French), 5 pp., 1963.
N64-14216 The minimum meteorological conditions (of visibility and cloud ceiling) for landing depend upon several factors. Here, only the case of a transport aircraft making an ILS approach is considered. Accuracy and safety requirements which must be fulfilled in lowering of the minimum weather conditions are examined.

RP437 **The Case for Variable Geometry.** A.WADKOVSKY.
AD-427-676 AGARD Rep. 437, 20 pp., 1963.
N64-13934 Discusses the case of the variable-geometry wing, primarily from the viewpoints of design and cost. Also discussed are such items as maintenance, structural complexity flutter, weight penalty, and external stores arrangement. A comparison is made between two designs which are identical except that one has a fixed wing and the other a variable-geometry wing.

RP438 **Some Structural and Aerodynamic Considerations of Variable Sweep.** A.N.CLIFTON.
AD-427-673 AGARD Rep. 438, 12 pp., 1963.
N64-14414 Discusses a number of considerations in connection with variable-sweep aeroplanes, particularly the question of where the pivot should be located. As well as the main advantages to be gained from matching sweep angles to speed, some less obvious possibilities of adjusting trim drag and stability, and a new method of lateral control at high sweep angles are presented.

RP439 **Flight Testing of a Variable Sweep Wing Aircraft.** C.H.MEYER.
AD-427-672 AGARD Rep. 439, 16 pp., 1963.
N69-80411 The flight-test programme developed for the Grumman XF10F variable-sweep-wing aircraft is described. A comparison is made with the McDonnell F3H aircraft, developed during the same time period.

RP440 **Study of Atmospheric Turbulence at Very Low Altitude.** J.PERROCHON.
AD-436-682 AGARD Rep. 440, (in French), 41 pp., 1963.
N64-19093 A report of research programme carried out in France into the characteristics of very low altitude turbulence and aircraft response to this turbulence. The objects of the programme were (i) to determine the static characteristics of low altitude atmospheric turbulence, and the corresponding loads experienced on aircraft, and (ii) to investigate the response of aircraft of various planforms to these gusts. The experimental method is described but evaluation of the results has not been completed.

RP441 **Measurement of Atmospheric Turbulence at Very Low Altitude and High Speed.** J.ANGELINI.
AD-431-318 AGARD Rep. 441, (in French), 4 pp., 1963.
N64-17541 During the year 1962, the Technical and Industrial Administration of Aeronautics of the French Official Services decided to undertake a project for measuring atmospheric turbulence, the aim being to study the behaviour of pilots and aeroplanes during very low altitude missions. This report briefly describes this project.

RP442 **Aircraft Tests in High-speed Low-level Flight, Including Impressions of a Spring Mounted Seat.**
AD-431-319 T.H.KERR, J.E.NETHAWAY, H.W.CHINN.
N64-16662 AGARD Rep. 442 33 pp., 4 refs., 1963.
An investigation of terrain-following flying at high speeds on a Hunter aircraft is described and examples are given of the flight paths achieved and the normal accelerations developed. Fatigue meter data are used to provide a measure of flight bumpiness and show good correlation with pilots' opinions. The possible effects of aircraft structural vibrations on crew comfort are considered and results given of tests made on a Canberra aircraft to assess the usefulness of a spring-mounted seat, for a range of frequencies and damping. Impressions of comfort on both aircraft correlate well with the rms of rate-of-change of acceleration.

RP443 **Low-Altitude, High-speed Handling and Riding Qualities.** R.C.A'HARRAH.
AD-431-320 AGARD Rep. 443, 44 pp., 13 refs., 1963.
N64-16292 The results of a combined flight and ground-based dynamic flight simulator study of the handling and riding qualities problems associated with low-altitude, high-speed flight are presented. Wide variations of the longitudinal stability and control characteristics, which can be considered representative of current and future strike aircraft, were pilot evaluated. The influence of these stability and control characteristics, as well as the effects of low-altitude turbulence on the pilots' terrain following performance, were measured. The results of this comprehensive investigation are presented in terms of iso-opinion and iso-performance boundaries defining the desired and required combinations of stability and control parameters for low-altitude, high-speed flight.

RP444 **Investigations on the Dynamic Stability of Personnel Guide Surface Parachutes.** R.LUDWIG, W.HEINS.
AD-436-670 AGARD Rep. 444, 20 pp., 9 refs., 1963.
N64-18716 To investigate the dynamic stability the system of the non-linear equations of motion is derived and integrated by electronic computers for a number of examples of personnel guide surface parachutes. The influence of the suspension line length, porosity of canopy, weight of load and apparent mass on the dynamic behaviour are studied. The results show that the oscillations of parachutes cannot be described by linearized equations of motion. With increasing porosity of the canopy, the damping increases and the oscillation period decreases.

RP445 **A Supersonic Parachute Based on the Inlet Diffuser Concept.** H.G.HEINRICH.
AD-431-321 AGARD Rep. 445, 31 pp., 9 refs., 1963.
N64-16298 Several aerodynamic principles are postulated and explored which in connection with a related combination of a solid cone and a flexible canopy lead to the development of an aerodynamic decelerator, called the Supersonic Guide Surface Parachute.

RP446 **Earth-Landing Systems for Manned Spacecraft.** J.W.KIKER, J.B.LEE, J.K.HINSON.
AD-427-671 AGARD Rep. 446, 43 pp., 14 refs., 1963.
N64-13448 The development and qualification programme of the Mercury spacecraft landing system, the impact skirt attenuation system, and the deployment methods are discussed. A summary of the parachute performance obtained from the development and qualification test programme is presented, together with the results of the performance of the landing system for the five manned Mercury flights. The design objectives and guidelines for the two-manned Gemini and the three-manned Apollo Command Module spacecraft are then described and their current status is discussed. A brief description of rotors, controllable parachutes, and combination of controllable parachutes and retrorockets for soft-landing applications to future spacecraft is also presented.

RP447 **NASA Variable-Geometry Research.** T.A.TOLL, E.C.POLHAMUS, W.S.AIKEN, Jr.
AD-431-322 AGARD Rep. 447, 15 pp., 1963.
N64-16538 The past, present, and probable future research activities of NASA with respect to applications of variable geometry are outlined. A general discussion is given of the reasons for considering variable geometry. Past developments are summarized to show how they have resulted in increased operational flexibility of aircraft. Emphasis is placed on the variable-sweep programme. The historical aspects and objectives of this activity are described briefly. The scope of the NASA programme with respect to configurations, mission studies, structures, mechanisms, flutter, and piloting problems is outlined. Future applications of variable geometry to both aeronautics and space programmes are indicated.

RP448 **Jet Noise.** M.J.LIGHTHILL.
AD-431-323 AGARD Rep. 448, 33 pp., 30 refs., 1963.
N64-16293 The acoustic efficiency of undisintegrated jets depends principally on the ratio M of the jet speed to the atmospheric speed of sound, varying approximately as $10^{-4} \times M^5$ for low M but being constant (about 0.006) for high M, and changing from one form to the other rather abruptly around M = 2. Improved measurement of jet turbulence and an improved theory of the acoustic radiation from eddies convected at speeds exceeding the atmospheric sound speed are used to show how this form of acoustic efficiency variation and the associated changes in directional distribution and frequency spectrum, can be explained in terms of a comprehensive theory, which represents a jet as a distribution of acoustic quadrupoles in an otherwise undisturbed atmosphere, the quadrupole strengths being well correlated only within convected eddies of limited extent and limited lifetime. Discussion.

RP449 **Measurements of Near Field Pressure of Subsonic Jets.** E.MOLLO-CHRISTENSEN.
AD-431-324 AGARD Rep. 449, 47 pp., 18 refs., 1963.
N64-16294 Describes a series of measurements of pressure space-time covariance in the near field of several subsonic jets. The data include measured mean flow data, turbulence levels, and power spectral densities of the pressure field outside the jet. Among the obvious conclusions is the fact that the far field is first established for high frequencies as the distance between jet and detector is increased. A

less expected result is the long correlation distances for the larger eddies and the strong correlation across a diameter observed, both in the transitional régime and in the fully turbulent domain. The correlation measurements show a distinction between phase velocity and group velocity of large scale disturbances. Discussion.

RP450
AD-436-671
N64-18720

Turbulence in the Noise-Producing Region of a Circular Jet. P.BRADSHAW, D.H.FERRISS, R.F.JOHNSON.
AGARD Rep. 450, 81 pp., 32 refs., 1963.
Measurements in a 2 in. cold air jet at M = 0.3 have shown that about a quarter of the Reynolds shear stress is produced by large eddies with a rather narrow range of wavelengths. These eddies take the form of mixing jets, inclined to the radial direction in any cross-sectional plane and appear to dominate the near-field pressure fluctuations. Artificial modification of these well-defined eddies seems to offer the best hope of increasing the jet mixing rate and permitting noise reduction by the use of acceptably short ejector shrouds. Experiments on the discrete-frequency howling of ejector shrouds show that the acoustic efficiency reaches a maximum at primary jet Mach numbers of only about 0.3. An explanation and possible methods for alleviating howling are suggested.

RP451
AD-436-672
N64-18721

Statistical Properties of the Turbulent Velocity Fluctuations in the Mixing Region of a Round Subsonic Jet. P.O.A.L.DAVIES, M.J.FISHER.
AGARD Rep. 451, 28 pp., 11 refs., 1963.
Gives the results of an experimental study of the structure and characteristics of the turbulent velocity fluctuations in the mixing region of a jet. These are presented as probability distribution functions of the velocity, or, more simply, as flatness and skewness factors. Discussion.

RP452
AD-436-673
N64-18722

Velocity Correlation Measurements in the Mixing Region of a Jet. M.A.KOLPIN.
AGARD Rep. 452, 17 pp., 1 ref., 1963.
Measurements of space-time correlations of the u-component of turbulence in the mixing region of a jet are presented. It is shown that the longitudinal correlation functions depend only on non-dimensional quantities.

RP453
AD-436-674
N64-31296

Wall-Pressure Fluctuations and Pressure-Velocity Correlations in Turbulent Boundary Layers. J.S.SERAFINI.
AGARD Rep. 453, 63 pp., 38 refs., 1963.
Measurements were made at a nominal free-stream Mach number of 0.6 and an average Re per foot of 3.45×10^6 in a wind-tunnel facility specially designed for the purpose. The pressure fluctuations were measured with miniature pressure transducers and the velocity fluctuations with hot-wire anemometers. Measurements of the correlations of the wall-pressure fluctuations with the longitudinal component of the velocity fluctuations indicate that the contributions to the former are from the inner region near the wall and an outer region linked with the intermittency.

RP454
AD-438-848
N64-19937

Wall Pressure Fluctuations under Turbulent Boundary Layers at Subsonic and Supersonic Speeds. G.M.LILLEY.
AGARD Rep. 454, 48 pp., 28 refs., 1963.
Reviews the theory of wall pressure fluctuations in incompressible flow, and shows how the character of the pressure fluctuations changes in passing from the flow to the wall. Attention is drawn to the more important interactions giving rise to the pressure fluctuations, as well as to the region of the boundary layer mainly responsible for the wall pressure fluctuations. The work is extended to include the effects of compressibility.

RP455
AD-431-325
N64-16313

Properties of the Fluctuating Wall-Pressure Field of a Turbulent Boundary Layer. M.K.BULL.
AGARD Rep. 455, 34 pp., 5 refs., 1963.
The results of measurements of various statistical properties of the fluctuating wall-pressure field associated with turbulent subsonic boundary layer flow in conditions covering a range of values of boundary layer thickness and flow speed are given. The measured quantities include overall rms pressures, frequency spectra, and longitudinal and lateral space-time correlations in both broad and narrow frequency bands. Some experimental values of space-time correlation between wall-pressure fluctuations and turbulent velocity fluctuations at various positions in the boundary layer are also presented.

RP456
AD-436-675
N64-17234

Measurements of the Correlation between the Fluctuating Velocities and the Fluctuating Wall Pressure in a Thick Turbulent Boundary Layer. W.W.WILLMARTH, C.E.WOOLDRIDGE.
AGARD Rep. 456, 62 pp., 23 refs., 1963.
Turbulent motion in a thick (5 in.) boundary layer with zero longitudinal pressure gradient which is produced by natural transition on a smooth surface was studied. Measurements were made of the space-time correlation between the fluctuating wall pressure and the fluctuating velocities in the layer and between the fluctuating wall pressure and the time derivative of the fluctuating velocity normal to the wall.

[illegible]
AD-436-650
[illegible]

On Convection Velocities in Turbulent Shear Flows. J.A.B.WILLS.
AGARD Rep. 457, 30 pp., 17 refs., 1963.
It is shown how the usual approach through properties of the space-time correlations, to the convection velocity of turbulent motions in jets and boundary layers leads to difficulties of interpretation when the flow departs from rigid convection. A more rigorous approach in terms of a wave-number/velocity spectrum overcomes the difficulties, and allows the definition of a wave-number-dependent convection velocity that is relevant to studies of aerodynamic noise and wave generation in panels and in water. A simple experimental method for obtaining the spectrum is described, the measurements are presented for various radial positions in the shear layer of a circular jet, and for pressure fluctuations under a turbulent boundary layer.

RP458
AD-431-326
[illegible]

Surface Pressure Fluctuations Produced by Attached and Separated Supersonic Boundary Layers.
A.L.KISTLER.
AGARD Rep. 458, 26 pp., 7 refs . 1963.
Measurements were obtained of the pressure fluctuations on a solid surface immersed in a supersonic stream up to Mach 5.0. The pressures resulting from both the attached and separated turbulent boundary layers were investigated. The results for these two cases are presented and discussed. Discussion.

RP459
AD-436-670
[illegible]

Thoughts on the Problem of Aerodynamic Noise Sources Near Solid Boundaries.
J.E.FFOWCS WILLIAMS.
AGARD Rep. 459, 29 pp., 20 refs., 1963.
Deals with a development of Curle's equations governing sound radiated by surface dipoles, which establishes, directly from those equations, the reflection phenomenon first noted by Powell. The development is for a particular situation, not easily treated by Powell's result, that of a turbulent boundary layer on a rigid flat plate radiating sound to a point so distant that the surface appears small.

RP460
AD-431-327
[illegible]

Incompressible Flows and Sound Radiation. A.R.PATERSON.
AGARD Rep. 460, 10 pp., 8 refs., 1963.
Examines the effect of compressibility on the generation of sound. Lighthill's theory effectively uses the turbulence as a small perturbation in a radiation field; this report uses the compressibility as a small perturbation in a turbulent flow. The results differ slightly and can be explained physically. Discussion.

[illegible]
AD-443-152
[illegible]

Recent Experimental Investigations of the Scattering of Sound by Turbulence. D.W.SCHMIDT.
AGARD Rep. 461, 23 pp., 7 refs., 1963.
Experimental investigations of the scattering of sound by turbulence were performed in a wind tunnel. Recent theoretical predictions concerning the sound attenuation were confirmed and partly extended by the measurements. In the range of the parameters which is of interest for practical applications the most important results obtained are the proportionality of the sound attenuation to the square of the sound frequency and to the square of the turbulent Mach number. A formula is derived from which the turbulent attenuation of directed sound (such as aircraft noise in the free atmosphere) can be calculated. A method for measuring large phase variations is described in preliminary form.

[illegible]

The Physical Picture of Flow Noise. E.J.SKUDRZYK, G.P.HADDLE.
AGARD Rep. 462, 37 pp., 1963.
Measurements were performed in the water tunnel and with the aid of buoyant units. The effect of surface roughnesses was studied with a rotating cylinder. Special attention is given to radiated noise, since hydrophones used in underwater acoustics are relatively large and record the radiation noise only. Flow noise was reduced by tripping the boundary layer by coating the surface with sound-absorbent varnishes. It seems probable that flow noise can be reduced by reducing wall vibrations. Discussion.

The Calculation of the Fluctuating Lift on a Circular Cylinder and its Application to the Determination of Aeolian Tone Intensity. J.H.GERRARD.
AGARD Rep. 463. 16 pp., 18 refs., 1963.
The formation of vortices behind a circular cylinder in incompressible flow is discussed both physically and theoretically. A comparison is made between theoretical and experimental values of the oscillating lift experienced by the cylinder. The variation of aeolian tone intensity with Reynolds number is discussed and related to the oscillating lift and the correlation length of fluctuation at points separated along the length of the cylinder.

RP464 **Measurements of Fluctuating 'Static' and Total-Head Pressure in a Turbulent Wake.** M.STRASBERG.
AD-436-678 AGARD Rep. 464, 26 pp., 15 refs., 1963.
N64-18717 The spectra of pressures have been measured in the turbulent wake behind a cylinder, at subsonic velocities and Re from 10^4 to 10^5, based on cylinder diameter. The spectra of the pressure are of the same form as the spectra of the longitudinal velocity fluctuations. The observed spectral magnitudes are compared with theoretical estimates. Possible sources of error in the fluctuating pressure measurements are evaluated. Discussion.

RP465 **An Experimental Investigation of Turbulence-Excited Panel Vibration and Noise (Boundary-Layer Noise).** M.Y. el BAROUDI, G.R.LUDWIG, H.S.RIBNER.
AD-435-911 AGARD Rep. 465, 33 pp., 17 refs., 1963.
N64-18992 A detailed study has been made of the flexural motion and noise generated by 11 x 11 inch steel panels flush-mounted in the wall of a turbulent flow channel. The mean square exciting pressure fluctuation at the wall, its spectral density, and two-point correlations of the pressure were measured with the use of pinhole microphones. The flexural response of sample panels was studied by correlation techniques. Discussion.

RP466 **Mechanisms of Aerodynamic Sound Production.** A.POWELL.
AD-431-329 AGARD Rep. 466, 20 pp., 21 refs., 1963.
N64-16540 The subject is treated mathematically under the following headings: vortex rings and dipole radiation; vortex motion and quadrupole radiation; resonating flow.

RP467 **Recent Free-Flight Boundary-Surface Aerodynamic Noise Measurements.** I.E.GARRICK, D.A.HILTON, H.H.HUBBARD.
AD-436-680 AGARD Rep. 467, 40 pp., 17 refs., 1963.
N64-32386 Measurements of fluctuating pressures due to airflow over surfaces include data from aircraft, missiles and space vehicles for wide ranges of dynamic pressure and Re for subsonic and supersonic speeds. Several sources of turbulence that result in severe vehicle loads and vibration environments are discussed, including results for surface flow conditions of developed boundary-layer turbulent flows and others for buffeting types of flow. Also included is brief mention of recent information on the large-scale turbulence characteristics of the atmosphere. Discussion.

RP468 **Some Practical Applications of Boundary Layer Pressure Fluctuation Work.** E.J.RICHARDS, P.E.DOAK.
AD-436-681 AGARD Rep. 468, 39 pp., 12 refs., 1963.
N64-18725 Presents a general description of some practical applications of boundary layer pressure fluctuation work, and aims at indicating the next steps which need to be examined in the overall problem of boundary layer noise. The first problem dealt with is that of the metal fatigue of structures due to turbulent boundary layer pressure fluctuations on high speed airliners. Internal noise levels in aircraft cabins are then discussed, and the method of calculation, or lack of method, is commented upon. The noise radiated from the boundary layer in two specific cases is considered; (i) the radiated noise from an axial compressor; (ii) the radiated noise from a submarine hull.

RP469 **Future Research on Noise.** J.J.GINOUX (Editor).
AD-438-929 AGARD Rep. 469, 36 pp., 1963.
N64-19853 A round table discussion held during the Specialists' Meeting on 'The Mechanism of Noise Generation in Turbulent Flow' sponsored by the AGARD Fluid Dynamics Panel, at the Training Centre for Experimental Aerodynamics, Rhode-Saint-Genèse, Belgium, 1-5 April 1963. A series of questions and answers followed by an open discussion and statements of intentions regarding future work in this field.

RP470 **Models for Helicopter Dynamic Stability Investigations.** L.R.LUCASSEN, F.J.STERK.
AD-438-930 AGARD Rep. 470, 9 pp., 1963.
N64-19891 A mathematical model is described, which was devised for improving the physical understanding of helicopter dynamic instability in hovering (two degrees of freedom). A demonstration model was built according to this principle. The influence of parameters, artificial stabilization and sling load on the dynamic characteristics is shown. (A short 16 mm film is available).

RP471 **A Rationale for the Determination of Certain VTOL Handling Qualities Criteria.** T.E.LOLLAR.
AD-815-718 AGARD Rep. 471, 32 pp., 17 refs., 1963.
N64-19854 Describes the results obtained in VTOL handling quality studies utilizing fixed-base simulators under instrument flight conditions. Simulation techniques are described which give reliable results when operated by experienced pilots. The approach to handling qualities criteria is made utilizing servo-analysis techniques and measurements of the pilot describing function.

RP472 **Review of Hovering Control Requirements for VTOL Aircraft by a Flight Dynamics Analysis.**
AD-438-878 H.M.DATHE.
N64-19855 AGARD Rep. 472, 26 pp., 8 refs., 1963.
In accordance with AGARD recommendations for handling qualities in hovering flight, the control power and control thrust requirements for aircraft gross-weights between 1 and 100 tons are estimated using statistical data for the moments of inertia. The results are compared with an analysis of the aircraft motions following disturbances and control inputs and with the manoeuvre capability. The effects of damping, dead time, gust level, etc., are investigated and some control system design criteria are obtained.

RP473 **The Interest of Aeronautical Engineers in Hydrofoil Development.** P.J.YANGOS.
AD-440-901 AGARD Rep. 473, 43 pp., 48 refs., 1963.
N64-22059 The aeronautical engineer's interest and possible contribution towards the development of hydrofoil craft is discussed in all aspects having equivalents in AGARD activities (namely Fluid Dynamics. Flight Mechanics, Avionics, Structures and Materials, and Propulsion). A presentation of contemporary hydrofoils and an examination of current projects are also included.

RP474 **Some Panel Aeroelastic Instabilities.** D.J.JOHNS.
AD-440-902 AGARD Rep. 474, 50 pp., 40 refs., 1963.
N64-21845 Several theoretical and experimental investigations are presented and discussed which indicate the possible range of static and dynamic aeroelastic instabilities of thin panels and membranes. Subsonic instabilities include panel and membrane flutter and panel divergence. The need for a suitable three-dimensional theory is shown. Supersonic flutter of flat panels and cylindrical panels shows considerable disparity between theory and experiment particularly in the Mach range below $\sqrt{2}$. More definite experiments and analyses which allow for viscous flow effects are required.

RP475 **Recent Panel Flutter Research and Applications.** M.H.SHIRK, J.J.OLSEN.
AD-438-931 AGARD Rep. 475, 33 pp., 13 refs., 1963.
N64-19913 Presents results that have been recently obtained from USAF research investigations of the flutter characteristics of panel and shell structures. A brief review is presented of the available literature on curved panels and shells and is followed by an extensive presentation of hitherto unpublished data from current programmes. The results are interpreted in terms of their application to future systems and are followed by a section on conclusions and recommendations.

RP476 **The Experimental Determination of Unsteady Hydrodynamic Forces due to the Oscillation of Liquid**
AD-452-713 **Propellants.** C.BEATRIX.
N65-12465 AGARD Rep. 476. (in French), 23 pp., 8 refs., 1964.
After summarizing the theory of unsteady hydrodynamic forces, the experimental methods and apparatus devised by ONERA for research on the title problem are described. Details are given of tests on models and on a missile (for the cases of (i) a missile with fuel tanks empty, (ii) a missile with liquid in each of its two tanks, (iii) a missile with liquid in only one tank). The scope of future research is indicated.

RP477 **The Preparation of Reports on Fatigue of Structures and Materials.** W.BARROIS, F.BOLLENRATH.
AD-476-042 AGARD Rep. 477, 12 pp., 1964.
N65-22610 The object of this report, prepared for the AGARD Structures and Materials Panel is to encourage the standardization of fatigue test reports so as to make them more readable and more usable. A formal Panel recommendation on the data required for the general use of test results is followed by sections on the terminology and symbols to be used. Finally, the factors affecting the resistance of materials under test are listed.

RP478 **The Application of Langmuir Probe Techniques to Flowing Ionized Gases.** C.L.BRUNDIN, L.TALBOT.
AD-476-043 AGARD Rep. 478, 48 pp., 60 refs., 1964.
N65-22264 A detailed theoretical and experimental investigation into the use of stagnation point Langmuir probe techniques in a flowing and partly ionized gas is reported. The analysis presented is restricted to (i) the supersonic flow of a weakly ionized gas, (ii) the determination of ion density from the saturated ion current, and (iii) the determination of electron temperature from the rate of change of electron current with probe potential. Numerical results are presented for argon, along with results of experiments conducted in an arc-heated supersonic low-density wind tunnel. It is concluded that ion density can be measured accurately with a stagnation point probe.

RP479 **Use of Dynamic Models in Launch-Vehicle Development.** H.L.RUNYAN, H.G.MORGAN, J.S.MIXSON.
AD-476-044 AGARD Rep. 479, 33 pp., 18 refs., 1964.
N65-22611 The rôle of reduced-scale models in the solution of the structural dynamic problems of large launch vehicles is considered. A general discussion of scaling principles is followed by tabulation of specific parameters for scaling of bending, longitudinal and local vibrations, liquid sloshing, combined elastic-aerodynamic buffet, flutter, ground wind phenomena. Three examples of the use of models are presented illustrating the utility of reduced scale models.

RP480 **Aircraft Manoeuvre Loads.** W.A.P.FISHER.
AD-476-045 AGARD Rep. 480, 52 pp., 32 refs., 1964.
N65-22612 This report was prepared to supply basic data for an Aircraft Loads Manual for AGARD. V-g and recording accelerometer data have been extracted from a number of U.S. and British reports, and are summarized. Also included are: a method for contracting manoeuvre-load information for design purposes, tabulated data on the frequency of normal accelerations for a wide range of military aircraft and missions, on the distribution of forward speeds associated with the high normal accelerations, and on the maximum speeds of numerous British service aircraft for standardized flying times, and an analysis of the percentage time spent at various speeds by some selected U.S. aircraft.

RP481 **A Survey of the Effects of Elasticity on the Control of Large Booster Rockets and the Possible**
AD-476-046 **Advantages of Using Adaptive Servo Techniques.** K.W.SMITH.
N65-22613 AGARD Rep. 481, 11 pp., 2 refs., 1964.
Topics considered include: a brief description of the guidance and control loops associated with ballistic vehicles; effect of structural flexibility on the autopilot loop; flexibility effects on the guidance loop; factors which complicate the stabilization of the autopilot loop in the presence of flexibility; the merits of conventional stabilization solutions; self-adaptive solutions; possible programme of future work.

RP482 **Basic Research on the Refractory Metals Molybdenum, Niobium, Tantalum and Tungsten.** R.SYRE.
AD-661-749 AGARD Rep. 482, (in English and French), 37 pp., 7 refs., 1964.
N65-29052 A survey of current research and development of these four metals has revealed the fields in which further basic research is most urgently needed. A basis for a co-operative research programme is suggested. The five most rewarding lines of research are considered to be equilibrium diagrams, diffusion couples, effect of impurities, reactions with gases and protective coatings.

RP483 **Composite Materials.** G.DIXMIER, G.GERARD.
AD-661-750 AGARD Rep. 483, (in English and French), 47 pp., 1964.
N65-28862 This is a consolidated report prepared from the findings of four individual co-ordinators (Messrs. Dixmier, Gerard, Gurney and Matting) who surveyed NATO country research activities on composite materials. The report is not a comprehensive state-of-the-art presentation but it does highlight research opportunities. The rôle, important properties and current research activities on the matrix, the reinforcement, the interface and the composite are first considered; research recommendations in these four areas are then presented.

RP484 **The Present Status of Panel Flutter.** D.J.JOHNS.
AD-476-047 AGARD Rep. 484, 37 pp., 220 refs., 1964.
N65-27726 A preliminary survey of recently published literature is presented. Methods of analysis and assumptions are reviewed for various panel configurations and boundary support conditions, and, where possible, theoretical and experimental results are compared and correlated. Inadequacies of available design criteria are indicated; recommendations on the use of analytical methods are made and the direction of future investigations is suggested.

RP485 **The Impact of V/STOL Aircraft on Instrument Weather Operations.** J.P.REEDER.
AD-476-048 AGARD Rep. 485, 16 pp., 12 refs., 1964.
N65-27727 The state-of-the-art of instrument operation for helicopters and the problems and possibilities of using V/STOL aircraft for effecting a reduction of weather minima are discussed. Problems associated with the air traffic control of a mixed traffic of V/STOL and conventional aircraft are considered. Research and development programmes which would lead to a reduction of instrument weather minima for safe operation of V/STOL are outlined.

RP486 **Status of V/STOL Studies in Germany.** X.HAFER.
AD-476-049 AGARD Rep. 486, 18 pp., 15 refs., 1964.
N65-27728 Three German V/STOL projects under development are described; these aircraft use jet engines to produce the thrust for vertical take-off, and incorporate various combinations of jet lift, vectored thrust and tilting nacelles. These aircraft are the VJ 101C, the VAK 191B and the Dornier Do 31. A general description of each aircraft is given with details of the experimental programme and aerodynamic and control system design.

RP487 **Present State of Studies on V/STOL in France.** G.LEBLANC, G.KLOPFSTEIN.
AD-476-050 AGARD Rep. 487, (in French), 4 pp., 1964.
N65-34253 The main studies in France relating to V/STOL aircraft concern the Mirage III V vertical take-off interceptor and the Breguet 941 short take-off transport. The main characteristics of these two families of aircraft are briefly described and then a short account is given of the results obtained during flight tests, with particular emphasis on those relating to flying qualities.

RP488 **Subsystem Requirements for an Airborne Laboratory to Study Zero-Zero Landing Systems.**
AD-476-051 G.R.ROBINSON, N.S.JOHNSON.
N66-23530 AGARD Rep. 488, 22 pp., 1964.
A flying laboratory, to provide information needed for landing aircraft (especially STOL) under zero-zero visibility, is being developed at Ames Research Center. Studies have reached the stage where the operation and performance of specific components can be discussed. Components for which the characteristics and details of operation are presented include: the distance-measuring system, the radar altimeter and the airborne digital computer.

RP489 **Approach and Landing Problems in Jet VTOL Aircraft.** F.P.YOUENS.
AD-476-052 AGARD Rep. 489, 32pp., 1964.
N65-27729 The title subject is discussed with emphasis on tactical aircraft operating from a dispersed base. The effects of operational environment and the general characteristics of this type of aircraft on the approach technique are considered; the transition phase of flight (including cross-wind transition limits and control techniques) is treated in detail. Piloting problems and the function of various instrument and control aids being developed for the S.C. 1 are also considered; experience gained on this aircraft and simulator assessment of the pilot's work load with varying degrees of instrument and automatic assistance are also discussed.

RP490 **Stability and Control for Instrument Flight.** A.G.BARNES.
AD-466-836 AGARD Rep. 490, 17 pp., 12 refs., 1964.
N65-29053 The limitations of conventional flight instruments for flying aircraft with poor stability and control characteristics are first discussed. The rôle of the pilot in the control loop is then considered. Experimental results and a theoretical analysis relating to aircraft stability are presented. Improvements to display systems to increase the part played by the pilot are also considered.

RP491 **Current Research on Advanced Cockpit Display Systems.** R.L.WINBLADE.
AD-476-053 AGARD Rep. 491, 22 pp., 9 refs., 1964.
N65-27730 Current cockpit display philosophy is discussed in terms of the pilot's informational requirements. Pilot's scan patterns obtained through the use of an eye-position camera and a ground-based simulator are depicted for a conventional display system and two advanced concepts. Preliminary results of flight-test and ground-simulation evaluations of advanced concepts, such as totally integrated displays and indirect pilot viewing systems, are also discussed.

RP492 **Aircraft Crosswind Performance.** J.F.O'GARA.
AD-476-054 AGARD Rep. 492, 19 pp., 2 refs., 1964.
N65-27731 Aerodynamic aspects of take-off and landing in severe crosswinds are reviewed and an attempt is made to derive design criteria. For approach and touchdown, alternative piloting techniques are described and minimum control requirements for a given crosswind are derived from flight data. The mechanics of the landing ground roll are discussed with emphasis on tyre effects; excessive lateral drift at high speed, especially on a wet runway, is shown to be the most critical factor and acceptable drift limits are established.

RP493 **United States Air Force Arresting Gear for All-Weather Operation.** P.D.KENNEDY.
AD-476-055 AGARD Rep. 493, 27 pp., 6 refs., 1964.
N65-34255 Developments in the field of aircraft arresting barriers in the USAF are reviewed under the headings Engaging Devices (MA-1A engaging device, arresting hooks, arresting cable supports, BAK-11 engaging device) and Energy Absorbers (BAK-9 energy absorber, dual BAK-9 aircraft arresting barrier energy absorber, BAK-12 portable aircraft arresting barrier, MA-1A and BAK-6 energy absorbers). A brief summary is then given of arresting gear engagements made between 1960 and 1964; these were successful in 99.8% of cases.

RP494 **The Influence of Weather on Aircraft Operations.** J.BURNHAM.
AD-476-056 AGARD Rep. 494, 12 pp., 1964.
N65-27732 The effects of weather conditions on the flight of conventional fixed wing aircraft are described in general terms. The following topics are considered: take-off – visibility, wind, runway surface conditions, temperature; in-flight – weather effects which occur in clear air, flight in or near clouds; approach and landing – visibility, winds, runway surface conditions.

RP495 **Testing of Doppler Phi Systems.** H.FABER.
AD-476-057 AGARD 495, 7 pp., 1964.
N65-27733 The components, testing and results obtained with the Bendix Doppler DRA-12 navigation system installed in the Fiat G-91 fighter-reconnaissance aircraft are described. There are three main components: the Doppler radar, the compass and the Positing Homing Indicator (PHI); an auxiliary device computes data from wind values in case of interruption of the Doppler system. The possible errors in the components and the system as a whole are analyzed.

RP496 **Testing of Navigation Systems.** J.D.ACKERMAN.
AD-476-058 AGARD Rep. 496, 31 pp., 1964.
N65-27734 The inherent accuracy and the operational accuracy of aircraft navigation systems are first discussed. Traditional methods of testing are then treated. Four papers by members of the A.A.E.E. Navigational Division on the testing of hyperpolic navigation systems, Doppler evaluation, the testing of a terrain-following system, and the testing of radio altimeters are presented as appendices and discussed briefly in the main text. Future developments in the testing of navigational equipment are also considered.

RP497 **Some Observations on Missile Vibration Flight Results and the Difficulties of Their Prediction.**
AD-476-059 B.E.GRANT.
N65-27735 AGARD Rep. 497, 15 pp., 1964.
The difficulty of predicting vibration levels analytically is discussed. The degree of spectral resolution necessary is considered and the conclusions from a survey of several thousand components and assemblies to determine the distribution of Q values likely to be encountered in missile equipment are summarized. The variation of spectral density with time, temperature, and construction standards is also discussed.

RP498 **The Application of Local Unsteady Pressure Measurements in Obtaining Aerodynamic Derivatives.**
AD-476-060 R.DESTUYNDER, H.BERGH.
N65-34254 AGARD Rep. 498, (Pt.1 in French, Pt.2 in English), 36 pp., 13 refs., 1964.
Pt.1, entitled "A Method for the interpretation of measurements of unsteady pressures", presents a partly theoretical and partly experimental method of determining unsteady pressures in subsonic conditions on three-dimensional profiles. Pt.2, entitled "Some aspects of unsteady pressure measurements", considers some aspects of the accurate experimental determination of unsteady pressures on harmonically oscillating wings and briefly describes a special measuring technique. The application of measured pressure distributions to flutter calculations is also discussed.

RP499 **Discussions Following the Presentation of Papers at the AGARD Fluid Dynamics Specialists Meeting "Arc Heaters and MHD Accelerators for Aerodynamic Purposes".** A.BENOIT (Editor).
AD-476-424 AGARD Rep. 499, 28 pp., 1964.
N66-11634 The above AGARD Fluid Dynamics Specialists Meeting was held at the Von Kármán Institute for Fluid Dynamics, Rhode-Saint-Genèse, Belgium, from 21st to 23rd September, 1964. The proceedings of this meeting are presented in AGARDograph 84. This report contains the text of the discussions which followed the presentation of the papers to this meeting.

RP500 **Problems Associated with the Presence of Water, Slush, Snow and Ice on Runways.** H.R.HERB.
AD-652-162 AGARD Rep. 500, 57 pp., 122 refs., 1965.
N66-33489 The importance of the effect of runway conditions on take-off and landing distances has been emphasized by the introduction of jet aircraft with high wing loadings and high take-off and landing speeds. At high ground speeds, precipitation on the runway changes the value of the tyre-to-surface coefficient, and may increase the drag (due to the force necessary for fluid displacement). Further, the hydrodynamic forces acting on wheels running through slush or water can, at high speeds, lift the tyres completely off the ground. A survey of the most recent investigations on these topics is presented together with a resumé of the resulting conclusions. Appropriate safety precautions to protect aircraft against these risks are also discussed.

RP501 **Shortening the Take-off and Landing Distances of High Speed Aircraft.** J.K.WIMPRESS.
AD-479-994 AGARD Rep. 501, 22 pp., 1965.
N66-21022 A review is first made of the fundamental parameters that determine take-off and landing distance, with particular emphasis on the influence of lift coefficient, lift/drag ratio, and thrust/weight ratio. Recent developments in high lift systems are then presented. Finally, the results of fitting various high-lift systems into the field length requirements of transport and STOL aircraft are discussed.

RP502 **Flight Development of a High Lift Research Aircraft using Distributed Suction.** D.G.CLARK.
AD-479-995 AGARD Rep. 502, 24 pp., 7 refs., 1965.
N66-21023 A modified single-engined light aircraft fitted with means for applying distributed suction to the wing upper surface has been flown at lift coefficients in excess of 5.0. The following aspects of these flight tests are described: the aircraft used, the instrumentation, the results of initial exploratory flights, leading edge modifications, overall results with the new leading edge, the stall pattern, the stall and general flight characteristics, comments on practical points.

RP503 **Low-Speed Flight Investigation of a Jet Transport with a Powered-Lift Boundary-Layer Control System.**
AD-479-996 R.O.SCHADE, H.L.CRANE.
N66-22222 AGARD Rep. 503, 25 pp., 4 refs., 1965.
The flight investigation reported was carried out at the Langley Research Center. The principal findings were: the speed margins appeared to be related primarily to power-on speeds; there were no large detrimental effects on handling qualities resulting from the use of powered lift; there were appreciable increases in noise levels.

RP504
AD-479-997
N66-21024

Stability and Control Considerations for STOL Aircraft. S.B.ANDERSON, H.C.QUIGLEY, R.C.INNIS.
AGARD Rep. 504, 36 pp., 9 refs., 1965.
For a number of years NASA has investigated STOL aircraft to obtain information on performance, handling qualities, and operational characteristics. This experience is reviewed with particular attention to the following aspects: lift performance, limitations in low-speed operation, solutions to handling qualities problems, and test methods used to investigate stability and control characteristics. The discussion is confined to the low speed landing approach portion of the flight regime.

RP505
AD-479-998
N66-21025

Determination of Take-off and Landing Data with an Airborne Forward-Looking Camera combined with Accelerometers. J.P.K.VLEGHERT.
AGARD Rep. 505, 30 pp., 4 refs., 1965.
Take-off and landing data can be determined with a forward-looking camera in the aircraft which photographs the runway lights 100 to 300 yds ahead of the aircraft with a pre-set time interval. Distance, height, angle of drift, bank and pitch, lateral displacement from the runway centre line can be calculated directly versus time, while ground speed is obtained via differentials. With a longitudinal accelerometer, and pitch reference furnished by the camera momentary accelerating or decelerating forces on the ground can be found. For evaluation of performance during lift-off or flare-out, the addition of a normal accelerometer is necessary. Ground speed can be obtained by integration. This method can be applied with relatively inexpensive equipment on any runway with edge lighting.

RP506
AD-479-999
N66-22322

Selected In-Flight Instrumentation Papers from AGARD Flight Mechanics Panel – Twenty-Sixth Meeting.
AGARD Rep. 506, 62 pp., 1965.
This report contains three papers read at the 26th Meeting of the AGARD Flight Mechanics Panel which was held in Paris in June, 1965. Details of these papers are given in the succeeding items.

RP506/1

Application of Airborne Digital Recording at A & AEE. R.P.DICKINSON, R.T.SHIELDS.
AGARD Rep. 506, 1-15, 1965.
Reviews experience in the application of in-flight digital recording to the Establishment's flight testing task, which is primarily that of acceptance testing. Types of data required to be recorded, and the preferred use of well-tried instrumentation techniques where possible are noted. Digital recording techniques employed (applied only to navigational trials so far) are described and the future possibilities of digital data acquisition are considered.

RP506/2

French Measurement Methods for In-Flight Testing. G.PETIT.
AGARD Rep. 506, (in French), 17-41, 1965.
After a brief review of the recording systems in use at the Flight Test Centre at Bretigny, and an analysis of current problems, the trends in the development of French test methods are surveyed.

RP506/3

The Rôle of Telemetry in Modern In-Flight Measuring Techniques. A.BECKER.
AGARD Rep. 506, 43-62, 11 refs., 1965.
General aspects and criteria of in-flight measuring systems are examined with special regard to the telemetry technique. The state-of-the-art is explained by reference to a complex measuring system. Telemetry standards are briefly discussed. Relations between the measuring problem and the measuring system are shown. The results of a telemetry user survey are discussed in a consideration of some known telemetry systems and subsystems.

RP507/1
AD-809-159
N67-19352

Selected Instrumentation Application Papers from AGARD Flight Mechanics Panel – Twenty-Sixth Meeting: Paper 1. – Flight Test Instrumentation Data Reduction and Data Processing in the VJ-101-C-X_1/X_2 Program. H.PORNITZ-RUMPFF.
AGARD Rep. 507, 1-22, 1965.
Report 507 includes two papers presented at the 26th Meeting of the Flight Mechanics Panel, held in Paris in June, 1965. Paper 1 covers the following topics relating to the VJ-101-C-X_1/X_2 experimental aircraft: principles and planning of test instrumentation, airborne and ground-based telemetry equipment, report of a typical test programme, data processing and data reduction methods for the X_2 and future aircraft.

RP507/2

Selected Instrumentation Application Papers from AGARD Flight Mechanics Panel – Twenty-Sixth Meeting: Paper 2. – An Airborne Data-Acquisition System for Use in Flight Testing the XB-70 Airplane. E.L.EDWARDS.
AGARD Rep. 507, 23-48, 1965.
The requirements and data acquisition capabilities of the title system are discussed. Analogue and digital recording techniques are used, details of the latter being stressed. The operational sequence is described and equipment packaging and environmental control provisions discussed. A brief account is given of data processing operations and system performance under flight test conditions.

RP508/1
AD-809-160
N67-19337

Selected Aircraft Integrated Data Systems Papers from AGARD Flight Mechanics Panel – Twenty-Sixth Meeting: Paper 1. – Flight Test Application of an Integrated Aircraft PCM Data System. R.J.GRISSMAN.
AGARD Rep. 508, 1-17, 1965.
Report 508 includes two papers presented at the 26th Meeting of the Flight Mechanics Panel, held in Paris in June, 1965. Paper 1 is concerned with the techniques and methods used to perform aircraft subsystems analysis at the US Air Force Flight Test Center (AFFTC). Aspects considered include: information requirements, data system implementation, difficulties encountered, data analysis future possibilities.

RP508/2

Selected Aircraft Integrated Data Systems Papers from AGARD Flight Mechanics Panel – Twenty-Sixth Meeting: Paper 2. – Integrated Aircraft PCM Data System for the C-141 Aircraft. L.D.HUPPERT.
AGARD Rep. 508, 19-5', 1965.
Deals with the hardware of the Integrated Aircraft Data System (IADS). This hardware comprises: existing aircraft transducers, additional transducers, a signal preconditioner unit, a signal data translator, a digital recorder, a control panel and a time generator and display unit. The system monitors 196 parametric inputs (plus 27 spares) which are sampled at rates varying from once per sec. to once per 16 sec. Future system expansion is considered.

RP509
AD-652-165
N67-29540

A State-of-the-art Survey of Methods Being Used for the Evaluation of Coatings for Super Alloys and Refractory Metals. W.A.JAMES.
AGARD Rep. 509, 24 pp., 61 refs., 1965.
This report is based on a survey conducted in 1964 in NATO countries on behalf of the AGARD Structures and Materials Panel. After a consideration of the reproducibility of test data, the following are discussed: isothermal oxidation tests, cyclic oxidation tests, cyclic oxidation combined with thermal fatigue and/or erosion, tests for erosion at high temperatures, corrosion by materials other than oxygen, mechanical and physical properties.

RP510
AD-668-254
N68-21153

The Potential Use of Mathematical Models in Materials Data Presentation with Particular Reference to the AGARD Materials Properties Handbooks. A.G.R.THOMSON.
AGARD Rep. 510, 32 pp., 19 refs., 1966.
Creep data in the AGARD Materials Properties Handbooks are reviewed and means are discussed for improving the scope and usefulness of the data. Advantages of using mathematical models for the correlation and presentation of various kinds of materials properties data are considered. A questionnaire is appended to elicit opinions on the type of data that are required and on the most useful form of presentation for design purposes.

RP511/1
AD-809-161
N67-19315

Selected Papers from AGARD Structures and Materials Panel – Nineteenth Meeting: Paper 1. – Calculation of Eigenvalues and Eigenvectors of Large Non-Hermitian Aeroelastic Matrices. HEINZ GÖLLNITZ, HILDEGARD GÖLLNITZ, F. WILLE.
AGARD Rep. 511, 1-41, 13 refs., 1964.
Report 511 comprises two papers presented to the 19th Meeting of the Structures and Materials Panel in Paris, 12th to 17th October, 1964. In Paper 1, the iteration procedures of von Mises and of Wielandt for solving eigenvalue problems are applied successively to complex non-Hermitian matrices. Using a two-root procedure and an electronic computer, all complex eigenvalues and eigenvectors of an aeroelastic matrix are obtained in a few seconds. Numerical examples of matrices up to the 12th order are given to eight figures. Examples of flutter calculations up to 12 degrees of freedom are given as diagrams.

RP511/2

Selected Papers from AGARD Structures and Materials Panel – Nineteenth Meeting: Paper 2. – A New Iterative Approach to Structural Eigenproblems. I.ERDELYI, G.OCCHINI.
AGARD Rep. 511, 43-83, 12 refs., 1964.
A new numerical iterative algorithm suitable for the simultaneous determination of partial eigensystems of both real and complex matrices is described. The use of this method in a programming system for the analysis of structures is currently being studied. Some numerical examples of the application of the method are included.

RP512
AD-804-637
N67-14107

Determination of Three-Dimensional Non-Stationary Aerodynamic Forces. L.DAROVSKY, R.DAT.
AGARD Rep. 512, (in French), 58 pp., 26 refs., 1965.
In modern aircraft with small wing spans, the problem of determining the aerodynamic forces is that of a lifting surface being distorted chordwise and spanwise in three-dimensional flow. After linearization, this leads to an integral equation for which it is possible to find approximate numerical solutions; this calculation as well as the determination of generalized forces is now performed automatically at Sud-Aviation. Three cases are considered in this report, (i) a wing in subsonic flow; (ii) a wing in supersonic flow, with subsonic leading edge and supersonic trailing edge; (iii) a control surface in supersonic flow. The different methods used are described and a justification of them is given in the form of a comparison of theoretical and experimental results.

RP513
AD-809-162
N67-19241

Predicting Material Behaviour Under Load, Time and Temperature Conditions. H.P.VAN LEEUWEN.
AGARD Rep. 513, 221 pp., 175 refs., 1965.
Methods are considered of accelerating mechanical tests on coupons, components and structures with reference to engineering designs involving prolonged service at elevated temperatures. Basic problems concerning fatigue, creep, ageing and their interaction are discussed. Emphasis is put on their quantitative treatment. Conclusions are drawn and recommendations made.

RP514
AD-652-166
N67-28880

The Production of Intense Shear Layers by Vortex Stretching and Convection. J.T.STUART.
AGARD Rep. 514, 29 pp., 17 refs., 1965.
A theoretical model is studied which shows how the flow field associated with the boundary layer, which is known to have a streamwise-vortex component upstream of transition, can convect the vortex lines into regions where they can be stretched very effectively, so producing strong concentrations of vorticity. The velocity profiles obtained are similar in shape to the instantaneous profiles measured by Klebanoff and by Kovasznay. The relevance of the model to experiment is discussed; the time scales required for the convection and stretching process are comparable with those of experiments.

RP515
AD-652-168
N67-28879

Application of the Model Technique to a Variable-Stability Helicopter for Simulation of VTOL Handling Qualities. J.F.GARREN, Jr., J.R.KELLY.
AGARD Rep, 515, 16 pp., 6 refs., 1965.
In order to provide a means for accurate in-flight simulation of V/STOL aircraft, a computer model technique has been adapted to a variable-stability helicopter. Unlike the stability-derivative simulation technique, this model approach produces a response which is essentially independent of the dynamics of the test vehicle. The aircraft response is thus a function only of the pilot's control inputs and the dynamics which are programmed into the analogue computing equipment. In-flight time histories of the helicopter response and the corresponding commanded response are presented to illustrate the effectiveness of the technique.

RP516
AD-809-163
N67-19242

Overcoming Ground Erosion Effects in the Operation of Jet Lift Aircraft. J.M.DENT.
AGARD Rep. 515, 16 pp., 1965.
A review is presented of rig tests carried out by Rolls-Royce, Ltd to investigate the ground erosion effects of jet lift aircraft, especially in relation to the damage caused by scattered debris. Different surfaces such as grass pasture land, portable trackway, concrete and asphalt were tested, and various operating techniques for solution of the problems of ground erosion are discussed.

RP517
AD-652-169
N67-28878

A Note on Rotary Wing Hovering and Take-off Performance, Data Acquisition and Analysis. J.C.KIDWELL.
AGARD Rep. 517, 10 pp., 1965.
Describes the test and data-analysis techniques used for helicopter hovering and take-off investigations at Edwards Air Force Base, where the tethered hovering technique was developed. The methods produce data suitable for defining helicopter hovering and take-off performance. The resulting data have proved to be repeatable and of sufficient accuracy to provide a basis for Flight Manual Performance Charts. The methods minimize the testing required and provide accuracy that cannot be attained by extrapolation or calculation.

RP518
AD-809-164
N67-19243

Testing the Kestrel. I.A.FISHER.
AGARD Rep. 518, 17 pp., 1 ref., 1965.
The Hawker Siddeley "Kestrel" was the first VTOL jet aircraft in service anywhere in the world; it has a speed range from backward flight to greater than Mach 1, without autostabilization. The flight tests reported were mainly qualitative. Discussion is concentrated on the more interesting aspects of V/STOL operation (stability in hovering and in accelerating transition to conventional flight, VTOL and STOL take-off and landing techniques, rough ground operation and V/STOL night flying).

RP519
AD-652-170
N66-33488

Results of Recent Investigations of V/STOL Control and Response Requirements Using Variable Stability Helicopters. D.G.GOULD.
AGARD Rep. 519, 31 pp., 15 refs., 1965.
Theoretical predictions, based on a pilot-aircraft system, of r.m.s. heading response and minimum pilot gain were found to correlate well with pilot opinion assessments of the directional control and response requirements for flight of simulated V/STOL in turbulence. The comparisons were made for two visual flight tasks, a circuit including approach and landing, and precision hovering in a simulated wind, for four values of the weathercock stability parameter. Pilot assessments of the pitch, roll and yaw control sensitivity and control power requirements for manoeuvre in calm air for visual circuit and hover tasks were compared for two aircraft weighing 2,900 lb and 15,000 lb. The results did not agree with predictions of the existing requirements for scaling control power with weight, indicating a trend opposite to that of the present recommendations.

RP520 **Correlation of Wind-Tunnel and Flight-Test Aerodynamic Data for Five V/STOL Aircraft.**
AD-652-172 D.H.HICKEY, W.L.COOK.
N67-29536 AGARD Rep. 520, 24 pp., 11 refs., 1965.
The five aircraft tested represent a wide variety of V/STOL concepts. Correlation between the wind tunnel and flight-test aerodynamic results is generally good when wind tunnel wall corrections are omitted; in some cases wall corrections degrade the correlation. The aircraft and wind tunnel geometry are related to model-tunnel sizing parameters and a VTOL lift parameter, in order to establish tentative sizing criteria for V/STOL wind-tunnel testing with small wall effects.

RP521 **Pilot Behaviour in VTOL Aircraft.** G.SCHWEIZER.
AD-804-363 AGARD Rep. 521, 88 pp., 18 refs., 1965.
N66-13399 In the course of development of the Dornier Do 31 VTOL aircraft, extensive investigations were made to assess the behaviour of the stabilizing and control system during hovering flight and the behaviour of the pilot during this phase of flight. Here, the following aspects of their investigations are treated; dynamic model for pilot behaviour; controllability of the hovering rig Do 31 without artificial stabilization; controllability of the hovering rig without artificial stabilization in the presence of strong external disturbances; some connections between control design and pilot behaviour in flights without artificial stabilization; transfer function of the pilot in flights without artificial stabilization; stabilization systems for the hovering mode of VTOL aircraft; pilot behaviour in a stabilized VTOL aeroplane.

RP522 **The Control Moment Distribution for the Do 31 Hovering Rig.** G.SCHWEIZER, H.SEELMAN.
AD-804-364 AGARD Rep. 522, 25 pp., 2 refs., 1965.
N66-13400 An attempt is made to determine the thrust control moments necessary under various flight conditions from flight results obtained on the Dornier hovering rig for the Do 31 VTOL transport aircraft. The moments actually required during flight for different control systems and under various external flight conditions were recorded and compared with control moments specified by AGARD. Test results from the Hawker Siddeley VTOL fighter P1127 were also taken into consideration.

RP523 **Trends and Applications of Structural Composite Materials.** D.L.GRIMES.
AD-804-638 AGARD Rep. 523, 18 pp., 7 refs., 1965.
N67-14108 The history and present status of development of composite materials is reviewed, with particular reference to current uses of reinforced plastics in aircraft and missiles, building construction, and boats. New composite materials with high-strength, high modulus reinforcements are then considered; research and development in hand, and future applications of these materials are discussed.

RP524 **Composite Materials.** G.GERARD, G.DIXMIER.
AD-804-365 AGARD Rep. 524, (in English and French), 49 pp., 1966.
N67-32008 This report comprises two parts: Pt.1 is entitled "The co-operative Programme" while Pt.2 is a re-issue of AGARD Report 483 entitled "Composite Materials". The original Report 483 was an appreciation of the fundamental research problems in the field of composite materials, and incorporated a questionnaire requesting information on current research programmes in this field, and on the willingness of organizations to take part on a co-operative programme of research. The replies to this questionnaire encouraged the AGARD Structures and Materials Panel to take the first-steps in establishing such a co-operative programme, and as is outlined in Pt.1 of the report, to specify the choice, availability and distribution of standard composites and constituents, and the administrative factors conditioning collaboration between laboratories.

RP525 **The Pitot Probe in Low-Density Flow.** S.A.SCHAAF.
AD-652-173 AGARD Rep. 525, 19 pp., 43 refs., 1966.
N67-29532 Discusses the measurement and interpretation of the impact pressure on a pitot tube in low-density flow. Viscous effects, relaxation effects, orifice-size effects, and internal flow effects are considered.

RP526 **Laminar Incompressible Leading and Trailing Edge Flows and the Near Wake Rear Stagnation Point.**
AD-804-639 S.WEINBAUM.
N67-14109 AGARD Rep. 526, 28 pp., 15 refs., 1966.
Investigates the behaviour of a viscous incompressible fluid in the vicinity of various two-dimensional separation and stagnation points. Locally valid series solutions to the Navier Stokes vorticity equation are developed to study the pressure-viscous force balance in the neighbourhood of the singularity and the transition to the flow region where inertial effects are important. The nature of the singularity is established for an arbitrary symmetric leading or trailing edge and a solution obtained to within an arbitrary constant that depends on the wall shear. The convergence of the series is examined via a term-by-term comparison with Howarth's exact numerical solution for a two-dimensional stagnation point. The solution for the near wake rear stagnation point shows that the wake cannot close in an arbitrary manner, but that the asymptotic direction of the dividing streamline prior to stagnation is a single-valued function of the ratio of the velocity on the dividing streamline to that on the wake centreline. Finally, the leading term for a series solution for a blunt-based trailing edge is obtained.

RP527
AD-804-640
N67-14110

Results of Flight Tests on the Short SC 1 VTOL Research Aircraft with Particular Reference to Handling Qualities in the Hover and Transition Modes. H.W.CHINN.
AGARD Rep. 527, 34 pp., 15 refs., 1965.
Results are given of flight tests made on the Short SC 1 jet VTOL research aircraft, covering control and stability characteristics, and performance throughout the flight envelope, but with particular reference to the hover and transition modes. Pilots' assessments of the aircraft in different conditions are considered in relation to its measured characteristics, and such features as cockpit layout, view and control arrangements which can have an important influence on the overall flying qualities.

RP528
AD-812-894
N67-23243

Use of a Large Jet Transport as an Inflight Dynamics Simulator. W.M.ELDRIDGE.
AGARD Rep. 528, 25 pp., 1966.
In order to obtain low-speed flight characteristics of projected supersonic transport aircraft, NASA contracted with Boeing Co. to modify the original Boeing 707 prototype (the model 367-80 aircraft) for use as an inflight simulator. This paper discusses the inflight simulation system developed for these tests. Included are discussions of the unique case of spoilers and thrust reversers to simulate variations in lift and drag with angle of attack; the ability to vary the longitudinal characteristics to simulate ground proximity, and the ground-based simulator and computer studies used to investigate problem areas and check the quality of simulation.

RP529
AD-812-984
N67-38428

Design, Development, and Utilization of a General Purpose Airborne Simulator. D.T.BERRY, D.A.DEETS.
AGARD Rep. 529, 13 pp., 5 refs., 1966.
The general purpose airborne simulator described is a variable stability and control Lockheed "Jet Star" with a broad range of simulation capabilities. The modifications and systems incorporated in the basic aircraft include a model-controlled system, response feedback system, variable fuel system, electrohydraulic control surface servos, and electromechanical throttle servos. The model-controlled system is the primary means of simulation; this system uses an airborne analogue computer which contains the programmed model and generates the desired responses. Expected utilization emphasizes SST and B-70 applications.

RP530
AD-812-986
N67-23247

Correlation of X-15 Simulation Experience with Flight Test Results. R.G.HOEY.
AGARD Rep. 530, 16 pp., 1966.
The simulations used in the X-15 rocket-powered research aircraft programme are described and the results from these simulator studies are compared with flight test results. Flight test and simulator pilot ratings are compared over a range of handling qualities from excellent to uncontrollable. Flight trajectories are presented and compared with simulator predictions; variations between simulator predictions and flight results are discussed. Improvements to the simulators resulting from these comparisons are also considered. Included is a description of a real-time simulation of aerodynamic heating and ablation.

RP531
AD-812-895
N67-23242

Recent Research Directed Toward the Prediction of Lateral-Directional Handling Qualities.
L.W.TAYLOR, Jr., K.W.ILIFF.
AGARD Rep. 531, 15 pp., 16 refs., 1966.
A survey of lateral-directional handling qualities was made with the object of developing a technique for predicting pilot ratings. The survey was made by obtaining pilot ratings of lateral control on a fixed-base simulator in conjunction with a colour contact analogue display. The effect of five lateral-directional handling qualities parameters were studied by systematically varying them over a wide range. Forty-five charts comprise the results of this survey; these have been condensed into three charts to provide a rapid means for hand-computing the pilot ratings. A digital computer program incorporating the data from all 45 charts was also written.

RP532
AD-654-118
N67-30025

Flying Qualities Problems Posed by Tail-less Slender-Wing Transport Aircraft. P.LECOMTE, E.FAGE.
AGARD Rep. 532, (in French), 41 pp., 22 refs., 1966.
Unusual aerodynamic features of such aircraft are analyzed from the point of view of the various tasks to be performed by the pilot; the applicability of conventional and new criteria is studied. Possible lateral stability characteristics are examined. In considering longitudinal stability, emphasis is on behaviour at low speeds. It is concluded that the stability and control characteristics of these aircraft compare favourably with those of more conventional aircraft, although they differ in many ways.

RP533
AD-812-892
N67-23244

Some Open- and Closed-Loop Aspects of Airplane Lateral-Directional Handling Qualities.
I.L.ASHKENAS.
AGARD Rep. 533, 61 pp., 90 refs., 1966.
The usefulness of closed-loop analysis, based on a mathematical model of the pilot, to explain and predict handling qualities problems is fairly well established. Open-loop response characteristics to specified control or disturbance inputs have long been considered pertinent indicators of potential control difficulties. Here, both types of analysis are used to explain, and to obtain correlating parameters for, a large body of lateral-directional handling qualities data. The study is divided into two basic

parts, one dealing with "ideal" single-degree-of-freedom rolling, the other with coupled lateral-directional motions.

RP534
AD-812-983
N67-23665

T.S.R.2 – A Comparison of Actual Handling Qualities with Estimates. W.D.HORSFIELD.
AGARD Rep. 534, 24 pp., 4 refs., 1966.
The T.S.R.2 was flown over a significant part of its flight envelope before cancellation. Pilot opinion on its handling qualities is compared with simulation experience and prediction based on various criteria. Flight opinion was more favourable than expected. The reasons for this are examined.

RP535
AD-812-891
N67-23534

Results of Flight Tests on a Slender Wing Low Speed Research Aircraft (H.P.115). P.L.BISGOOD.
AGARD Rep. 535, 20 pp., 3 refs., 1966.
Flight tests to determine the stability derivatives of a slender-wing low-speed research aircraft are described together with miscellaneous supporting tests. The results obtained are compared with wind tunnel tests; agreement is generally good but some notable discrepancies occur and these are discussed further. The more important handling qualities are described and are compared with existing criteria and with a ground-based simulation of the test aircraft. The handling qualities of the aircraft have proved remarkably docile and free from serious problems.

RP536
AD-812-982
N67-23246

Flight Experience of Rate Demand Control Using Electric Signalling in the AVRO 707C Aircraft. G.C.HOWELL.
AGARD Rep. 536, 17 pp., 1966.
Results are given of flight tests of a pitch and roll rate demand system using full authority electric signalling in the AVRO 707C aircraft. The effect of pilot-induced oscillations is considerably reduced when a miniature two-axis controller is used in place of a conventional stick – even when the response time is very short. It was found that control of the aircraft was very natural with a miniature controller of the type described and it is concluded that such a system with no mechanical revision is the only final solution to allow an optimum design to be used.

RP537
AD-654-038
N67-29526

Variable Stability Aircraft. G.KLOPFSTEIN.
AGARD Rep. 537, (in French), 24 pp., 1966.
Details are given of the first French variable-stability aircraft which was designed by Centre d'Essais en Vol and Société Francaise d'Equipments pour la Navigation Aérienne. The aircraft was a modified version of the "Mirage III B". The details given relate to: the modification effected; methods of piloting; safety aspects; use of the aircraft as a simulator; flight test operation. An appendix treats the automatic analysis of the aerodynamic coefficients.

RP538
AD-653-927
N67-29564

Flight Experience with the Ogee Wing at Low Speed. F.J.DRINKWATER, 3rd., L.S.ROLLS.
AGARD Rep. 538, 18 pp., 6 refs., 1966.
A basic delta-wing aircraft was modified to an ogee planform and tested in flight after full-scale wind tunnel tests. Details are given of the test aircraft modifications and instrumentation. The ogee aircraft characteristics determined in the flight tests are presented as is a landing-approach speed evaluation.

RP539
AD-812-893
N67-23249

Changes in the Flow at the Base of a Bluff Body due to a Disturbance in its Wake. R.HAWKINS, E.G.TREVETT.
AGARD Rep. 539, 19 pp., 5 refs., 1966.
An experimental study is presented of the interaction between a shock wave and the turbulent wake shed from a bluff-ended cylinder at free-stream Mach numbers between 1.2 and 2.9. A critical interaction distance is defined, beyond which point disturbances have no effect upon the flow at the base of the body. Correlation is made with comparable data for transitional wake flow. Discussion.

RP540
AD-812-889
N67-23248

Corrosion of Aircraft. H.G.COLE (Editor).
AGARD Rep. 540, 55 pp., 1966.
A one-day symposium on corrosion in aircraft, organized by the AGARD Structures and Materials Panel, was held in Delft during April, 1966. Here, edited and abridged versions of the ten papers presented are reproduced. The symposium was divided into four sections as follows: Corrosion in service (three papers); Design to avoid corrosion (three papers); Inspection in service (three papers); Damage and assessment (one paper). A discussion followed each section, and the pertinent points from these discussions are included in this report.

RP541
AD-653-918
N67-29470

Application of Microfractography to the Study of Crack Propagation under Fatigue Stresses. G.JACOBY.
AGARD Rep. 541, 187 pp., 196 refs., 1966.
A recapitulation of various observations and hypotheses concerning crack propagation is followed by a consideration of the possibilities of applying macro- and, more particularly, microfractography to this phase of the fatigue process. Microfractography makes it possible to study the mechanism of crack propagation under fatigue stresses in relation to external and internal parameters which are otherwise difficult or impossible to observe.

RP542 **Transonic Stability of Fin and Drag Stabilized Projectiles.** B.CHEERS.
AD-812-888 AGARD Rep. 542, 33 pp., 101 refs., 1966.
N67-23245 A review is presented of data, published in the unclassified literature, on the stability and drag characteristics of projectiles, with either spike noses (high drag) or pointed noses (low drag), at supersonic and transonic speeds. Both experimental and theoretical results are considered, where available, and areas where further work may prove useful are indicated.

RP543 **Developments in the Theory of Michell Optimum Structures.** D.M.RICHARDS, H.S.Y.CHAN.
AD-812-890 AGARD Rep. 543, 20 pp., 16 refs., 1966.
N67-23533 The fundamental problem of optimum structural design is discussed. Solutions to specific problems, suggested by the theorem of Michell, are described. Suggestions for the practical realization of Michell type structures as frameworks, fibrous composites, variable thickness plates and shells are examined, and work leading to approximate solution by digital programming methods is reported.

RP544 **By-Products of Space Research and Development.** R.L.BISPLINGHOFF.
AD-661-166 AGARD Rep. 544, 19 pp., 8 refs., 1966.
N68-12715 The stimulus that space research has given to scientific education is first discussed. The by-products of the space research and development programmes in the field of pure science are examined and some specific examples quoted (e.g. astronomy, knowledge of energetic particles and magnetic fields). A similar approach is used to discuss the stimulus given to engineering.

RP545 **Status and Organization of Technical and Scientific Documentation and Information in the Federal**
AD-653-254 **Republic of Germany.** H.LECHMANN.
N68-21187 AGARD Rep. 545, 16 pp., 1965.
A pattern of specialized and decentralized documentation systems is gradually emerging in W.Germany; complementing these specialized systems are several documentation institutions of a general nature which fulfil a linking and co-ordinating role. Brief notes on this arrangement are followed by a short survey of defence documentation organization. A list of documentation institutions of a general nature is appended as is one of specialized centres in the following subject areas: (a) mathematics, physics, chemistry, earth sciences, engineering, traffic and transport; (b) biology, medicine, and agriculture; (c) politics, law, education.

RP546 **The Use of Wind Shears in the Design of Aerospace Vehicles.** R.S.RYAN, J.R.SCOGGINS.
AD-653-928 AGARD Rep. 546, 37 pp., 15 refs., 1966.
N67-29576 The effects of various wind profile properties and disturbances on launch vehicle flight dynamic responses is studied. Emphasis is on the influence of wind shears and turbulence on dynamic response during the boost phase of flight. The primary wind inputs for this analysis are provided by 407 individual detailed wind profiles. The time response of the vehicle to each profile is computed and a statistical evaluation of the results made.

RP547 **Avoidance of Thermal Strain.** W.H.GOESCH.
AD-812-985 AGARD Rep. 547, 17 pp., 11 refs., 1966.
N67-23666 Thermal structural design concepts are reviewed for the avoidance of thermal strain in high speed aerospace vehicles. Absorptive and radiative design concepts are discussed. Specific arrangements of typical design concepts are shown and examined with respect to problem areas, advantages and disadvantages. Insulative, absorptive, and radiative materials are reviewed with regard to the design concepts, and when appropriate, specific limits are indicated and problem areas defined.

RP548 **Separated Flows: A Round Table Discussion.** J.J.GINOUX (Editor).
AD-653-841 AGARD Rep. 548, 19 pp., 1966.
N67-29531 A preliminary discourse by P.Legendre (touching on a number of fundamental points) is followed by the text of the discussion between a Panel (comprising A.D. Young (moderator), P.Carrière, K. Gersten, H. Korst, A. Roshko) and the audience. The discussion was held on the last day of the Specialists' Meeting on Separated Flows at the von Kármán Institute for Fluid Dynamics, Rhode Saint Genèse, Belgium, 10th to 13th May, 1966.

RP549/1 **Considerations in the Determination of Stability and Control Derivatives and Dynamic**
AD-654-582 **Characteristics from Flight Data.** C.H.WOLOWICZ.
N67-30135 AGARD Rep. 549, Pt.1, 116 pp., 67 refs., 1966.
The various factors that influence the determination of stability and control derivatives and other behaviour characteristics from flight data are discussed. Included are illustrations of the application of flight derivatives to the verification of predictions and to the determination of aeroelastic effects, stability criteria, and flight guidance.

RP549/2/1 **A New Type of Modulator Functions for the Shinbrot Method.** J.PERE.
AD-657-489 AGARD Rep. 549, Pt.2, (in French), pp. 1-16, 3 refs., 1966.
N67-38041 Shinbrot's method, using modulator functions for the analysis of aerodynamic responses in flight mechanics presented difficulties of application in its original form. The method was therefore re-examined and the presentation modified. The modified method gave excellent results when applied to the investigation of the aerodynamic coefficients of the "Mirage III" aircraft.

RP549/2/2 **Experience with Shinbrot's Method of Transient Response: Analysis for the Extraction of Stability and Control Derivatives.** B.R.A.BURNS.
AGARD Rep. 549, Pt.2, pp. 17-54, 12 refs., 1966.
The reasons for using the transient response analysis technique for extracting stability and control derivatives from flight records on an autostabilized aircraft are stated. Test and analysis methods are briefly reviewed and reasons for using the Shinbrot method are given. The Shinbrot method and its application are described. Experience with the method, applied to the analysis of highly damped responses recorded on a "Meteor" and a "Dove" with sensitive test instrumentation is described. Possible future developments are outlined.

RP550 **A New Special Solution to the Complete Problem of the Internal Ballistics of Guns.** T.K.THORNHILL.
AD-816-447 AGARD Rep. 550, 44 pp., 8 refs., 1966.
N67-29568 A new special solution is given to the complete problem of the internal ballistics of guns, of which Pidduck's special solution to Lagrange's ballistic problem is a simple special case. The solution is special in the sense that it is a similarity solution, in which the essential space variable is separated from the time variable and so it is derived by solving ordinary rather than partial differential equations.

RP551 **A Review of Some Recent Progress in Understanding Catastrophic Yaw.** J.D.NICOLAIDES.
AD-654-035 AGARD Rep. 551, 17 pp., 7 refs., 1966.
N67-29525 Catastrophic Yaw and Roll Lock-In (both of which occur in fin-stabilized missiles) are studied at supersonic and subsonic speeds. Roll Lock-In is found to occur on isolated fins and is traced to a leading edge vortex. Free rolling motions are found to be accurately represented by the Roll Lock-In Theory. Catastrophic Yaw is observed in three-degree-of-freedom and six-degree-of-freedom wind tunnel tests. Mass asymmetry in a 10 deg. cone is found to cause rolling velocity, Roll Lock-in and Catastrophic Yaw.

RP552 **Comparison of the Results of the Measurement of the Total Electron Content Obtained by the**
AD-657-488 **Faraday Differential Method and by the Method of Coincidences.** F.BERTIN, J.PAPET-LEPINE.
N67-36456 AGARD Rep. 552, 7 pp., 1966.
Calculation of total electron content by measuring the Faraday differential effect necessitates equipment for recording signals which are transmitted on two adjacent frequencies. From the fundamental equation, two methods of calculation can be derived, one using the coincidence between two Faraday zeroes produced on each transmitted frequency, the other based upon the angular deviation between the Faraday effect on these two frequencies. Programming of all the digital calculations is described, and results obtained by these two methods are compared. The mean difference does not exceed 5%.

RP553 **On the Study of the Amplitude of the Radio-Electric Field of a Satellite at the Horizon of the**
AD-653-930 **Ground Station.** J.F.AUREJAC, J.PAPET-LEPINE.
N67-29572 AGARD Rep. 553, (in French), 26 pp., 1966.
Using a 40 Mc/s high gain aerial which can be pointed in all directions of azimuth, the Val-Joyeuse station can receive signals from "Explorer 22" for all revolutions from 330 to 206 deg. longitude W when passing over the Equator. A large increase in scintillations is observed when the angle of elevation is approximately 20 deg. or less. Some correlation between magnetic activity and the scintillation coefficients has been observed. A systematic comparison with the results obtained by other stations is then made to define the areas giving rise to such scintillations.

RP554 **Survey of Ionospheric Irregularities over Europe.** O.BRATTENG, J.FRIHAGEN.
AD-654-036 AGARD Rep. 554, 33 pp., 19 refs., 1966.
N67-29471 The height of the ionospheric irregularities giving rise to satellite scintillation has been found using spaced receiver observations from several places in Europe and on Spitsbergen. The irregularities are found to be in the 200 to 400 km range over Europe. Only two observations from Spitsbergen were reducible and these gave heights above 400 km.

RP555
AD-654-637
N67-29434

Flight-Measured Turbulence in the NATO Nations. C.G.PECKHAM.
AGARD Rep. 555, 48 pp., Many refs., 1967.
Available data on turbulence were surveyed. Most of the data were collected with instruments that record airspeed, altitude, and acceleration at the centre of gravity plus elapsed time from take-off. The use of the discrete gust and the continuous turbulence concepts is discussed. All data are reported by contributors from the individual countries. In addition to the turbulence data, flight loads, commercial survey loads, ground loads, sinking speeds, and runway profile data were also surveyed. There is an extensive bibliography.

RP556
AD-669-769
N68-22320

Manoeuverability and Gust Response Problems Associated with Low-Altitude High-Speed Flight.
R.C.A'HARRAH.
AGARD Rep. 556, 56 pp., 321 refs., 1967.
The fundamental factors associated with the flying qualities and riding qualities problems in low-altitude high-speed flight are reviewed from rigid-body considerations. The implications of various potential solutions from the viewpoint of improving the low-altitude high-speed characteristics of both current and future aircraft are indicated. The results pertain primarily to relatively small, high-load factor aircraft. There is an extensive bibliography.

RP557/1
AD-669-766
N68-12678

Technical Supplement to Information Bulletin 67/3: Italian Research and Development Activities in the Space Field. G.CIAMPOLINI.
AGARD Rep. 557, 1-35, 23 refs., 1967.
Brief details are given of the ELDO, ESRO and US-Italy San Marco space programmes, and Italian participation therein. There follows a more detailed account of the space activities of FIAT, D.A. The work includes: the development of heat shields, vibration problems, in-flight separation systems, temperature control of satellite equipment, and the study of the effect of ionizing radiations on solid state electronic components. Tables give details of the various European space programmes and of the organization and research and development activities of FIAT in the space field.

RP557/2

Technical Supplement to Information Bulletin 67/3: Organisation of Scientific Research and Technology in Italy, July 1967. N.B.CACCIAPUOTI.
AGARD Rep. 557, 37-55, 1967.
The principal activities of the organisations charged with scientific research and technology in Italy are first reviewed. These organisations include: the Ministry of Education, Ministry of Industry and Commerce, Ministry of Health, Ministry of Agriculture, Ministry of Posts and Telecommunications. There follows a detailed account of the organisation and functions of the National Research Council; the CNR is a state body with autonomous administrative powers and comprises directorial, consultative bodies and operative bodies.

RP557/3

Technical Supplement to Information Bulletin 67/3: Research and Development Activities of the NATO Anti-Submarine Warfare Research Centre. R.WEILER.
AGARD Rep. 557, 57-76, 1967.
The SACLANT Anti-Submarine Warfare Research Centre, its structure and its place in NATO are first described. Problems involved in anti-submarine warfare, and particularly those associated with acoustic detection are discussed. An account is then given of the activities of the Centre, these involve the study of the basic principles involved in sonar and the study of the sea as an acoustic medium.

RP558/1
AD-669-770
N68-25764

Experimental Methods in Wind Tunnels and Water Tunnels, with Special Emphasis on the Hot-Wire Anemometer: Pt.1. Experimental Methods in Wind Tunnels and Water Tunnels. K.WIEGHARDT.
AGARD Rep. 558, 1-23, 70 refs., 1967.
This paper first gives details of the less-known devices for low-speed wind tunnels; particular attention is then given to experimental methods in naval hydrodynamics. In this latter section, the topics covered include: towing tanks; circulating water channel; water tunnels.

RP558/2

Experimental Methods in Wind Tunnels and Water Tunnels, with Special Emphasis on the Hot-Wire Anemometer: Pt.2. The Hot-Wire Anemometer. J.KUX.
AGARD Rep. 558, 25-47, 28 refs., 1967.
Technical difficulties associated with the use of hot-wire anemometers and the requirements which these instruments have to meet are first outlined. The theory of the hot-wire anemometer is then treated in detail. Effects which disturb hot-wire measurements are discussed. Finally, recent developments in data processing are summarized.

RP559
AD-670-124
N68-25763

Survey on the Measurements of the Total Electron Content Variation by Means of Geo-Stationary Satellite Transmission. R.S.ALLEN, P.F.CHECCACCI.
AGARD Rep. 559, 18 pp., 1967.
This report describes current methods of using the Atlantic synchronous satellite "Early Bird" and gives the total electron content and scintillation results obtained by a co-operative association of laboratories, the Joint Satellite Studies Group. Indications are given of future developments and applications in this field.

RP560
AD-672-580
N68-30129

V/STOL Approach and Landing Systems.
AGARD Rep. 560, 28 pp., 15 refs., 1967.
This report presents the results of a survey sponsored by the AGARD Flight Mechanics and Avionics Panels on the practicalities of providing approach and landing guidance for V/STOL aircraft in accordance with the recommendations of AGARD Rep. VLS 1965. While specific equipments have been examined, the findings are framed in terms of general systems, and should be interpreted in this light.

RP561
AD-674-978
N68-33875

Application of Aircraft Integrated Data Systems. C. den HARTOG.
AGARD Rep. 561, 105 pp., 49 refs., 1967.
The following topics are treated: accident/incident, design, airworthiness data systems; maintenance data systems; mission performance data systems; commonalities of requirements for aircraft integrated data systems; integration.

RP562
AD-676-709
N68-37763

Verification of Three-Dimensional Flutter Calculations by Means of Wind-Tunnel Tests on a Flexible Model. R.DESTUYNDER, L.DAROVSKY.
AGARD Rep. 562, 16 pp., 2 refs., 1966.
A model representing a supersonic design was tested in a wind tunnel for comparison with calculations. Planform and stiffnesses were represented but the model had a symmetrical section without camber or twist.

The model showed significant changes in frequencies, approached flutter condition and its natural mode shapes included chordwise and spanwise deformation.

Comparison between the theoretical and experimental results justifies the method of calculation used.

RP563
AD-676-576
N68-37762

Calibration Models for Dynamic Stability Tests. R.FAIL, H.C.GARNER.
AGARD Rep. 563, 5 pp., 8 refs., 1968.
This report prepared at the request of the AGARD Flight Mechanics Panel, describes three further calibration models in the AGARD Series.

Model G – A slender wing suitable for tests over a wide speed range.
Model H – A thin tapered wing suitable for high speed tests.
Model J – A 10° semi-angle cone, suitable for high supersonic speed testing.

RP564
AD-687-973
N69-22828

Possible Effects of Service Changes in Compression Stress – Strain Curves on Buckling. W.BARROIS.
AGARD Rep. 564, 16 pp., 17 refs., 1968.
This report prepared for the AGARD Structure and Materials Panel examines the possible reduction in buckling strength due to fatigue and discusses the effect of creep or hot fatigue on the strength of supersonic aircraft.

RP565
AD-687-974
N69-26157

A Literature Survey on the Aerodynamics of Air Cushion Vehicles. A.HARTING.
AGARD Rep. 565, 232 pp., 341 refs., 1969.
This report gives the results of an exhaustive search of published literature on means of forming a cushion of air cushion vehicles. A classification of air cushion sealing systems is proposed and some original thoughts on the hovering flight of annular jet ACV's have been included.

RP566
AD-689-721
N69-29861

Scintillation of Synchronous Satellite Transmissions at 136 MHz. J.AARONS.
AGARD Rep. 566, 14 pp., 1968.
This report prepared at the request of the Consultant and Exchange Programme and the Electromagnetic Wave Propagation Committee of AGARD, discusses the preliminary results of observations by a number of ground stations on signals at 136 MHz from Intelstat F-2. The intention is to standardise methods of reducing results from a number of observing stations which are proposed for studying techniques for using the upper portion of the VHF band for communications and navigation.

Initial qualitative results show that invariant latitude and conjugate point effects may play important roles in the scintillation process.

RP567
AD-689-722
N70-13083

The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities. C.E.COOPER, R.P.HARPER.
AGARD Rep. 567, 55 pp., 9 refs., 1969.
This report was prepared at the request of the Flight Mechanics Panel of AGARD following the Specialists meeting reported in AGARD Conference Proceedings No.17. Pilot rating scales and their use in assessing aircraft handling qualities are reviewed historically, and objections that have been raised to limitations of earlier scales are considered in the development of a revised scale. Terminology used in the evaluation of handling qualities is reviewed and new definitions are proposed to improve communication and international understanding. Of particular significance is the new definition of handling qualities, which emphasizes the importance of factors that influence the selection of a rating other than stability and control characteristics.

RP568
AD-696-636
N70-11423

Cooperative Programme on Mechanical Testing of Refractory Metals. D.COUTSOURADIS, B.P.MULLINS (Editor).
AGARD Rep. 568, 121 pp., 9 refs., 1968.
This report, prepared at the request of the Structures and Materials Panel of AGARD to record the results of the interlaboratory cooperative programme, in which 11 laboratories from different NATO countries have participated, deals with:
- the determination of room temperature tensile properties of Vascojet 90 (15CDV6) steel sheet, for conventional testing techniques.
- the same, under high temperature testing conditions.
- the determination of the recrystallization temperature of TZN molybdenum alloy sheet.
- the determination of the tensile properties of TZM molybdenum alloy sheet at RT, 1050°, 1450° and 1800°C.

The objective of the programme was to generate information on the adequacy of test techniques and specifications and also on the properties of the materials tested. The report reproduces data on the variability of test results within and between laboratories. For most of the tests performed the interlaboratory variability was significantly larger than the intralaboratory one.

The adequacy of test techniques and specifications is discussed in terms of the available results. Suggestions are made on the modifications of the original specifications.

RP569
AD-698-829

A Review of Special Techniques for Measuring Plastic Strain. T.R.WILSHAW.
AGARD Rep. 569, 28 pp., 48 refs., 1969.
This report was presented at the 28th meeting of the Structures and Materials Panel of AGARD in April 1969 at Dayton, OHIO, U.S.A. It is a review of strain measuring techniques other than transducer techniques, many of which are currently not widely known to engineers. The first section reviews *surface* strain and displacement techniques, grids, interferometry, hologram interferometry, moiré fringes, photoelastic coatings and diffraction grating techniques. The second section reviews techniques for *internal* strain measurement, which include X-ray, microhardness, internal markers, dislocation etch pit and direct observation of dislocation techniques. In all cases accounts of the physical principles of the techniques are given and their applications and practical implications are discussed. Where possible the applications to strain distributions around notches and cracks have been presented as a common example for direct comparison. Finally, an attempt to compare the various techniques has been made.

RP570
AD-696-637
N70-11481

Stress Corrosion – Practical Considerations. G.B.EVANS.
AGARD Rep. 570, 44 pp., 30 refs., 1968.
This report was produced at the request of the Structures and Materials Panel of AGARD and is a study of the present position on stress corrosion from the point of view of designers and constructors, made during 1968 for the AGARD Structures and Materials Panel. The survey is divided into two parts: Part I is a collection of information and views obtained by the author by written questionnaire and visits and is intended for designers and production personnel in the aerospace industry. Part II contains a summary of areas within the field of stress corrosion to which further research could be usefully directed, in addition to the pure research currently proceeding on the behaviour of surfaces and the various mechanisms of cracking involved. This part is intended for the AGARD Structures and Materials Panel, and will not be available for general distribution.

RP571
AD-700-330
N70-32234

North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development – A Survey of Scintillation Data and its Relationship to Satellite Communications.
AGARD Rep. 571, 96 pp., January 1970.
The application of atmospheric studies to practical programs always requires a reorientation of those making the observations as well as the reworking of the data and theory to fit the new needs of an engineering group. This report on scintillation or amplitude and phase fluctuation of radio waves has brought together observational and theoretical material collected predominantly by the Joint Satellite Studies Group and by the Radio Astronomy Branch of the Air Force Cambridge Research Laboratories. This includes general concepts on the physics and irregularities as well as observational material on occurrence of scintillations in distinctive regions of the earth.

RP572
AD-707-634
N70-33059

Effect of Loading Frequency on Strain Behaviour and Damage Accumulation in Low Cycle Fatigue.
D.GUCER, M.CAPA.
AGARD Rep. 572, June 1970.
Experimental data on the effect of loading frequency on the fatigue behaviour of materials are few and far between. This effect manifests itself in various degrees and, sometimes, in a contradictory manner, depending on the type and the level of loading and on the range of frequencies concerned.

RP573
N71-16039

Flight Test Methods – Experimental Techniques. G.PIAZZOLI.
AGARD Rep. 573, December 1970.
This is one of the series of papers which were formerly contained in the AGARD Manual on Aeroelasticity. The report is a general survey of flight test methods for investigating the dynamic stability of aircraft, including an appraisal of the capabilities of recently developed practical techniques and their applications.

The close interdependence between flight tests and other methods such as ground vibration tests, the determination of aerodynamic coefficients, either theoretically or experimentally, and the calculation of critical speed are defined. The choice of flight test methods will depend on particular considerations such as weight, overall dimension, electrical power of the installation, nature and frequency of the modes and means of analysis. Emphasis is made of the importance of step by step exploration of critical areas of the flight range and the value of a prototype even if it means prolonging the flight test program.

RP574
N71-10175

Bibliography of Documents Containing Numerical Data on Planar Lifting Surfaces. R.DAT.
AGARD Rep. 574, August 1970.
Covers the years 1951 to 1968, in chronological order, and lists documents that are unsuited to systematic classification but which nevertheless make a considerable contribution to the literature on unsteady aerodynamic forces. Emphasis has been placed on experimental results and on comparisons between theory and experiment; program descriptions, which may be useful as guides, are presented and abstracts include the nature of the results and their importance. Captions indicate at a glance the speed range (subsonic, transonic, supersonic), whether the results are theoretical or experimental, whether control surfaces are considered, and whether pressure distributions are given. Consideration is limited to planar surfaces and to calculations resulting from the general formulation of the problem: the integral equation or 'box' method. Experimental results quoted do not take into account non-linearities.

RP575
N71-12674

Test Cases for Numerical Methods in Two-Dimensional Transonic Flows. R.C.LOCK.
AGARD Rep. 575, November 1970.
In order to provide test cases for the development of numerical methods for the computation of two-dimensional transonic flows around aerofoils, 6 aerofoil shapes have been selected for which accurate solutions are available. These include both symmetrical and cambered profiles, non-lifting and lifting, in subcritical and supercritical (shock-free) flow.

RP576
N71-12545

Standardization of the Principal Electromagnetic Symbols.
AGARD Rep. 576, December 1970.
The Electromagnetic Wave Propagation Panel has decided to participate in the general effort for the standardization of symbols, units and appellations in the field of study with which it is concerned, and to apply and extend the international recommendations formulated for this purpose.

Under the sponsorship of UNESCO, and within the framework of the International Union of Pure and Applied Physics, the Symbols, Units and Nomenclature Committee published document U.I.P. 11 (S.U.N. 65-3). The International Standardization Organization (I.S.O.) which includes 54 member countries also published documents which generally agree with those of the S.U.N. Committee.

The present document is, in the first place, an application as faithful as possible of the international recommendations. It is also the development thereof in the particular field of electromagnetic waves. Its main interest lies in the fact that it enables readers to listen to, and understand to a large extent, lectures presented to them in a language with which they are not familiar, provided the authors have applied themselves to adopting the common language recommended. This document is undoubtedly imperfect, in spite of the care brought to its preparation. It should be improved, and especially completed in the future, particularly in the field of optics.

RP577
N71-12248
(See also RP408 and RP408A)

V/STOL Handling – I. Criteria and Discussions.
AGARD Rep. 577, December 1970.
This report presents the recommendations of the Working Group sponsored by the Flight Mechanics Panel on desirable handling qualities for military V/STOL aircraft. The recommendations, particularly as regards their application to large aircraft, are based in some respects on requirements for U.S. military helicopters, but considerable use has been made of the results of flight assessments of handling qualities of a number of V/STOL research aircraft.

AGARDographs

AG1
AD-020-810
N-25292
Design and Operation of Intermittent Supersonic Wind Tunnels. A.FERRI, S.M.BOGDONOFF.
AGARDograph 1, 108 pp., 57 refs., 1954.
Considers low cost and flexibility; detailed performance of the components; typical construction, test set-up, instrumentation, extension to the transonic and hypersonic region; and examples of operating intermittent tunnels.

AG2
AD-059-534
N-35025
Methods and Criteria for the Selection of Flying Personnel.
AGARDograph 2, 58 pp., 1954.
The papers at this symposium (held in Paris during February, 1953) were divided into three parts: (i) psychological and psychiatric methods of selection and assessment of flying personnel; (ii) clinical selection criteria and methods; (iii) physiological selection criteria and methods. At the conclusion of each part of the symposium, specially appointed subcommittees summarized the papers and made recommendations for future work. The original papers, the summaries and recommendations are presented in this AGARDograph. For abstracts of the individual papers, see the succeeding items.

AG2/1
Psychological and Psychiatric Methods of Selection and Assessment of Flying Personnel in the Netherlands Air Force. P.M. van WULFFTEN PALTHE.
AGARDograph 2, 1-2, 1954.
The selection procedure described was originally based on the leading principle of selecting the best out of a sufficiently large number of candidates, and is thus positive in character. The emphasis was laid on assessment of the most suitable (selection sensustrictiori), and not on a sifting out of the unfit.

AG2/2
Psychiatric Selection of Flying Personnel. D.W.HASTINGS.
AGARDograph 2, 3-5, 1954.
The selection of flying personnel by standards of emotional stability and prediction of ability to tolerate stresses of flying and combat flying is briefly discussed. Particular attention is given to the concept of selection in depth, i.e., a concept which considers the selection process as a continuous one.

AG2/3
The Psychological Selection of Flying Personnel. (In French.) T.PLACIDI.
AGARDograph 2, 6-10, 1954.
Describes the selection system employed in France; the set of tests used is an adaptation of that used by the U.S.A.F. in 1943-44. The tests comprise 10 written tests and 5 psychomotor tests; the latter are described and the results obtained with them are discussed.

AG2/4
The Validation of Psychological Aptitude Testing. A.CASSIE.
AGARDograph [illegible]14, 1954.
In order to disc[illegible]alidation of pilot aptitude tests, the nature and aims of the aircrew selection system [illegible]d in the U.K. are described. The following aspects are considered: form of the validation, choice of a suitable stage as a criterion, confusion of criteria, reliability of criteria, restricted samples, quality of the selection system, and direction of further effort.

AG2/5
Problems Relating to Clinical Methods of Selecting Flying Personnel. (In French.) E.EVRARD.
AGARDograph 2, 19-30, 19 refs., 1954.
After a general discussion of the problems of selecting personnel for flying duties, the following aspects are considered in some detail: (i) measurements of height and weight, indices of robustness; (ii) vision; (iii) hearing; (iv) equilibrium; (v) conventional medical examination.

AG2/6
The Relationship of Present Clinical Selection Methods to Aircraft Performance. (The Medical Assessment of Aircrew for Modern Military Flying.) M.G.WHILLANS.
AGARDograph 2, 31-34, 4 refs., 1954.
A brief discussion of many of the factors influencing the medical assessment of aircrew, based upon the author's experience with the Royal Canadian Air Force.

AG2/7
The Relationship of Clinical Normality to Physiological Abnormality. W.K.STEWART.
AGARDograph 2, 35-38, 1954.
A discussion of the following factors: examination of simple test methods of respiratory and circulatory efficiency, abnormal physiological reactions to stress and formation of new test methods. It is concluded, inter alia, that the development of accurate methods of recording physical efficiency tests is overdue, and that further tests should be devised to yield additional information in those cases where physiological abnormal reactions have occurred (in response to fear or stress) in subjects whose routine tests have shown no clinical abnormality.

AG2/8 **Tests of Respiratory and Cardio-Vascular Functions Useful for the Selection and Control of Aptitude of Flying Personnel of the Air Force.** (In French.) R.GRANDPIERRE.
AGARDograph 2, 43-46, 19 refs., 1954.
The following subjects are discussed, with frequent reference to the literature of other workers: tests of the respiratory function, tests of cardio-vascular function, and cardio-vascular tests and respiratory resistance to anoxia.

AG2/9 **Physiological and Biochemical Assessment of Individual Resistance to Stress.** R.MARGARIA.
AGARDograph 2, 47-50, 1954.
Discusses: the possible factors involved in fatigue, the emotive component in the fatigue of the aviator, the general adaptation syndrome, practical value of Selye's description, difficulty of evaluating the condition of fatigue or stress, the problem of evaluating muscular fatigue, the way to study fatigue in the aviator.

AG2/10 **Decompression Sickness Selection.** H.L.ROXBURGH.
AGARDograph 2, 51-55, 1954.
Selection by exposure of subjects to decompression is discussed, and the value of this test method is considered. The method in which the rate of take-up of radioactive krypton into the tissues of the distal parts of the body is used as a measure of susceptibility, is also described. Post-decompression effects and future research tasks are briefly considered.

AG2/S **Selected Papers from Symposium held 16-17 June, 1958, Paris, France.**
AD-248-341 AGARDograph 2, Suppl., 107 pp., 1960.
N64-85868 Part 1 presents ten papers on methods and criteria for the selection of flying personnel; abstracts of these papers are given in the succeeding items. Part 2 presents the recommendations of two subcommittees of the AGARD Aeromedical Panel for Pilot Selection Criteria for NATO Air Forces.

AG2/S/1 **Use and Value of the Step Test for Selecting Airmen and Evaluating their Cardiac Tolerance to Stress.** (In French.) E.EVRARD.
AGARDograph 2, Suppl., 3-5, 1958.
A study of the relation between the step-test index and the psycho-physiological selection of Air Force pilots. It is concluded that: (i) the step-test as a screening test is justified; it enables an assessment of the minimum threshold of cardiac tolerance to stress to be made; (ii) the step-test is not justified as a classification test in order to predict the successful results of training; (iii) the step-test provides objective information for the medical examination and care of airmen.

AG2/S/2 **The 'Stool' Test.** (In French.) L.TABUSSE, R.FLANDROIS.
AGARDograph 2, Suppl., 7-14, 5 refs., 1958.
This is an improvement to the step-test, and has the following features: (i) two lateral handles are provided, and the candidate grips these with both hands in order to obtain a better distribution of the strain in the muscular groups of the body; (ii) oxygen consumption and lung ventilation are steadily registered.

AG2/S/3 **Response Evaluation in the Muscular Exercise Fitness Test and Respiratory Responses to the Stool Test.** (In French.) R.GRANDPIERRE, C.JACQUEMIN, P.MASES, R.FALET.
AGARDograph 2, Suppl., 15-20, 7 refs., 1958.
The stool test is of use in evaluating the respiratory changes involved. The authors evaluate the ventilatory frequency, ventilation flow and oxygen concentration in expired gases. Special consideration is given to changes in oxygen consumption.

AG2/S/4 **The Work Electrocardiogram.** A.GRAYBIEL, N.ALLSBACH.
AGARDograph 2, Suppl., 21-46, 14 refs., 1958.
The value of the work electrocardiogram is discussed mainly on the basis of the findings of ten illustrative cases. It is pointed out that the use of the work cardiogram should not be limited to dividing patients suspected of having coronary heart disease into positive and negative categories, but rather placing these patients along a continuum in terms of probable degree of coronary insufficiency.

AG2/S/5 **A Test Battery for Evaluation of the Circulatory Function During Pressure Breathing.** (In French.) C.JACQUEMIN, J.COLIN.
AGARDograph 2, Suppl., 47-49, 1958.
A test battery developed by the authors is described. Electronic registration of oro-nasal pressures, heart rate and systolic blood pressure is carried out.

AG2/S/6 **Blood Pressure Changes in the Flack Test.** (In French.) C.JACQUEMIN, R.MAINARD.
AGARDograph 2, Suppl., 51-59, 19 refs., 1958.
Simultaneous registration of arterial blood pressure and heart-rate frequency during the Flack test provides an accurate evaluation of neurovegetative systems, as has been shown by the examination of 60 healthy young men. Development of a quantitative measurement scale should be based on a more extensive statistical study.

AG2/S/7 **Experimental Research on the Calibration of some Respiratory and Cardio-Circulatory Functional Tests.** (In French.) T.LOMONACO.
AGARDograph 2, Suppl., 61-65, 4 refs., 1958.
The increase of pulmonary ventilation, cardiac output, and arterial blood pressure arising from muscular exercise can be used as calibration data of respiratory and cario-circulatory functions of the candidates belonging to a homogeneous group. The author intends to integrate such evaluations into the conventional physical examination of aircrew candidates in order to obtain a classification of psycho-physiological fitness.

AG2/S/8 **Calibration in Groups of Pilots of the Main Respiratory and Cardio-Circulatory Responses to Low Barometric Pressure.** (In French.) A.SCANO.
AGARDograph 2, Suppl., 67-76, 3 refs., 1958.
The individual values of heart rate, respiratory rate, pulmonary and alveolar ventilation, humeral blood pressure and electrocardiogram were measured in a group of 96 young jet pilots at 3,000 to 5,000 m. It was found that group and individual variability did not exceed ±13% and ±15% respectively. Discontinuous exposure to hypoxia appeared to give a reasonable acclimatization to altitude.

AG2/S/9 **The Stipple Test: A Follow-Up Study Including Notes on Hyperventilation.**
P.M. van WULFFTEN PALTHE.
AGARDograph 2, Suppl., 77-90, 4 refs., 1958.
Modifications to the Bourdon-Wiersma Stipple test for the evaluation of the fluctuations in the level of consciousness are first described. Results of such tests on 1193 aviation applicants and pilots are presented and discussed. The notes on hyperventilation consider the effects of voluntary hyperpnoea and emotional hyperventilation.

AG2/S/10 **Biophysical and Physiological Considerations of Skin Resistance with Special Reference to Findings in Isolation.** G.E.RUFF, E.Z.LEVY, V.H.THALER, G.E.JOHNSON.
AGARDograph 2, Suppl., 91-95, 1958.
The nature of peripheral and central mechanisms which underlie changes in the electrical resistance of the skin are discussed. The work of other investigators is summarized, and recent studies at the Wright-Patterson Aero-Medical Laboratories in which measurements of galvanic skin reflex (GSR) were made for a period of several days, are described

AG3 **A Summary of the Techniques of Variable Mach Number Supersonic Wind Tunnel Nozzle Design.**
AD-056-640 J.T.KENNEY, L.M.WEBB.
N-33959 AGARDograph 3, 133 pp., 47 refs., 1954.
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.

AG4 **Spontaneous Ignition of Liquid Fuels.** B.P.MULLINS.
AD-688-922 AGARDograph 4, 117 pp., 347 refs., 1955.
N69-77111 Reviews the present state of knowledge of spontaneous ignition of combustibles that are liquid at normal temperature and pressure. The chemical reactions occurring during the ignition process are considered theoretically. The various test methods available are described in detail. Spontaneous ignition temperature data are presented for 433 substances.

AG5 **Anthropometry and Human Engineering.**
AD-695-339 AGARDograph 5, 123 pp., 1955.
N69-75814 The papers presented to the AGARD Symposium on Anthropometry, (introduced by E Evrard) and Human Engineering and Related Subjects (introduced by H.P.Ruffell Smith) held at Scheveningen in May, 1954 are reproduced. Abstracts of the individual papers are given in the succeeding items.

AG5/1 **Body Measurements in Relation to Work Spaces in Aircraft.** G.M.MORANT.
AGARDograph 5, 3-17, 9 refs., 1955.
Discusses the use of records of body measurements in dealing with problems relating to the dimensions of crew positions in aircraft. Summarizes research and applications carried out for the Royal Air Force.

AG5/2 **Statistics of Elementary Medical Biometry Relative to Flying Personnel of the French Army and Air Force.** (In French.) P.DUCROS.
AGARDograph 5, 18-30. 1955.
Measurements were made of the following: height, weight, chest, and leg-length, and for some of the subjects, also cranial circumference, length from elbow to finger-tip, distance from base of nose to chin. The distribution of these measurements is shown graphically. The Pignet-Mayet index is derived to obtain a classification of the physique of the subjects.

AG5/3 **Sheldon Types and Success in Flight Performance.** J.DOSSING.
AGARDograph 5, 31-35, 13 refs., 1955.
There is a slight tendency for the qualified to have higher values in the mesomorphic component than the normal population and the failed and rejected group; but in selection care must be taken not to select cadets for the reason that the mesomorphic component is more dominant.

AG5/4 **Adapting the Aeroplane to the Pilot.** W.K.STEWART.
AGARDograph 5, 41-46, 1955.
Contents: Assessment of results; Application of results (pressurization, temperature control, escape, cockpit dimensions and layout, instrumentation); Future problems.

AG5/5 **Instrument Dials, Instrument Arrangement and Cockpit Design.** W.F.GRETHER.
AGARDograph 5, 47-62, 16 refs., 1955.
In order to counteract the increasing complexity of modern aircraft and the resulting possibilities of pilot error, human engineering effort is being directed to the design of aircraft cockpit equipment to suit the psychological requirements of the pilot. Here research data and design applications which illustrate a variety of instrument and cockpit design problems are discussed.

AG5/6 **A Methodology for Instrument Display Design.** G.W.HOOVER.
AGARDograph 5, 63-72, 1955.
The purpose of this paper is to establish a methodology for display design for those flight instruments which provide visual data, without permitting the design decisions to be influenced by personal opinion.

AG5/7 **Factors Affecting the Validity and Utility of Aeromedical Research Data.** R.B.PAYNE.
AGARDograph 5, 77-89, 13 refs., 1955.
Contents: The statistician's rôle in aeromedical research; The general nature of statistical collaboration; The importance of experimental design; The sampling problem; Statistical interpretations.

AG5/8 **The Establishment of a Longitudinal Study of the Medical and Psychological Aspects of the U.S. Naval Aviator.** A.GRAYBIEL.
AGARDograph 5, 90-103, 11 refs., 1955.
The argument is put forward that the military aviator is of such importance that he should warrant close observation and care throughout his entire career. Aspects discussed include: manpower policy; selection; training and indoctrination; identification and recognition of success; protection from stress and strain.

AG5/9 **Somatotyping.** P.M. van WULFFTEN PALTHE.
AGARDograph 5, 104-112, 1955.
The importance of knowing the height and size of the human body, its average and extreme values, together with those values most frequently occurring, (not only for the body as a whole, but also for its parts) is discussed, in relation to its significance in the construction of aircraft and their equipment.

AG5/10 **Human Factors in Aircraft Design.** M.G.WHILLANS.
AGARDograph 5, 113-123, 9 refs., 1955.
The importance of human factors in aircraft design is stressed. It is proposed that the operational demands to be made on aircrew should be set forth carefully and completely before development of a new aircraft is seriously begun.

AG6 **Collected Papers on Aviation Medicine.**
N69-75828 AGARDograph 6, 209 pp., 1955.
The papers reproduced in this AGARDograph were delivered during various meetings of the AGARD Aeromedical Panel, and before AGARD General Assemblies. Abstracts of the individual papers are given in the succeeding items.

AG6/1 **Aeromedical Research and Aeronautical Technology.** (In French.) P.BERGERET.
AGARDograph 6, 1-4, 1955.
General considerations affecting the techniques to be used in aeromedical research are first discussed. Equipment that is of use in such investigations is then briefly described. The advantages of employing the Hussenograph and strain gauges are stressed.

AG6/2 **A Brief Survey of Aviation Medicine.** P.B.LEE-POTTER.
AGARDograph 6, 5-11, 1955.
Contents: Speed (effects of g, temperature, vision); Anoxia, Decompression effects; Escape, other problems; Air crew selection; Aeromedical indoctrination.

AG6/3 **Aeromedical Interests – Looking Forward.** O.O.BENSON, JR.
AGARDograph 6, 12-15, 1955.
The importance of co-operation in research efforts is discussed, and particularly co-operation between aeromedical scientists and designers of aircraft and equipment. The effects of reduced gravity states on aircrew is then considered, and the requirements that such environments necessitate are listed.

AG6/4 **Tolerance Variations in Respiration Under Pressurization.** (In French.) R.GRANDPIERRE, F.VIOLETTE.
AGARDograph 6, 16-18, 1955.
A brief report is given of experiments carried out by the authors into the reactions of dogs to low levels (20 cm of water) of pressurization. The findings of other workers on the reactions of human subjects to similar levels of pressurization are also discussed.

AG6/5 **Speed of Inspiration in Anoxic Anoxia as a Method of Investigation of the Respiratory Function.** (In French.) T.LOMONACO.
AGARDograph 6, 19-30, 1955.
A report of an experimental investigation in which 14 healthy subjects were submitted to a progressive anoxia by means of the re-breathing method, in order to assess the effects of the variations in the alveolar gas pressures on the inspiratory capacity and the time of inspiration.

AG6/6 **Medical Tests for Detecting Latent Epilepsia and Fluctuations in the Level of Consciousness.** P.M. van WULFFTEN PALTHE.
AGARDograph 6, 31-40, 1955.
The development of the stipple test is described, and the history is given of its use (i) for detecting latent epilepsia, (ii) determining the effects of anoxia on the level of consciousness, and (iii) determining the effects of alcohol intoxication. The relationship between electro-encephalograms and the results of stipple tests is also discussed.

AG6/7 **Arctic Survival Problems.** K.RODAHL.
AGARDograph 6, 41-51, 1955.
Problems related to human survival in the North Polar Basin of the Arctic are discussed. Factors considered include: environment, topography, environmental protection, rations, water, and indoctrination.

AG6/8 **British Theory and Practice in the Layout of Aircraft Cockpits.** H.P.RUFFELL SMITH.
AGARDograph 6, 52-61, 1955.
The planning of the 'work-space' in an aircraft in order to enable the aircrew to carry out their tasks with the maximum efficiency is described. The factors affecting cockpit layout are: dimensions, view out, controls, information, crash protection, and escape.

AG6/9 **Physiological Requirements of Pressure Cabins.** H.L.ROXBURGH.
AGARDograph 6, 62-67, 1955.
Pressure requirements for systems in which the occupants use oxygen equipment, and those in which they do not, are discussed; the effects of loss of pressure are also considered. Air-flow requirements for both ventilation and control of thermal conditions are then discussed.

AG6/10 **Consequences of Loss of Cabin Pressure.** D.I.FRYER.
AGARDograph 6, 68-78, 34 refs., 1955.
The following consequences are considered: the effects of air blast, anoxia, the effects of gas expansion within hollow organs, lung damage in explosive decompression, and the risk of decompression sickness.

AG6/11 **Recent Advances of Instrumentation of Interest in Aviation Medicine.** Pt. 1, J.CLARK.
AGARDograph 6, 79-86, 3 refs., 1955.
Progress in the field of diaphragm design, and improved transformer materials has led to the development of new transformer pressure pick-ups. The design characteristics, performance characteristics, circuitry and recording equipment of a different (dual) transformer type transducer, and a flush diaphragm single transformer type are described.

AG6/12 **Recent Advances of Instrumentation of Interest in Aviation Medicine.** Pt. 2, C.S.WHITE, W.R.LOVELACE, 2nd.
AGARDograph 6, 86-104, 22 refs., 1955.
Methods of continuous gas analysis as applied to respiratory problems are discussed, commencing with that described by Lilly and Anderson (1944). Considerable attention is given to the calibration of the Ekeroot modified Lilly-Anderson-Kervey nitrogen meter.

AG6/13 **Recent Advances of Instrumentation of Interest in Aviation Medicine.** Pt. 3, N.P.V.LUNDGREN.
AGARDograph 6, 104-111, 10 refs., 1955.
A method for obtaining end-expiratory air from the oropharynx of a subject is described, which is useful mainly in experiments with rebreathing in a closed circuit with circulating gas. Comparisons made in an open circuit with the Rahn-Otis sampler showed good agreement. A study was also made of the time-delay due to mixing in the latter sampler during large and rapid changes in the composition of the alveolar gas.

AG6/14 **The Nature of Cold-Induced Tissue Injury.** R.B.LEWIS.
AGARDograph 6, 112-116, 1955.
Cold-induced tissue injury was studied by observing microscopic sections made from the tibialis anticus muscle of rabbit legs following exposure to an alcohol bath (−12 deg.C). Further examinations were made of tissue exposed to temperatures as low as −36 deg.C. The results obtained are described, and illustrated in 28 plates.

AG6/15 **The High Intensity Noise Problem in the U.S. Navy.** C.P.PHOEBUS.
AGARDograph 6, 117-121, 1955.
The problem of noise on-board aircraft carriers, especially that due to jet aircraft, is considered. The effects of noise, the tolerable limit of noise, the nature and attenuation of jet engine noise, and the use of ear protective devices, are discussed.

AG6/16 **Tolerance to Abrupt Deceleration.** J.P.STAPP.
AGARDograph 6, 122-169, 19 refs., 1955.
A detailed account of American research into tolerance to abrupt deceleration. Tests performed on chimpanzees, hogs, human subjects and anthropomorphic dummies, using linear decelerators, are described. It was concluded that the tolerance limits for human subjects approximate 50 g peaks at 500 g/sec rate of onset for 0.25 sec duration, provided restraints are adequate.

AG6/17 **Night Vision.** (In French.) A.MERCIER.
AGARDograph 6, 170-178, 1955.
Nocturnal vision in aviation poses several problems; here only three of these are considered: (i) evaluation of nocturnal vision, and control of its variations; (ii) methods of improving nocturnal vision; (iii) protection of nocturnal vision.

AG6/18 **Some Problems in Testing Colour Vision.** M.A.BOUMAN, P.L.WALRAVEN.
AGARDograph 6, 179-185, 3 refs., 1955.
Aspects discussed include: physiological basis of colour discrimination, tests of colour vision, the colour-naming of signal lights. It is pointed out that a pass/fail test is no longer satisfactory, and that attempts should be made to match the colour-discriminating abilities of subjects to the tasks they are asked to perform.

AG6/19 **Heterophoria.** G. Ten DOESSCHATE.
AGARDograph 6, 186-194, 1955.
The variability of heterophoria, the inaccuracy and unreliability of the results obtained in experimental investigations made by the author, and the inconsistencies between the results obtained by different test methods are discussed.

AG6/20 546. **Practical Aspects of Heterophoria in Aviation.** J.C.NEELY.
AGARDograph 6, 196-209, 7 refs., 1955.
The theory that exophorics under-estimate, and esophorics over-estimate distances is critically examined. The following aspects are then discussed: assessment of heterophoria, incidence of heterophoria, practical experience of heterophoria and flying, surgical correction of heterophoria, and recommended standards.

AG7
AD-688-923
N69-77112

Introduction to the Study of Chemical Reactions in Flow Systems. S.S.PENNER.
AGARDograph 7, 86 pp., 71 refs., 1955.
The subject is discussed under the following headings: (i) classical chemical kinetics (phenomenological description of reaction rates in stationary, isothermal systems); (ii) conservation laws and transport coefficients in reacting mixtures; (iii) chemical reactions during adiabatic expansion through a Laval nozzle; (iv) heterogenous chemical reactions.

AG8
AD-688-924
N64-84030

Theory of Combustion Instability in Liquid Propellant Rocket Motors. L.CROCCO, SIN-I-CHENG.
AGARDograph 8, 200 pp., 36 refs., 1956.
The four sections of the text are: (i) general considerations, including combustion process, mechanisms of unstable combustion and equations for time lag and space lag; (ii) chugging analysis (low frequency instability); (iii) discussion and comparison with experiment. Appendices consider the analytical nature and methods of solutions of equations, and discuss some of the equations used.

AG9
AD-688-925
N-37722

Combustion Researches and Reviews – 1955. B.P.MULLINS (Editor).
AGARDograph 9, 187 pp., 1955.
Papers read at the 6th and 7th meetings of the AGARD Combustion Panel, held in Scheveningen, Netherlands, May 1954, and in Paris, France, November 1954 are presented. Abstracts of the individual papers are given in the succeeding items.

AG9/1

Diffusion Flames in the Laboratory. J.BARR.
AGARDograph 9, 1-9, 55 refs., 1955.
The following aspects relating to laminar diffusion flames are considered; flame structure, flame length, simple theories, laminar flame limits (open flames and enclosed flames), and anchoring of laminar flames. Turbulent and vibrating diffusion flames are briefly described. Suggestions are made for future research.

AG9/2

Some Problems Pertinent to the Combustion of Sprays. M.GERSTEIN.
AGARDograph 9, 10-22, 40 refs., 1955.
The object of this paper is to present the status of U.S. research relating to the combustion of sprays in order to indicate worthwhile areas for further research. The following topics are considered: atomization, drop distribution, drop dynamics, evaporation, combustion.

AG9/3

Some Aspects of Combustion of Liquid Fuel. C.C.GRAVES, M.GERSTEIN.
AGARDograph 9, 23-38, 25 refs., 1955.
This discussion is limited to those factors normally associated with diffusion flames. The combustion of liquid sprays is considered in terms of such individual processes as fuel spray spreading and evaporation. The efficiency of combustion of liquid fuels in turbojet combustors as affected by fuel volatility, spray characteristics, and the burning rate of single drops is also treated.

AG9/4

The Formation and Evolution of Combustible Mists. (In French.) R.KLING.
AGARDograph 9, 39-49, 9 refs., 1955.
Work done in recent years has made it possible to study the constitution of fuel mists, and particularly the mists occurring in turbojets and in rockets in the region near the flame. Such methods will make it possible to study the relation between the nature of the mist and the combustion characteristics, particularly its stability.

AG9/5

Some Notes on Spray Combustion. J.R.JOYCE.
AGARDograph 9, 50-52, 1955.
In this discussion of fuel atomization, spray production was demonstrated under four different sets of conditions; in each case the spray was ignited to give an indication of its quality. These simple tests clearly showed the importance of a reasonable proportion of droplets in the size range $<50\mu$.

AG9/6

The Correlation of Combustion Efficiency and Injector Characteristics under Simulated Altitude Idling Conditions. NATIONAL GAS TURBINE ESTABLISHMENT.
AGARDograph 9, 53-57, 1 ref., 1955.
The data analyzed are taken from the results of combustion chamber tests under high altitude conditions which were standardized. Examination of the results showed that, in a general way, combustion efficiency falls off as fuel flow is decreased by either increasing altitude or increasing air/fuel ratio.

AG9/7 **Flame Stabilization and Flame Propagation in Ramjet Combustors.** J.P.LONGWELL.
AGARDograph 9, 58-71, 22 refs., 1955.
The problem of flame stabilization is first considered. Data on stabilization by baffles are then presented and discussed. Some data on 'can' stabilizers are also included as it is believed that such devices are as important as bluff-body stabilizers. Information, obtained from the literature, on the rate of flame propagation downstream from the baffles is discussed.

AG9/8 **Study of the Stability Limits in Relation to the Resistance of Obstacles to the Flow.** (In French.) A.MESTRE.
AGARDograph 9, 72-86, 3 refs., 1955.
Contents: Description of the stabilization of a flame by an obstacle; Correlations deduced from the thermal balance; Experimental results (measure of the resistance to the flow, measurement of stability limits); Conclusions.

AG9/9 **A Spontaneous Ignition Theory of Combustion Intensity and Combustion Stability Behind a Baffle.** B.P.MULLINS.
AGARDograph 9, 87-107, 11 refs., 1955.
Combustion intensity and combustion stability are examined in the light of a spontaneous ignition parameter; critical combustion conditions occur when this parameter t/τ equals unity (t = available residence time, τ = the required ignition delay period under the existing conditions of pressure, temperature, mixture strength, etc.). The present treatment is mainly qualitative, and many simplifying assumptions have been made.

AG9/10 **The Mechanism of Carbon Formation.** G.PORTER.
AGARDograph 9, 108-124, 26 refs., 1955.
The chemical processes leading to carbon formation in the following systems are considered: pyrolysis of pure hydrocarbons, pyrolysis of acetylene, diffusion flames, explosions in closed vessels, premixed flames. The results of investigations by flash photolysis are included.

AG9/11 **Formation and Deposition of Carbon in the Combustion Chambers of Aircraft Turbine Engines.** (In French.) C.FOURE.
AGARDograph 9, 125-139, 13 refs., 1955.
Contents: Knowledge acquired concerning the formation of carbon deposits in combustion chambers; Effect of the nature of the fuel; Study of carbon particles formed in the flame; Examination of possible ways of avoiding carbon deposits in combustion chambers; Conclusions.

AG9/12 **Similarity Analysis for Chemical Reactors and the Scaling of Liquid Fuel Rocket Engines.** S.S.PENNER.
AGARDograph 9, 140-162, 10 refs., 1955.
Presents a new development of similarity criteria (an improvement on existing criteria) for flow problems with chemical reactors (and useful for scaling rocket engines). Results obtained with this method are compared with Damköhler's five similarity criteria. The use of the similarity parameters for the determination of rational scaling procedures is illustrated.

AG9/13 **Radiation of Flames and Similarity.** (In French.) C.CODEGONE.
AGARDograph 9, 163-166, 3 refs., 1955.
A mathematical treatment of this subject is presented. It is shown that for geometrically similar flames (of small dimensions, and burning with excess air) the radiant energy on the flame surface is proportional to a linear dimension (e.g. the diameter).

AG9/14 **The Rôle of Wake Transition in the Process of Flame Stabilization on Bluff Bodies.** E.E.ZUKOSKI, F.E.MARBLE.
AGARDograph 9, 167-180, 11 refs., 1955.
Experimental results are described to (i) demonstrate the importance of wake transition on flame-holding, (ii) clarify certain steps in the process of flame stabilization, (iii) establish that, in the presence of wake transition, the blow-off velocity of a bluff-body flame-holder increases as the square-root of the characteristic flame-holder dimension over a substantial range of mixture ratios.

AG10
AD-077-895
N-39765 **Automatic Pressure Measuring Systems used with High-Speed Wind Tunnels.** C.L.FREDERICK.
AGARDograph 10, 51 pp., 24 refs., 1955.
A brief review of high-speed wind tunnel characteristics with particular reference to instrumentation needs is given. This is followed by a survey of the major elements of pressure-measuring systems. Representative systems in actual use in the U.S.A. are described.

AG11
AD-092-531
N-41796 **Dynamic Measurements in Wind Tunnels.** L.ARNOLD.
AGARDograph 11, 68 pp., 42 refs., 1955.
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.

AG12
AD-077-894
N-39888

Turbulence Measurements with the Hot-Wire Anemometer. R.D.COOPER, M.P.TULIN.
AGARDograph 12, 58 pp., 63 refs., 1955.
After a review of the current status and techniques, certain essential definitions and ideas of the statistical theory of turbulence are discussed. Features of experimental investigations are tabulated. The anemometer is described, and the principle sources of hot-wire turbulence measurements given. Finally, progress in the measurement of turbulence in high-speed flows is reviewed.

AG13
AD-655-967
N-51964

The Problems of Vision in Flight at High Altitude. T.C.D.WHITESIDE.
AGARDograph 13, 162 pp., 98 refs., 1957.
Effects of changes in intensity and spectral distribution of sunlight at high altitude and physiological changes affecting visibility of objects inside the cockpit and affecting air to air visibility are considered. Most of the problems investigated appear at present to be peculiar to high altitude. With one exception the problems dealt with do not arise from speed.

AG14
AD-109-912
N-47258

Compressors for High-Speed Wind Tunnels. A.A.FEJER, J.CLARK.
AGARDograph 14, 216 pp., 79 refs., 1956.
Concerns continuous type tunnels and contains information regarding (i) the aerodynamic characteristics of tunnel circuits from which the compressor requirements can be established, (ii) selection of the compressor type, (iii) compressor drives, and (iv) aerodynamic and mechanical considerations underlying the design and operation of wind tunnel drives including a vibrational problem.

AG15
AD-695-270
N69-76191

Combustion Researches and Reviews. B.P.MULLINS, J.FABRI (Editors).
AGARDograph 15, 204 pp., 227 refs., 1957.
The ten papers of this book are given in following abstracts and cover flame phenomena, pulse-jets, and shock tubes.

AG15/1

Stationary Flames at Pressures Above One Atmosphere. G.A.McD.CUMMINGS.
AGARDograph 15, 1-16, 34 refs., 1957.
In this review of literature, it is shown that only comparatively recent information on this subject is trustworthy. Certain general relationships have now become apparent about the effects of pressure on such fundamental properties of premixed and diffusion flames as burning velocities, temperature and spectra. Some details of these are given.

AG15/2

Hydrogen-Halogen Flames. R.C.ANDERSON.
AGARDograph 15, 17-30, 38 refs., 1957.
Summarizes the results of experiments on flame temperatures and velocities, and flame spectra for hydrogen-bromine, hydrogen-chlorine, and hydrogen-fluorine. Attempts at theoretical calculations of flame velocities are also reviewed.

AG15/3

Flame-Spreading Characteristics in Combustion. N.R.L.MacCALLUM.
AGARDograph 15, 31-39, 22 refs., 1957.
A discussion of the mechanism of stabilization is given for each of the flame-spreading systems considered, which include turbulence-increasing devices and inclined metal fingers. Future work might fruitfully be directed towards achieving the controlled mixing necessary to give the optimum heat release rate.

AG15/4

Study of Flames in Air-Kerosine Mixtures. (In French.) J.RAPPENEAU.
AGARDograph 15, 40-54, 25 refs., 1957.
A laboratory burner is described for studying mixtures of air and vaporized kerosine. This burner, constructed so that one may obtain laminar or turbulent flames, is used so that these flames may be compared with flames of the usual hydrocarbon mixtures. A second burner embodying flame-holders permits the study, at low speeds, of the properties of stabilized flames, especially those which concern their stability limits and the constitution of their nuclei.

AG15/5

Bubble-Points, Flammability Limits and Flash-Points of Petroleum Products. B.P.MULLINS.
AGARDograph 15, 55-75, 10 refs., 1957.
These relationships have been demonstrated numerically for aviation spirits to gas oil fuels. Mean molecular weights are computed of fuel vapours at the bubble points, and nomographic methods of presenting bubble point data are applied. Weak and rich flammability limits of the fuels were calculated over a range of static pressures and a flash-point correction factor was obtained for each fuel.

AG15/6 **A Theoretical Analysis of Reaction Rate Controlled Syrtems.** Pt.1, M.V.HERBERT.
AGARDograph 15, 76-111, 22 refs., 1957.
Absolute limits of air loading are determined for an adiabatic and homogeneous reaction zone; a loading parameter is defined, which includes the effect of inlet temperature. The application to 'can' and baffle stabilizing systems is considered, and the influence of pressure drop discussed.

AG15/7 **Comments on Pulse-Jets.** (In French.) J.DUCARME.
AGARDograph 15, 112-122, 1 ref., 1957.
After having established the theoretical efficiency of the ideal cycle employed, the author seeks to determine the actual efficiency which, by comparison with the former, gives information on the extent of possible improvements. The influence of the pulsatory flow is examined.

AG15/8 **Some Results Obtained at S.N.E.C.M.A. in the Study of Pulse-Jets.** (In French.)
J.BERTIN, B.SALMON.
AGARDograph 15, 123-133, 2 refs., 1957.
Studies pulse-jet back flow which gives a method for determining the rear length of the engine. Instantaneous pressure and temperature measurements are discussed in the light of pulse-jet operation and performance. Finally the pattern of periodic flow is derived from the pressure and temperature measurements.

AG15/9 **An Introduction to the Use of the Shock Tube for the Determination of Physico-Chemical Parameters.** S.S.PENNER, F.HARSHBARGER, V.VALI.
AGARDograph 15, 134-172, 80 refs., 1957.
Presents a qualitative survey of shock tube development and describes the use of optical techniques suitable for use in shock tubes. This is followed by a summary of determinations of physico-chemical parameters behind incident and reflected shock waves. Use of the shock tube in combustion researches is discussed.

AG15/10 **An Outline of a Method for Preparing Enthalpy Charts for Dissociating Gas Mixtures in the Temperature Range 600°-4000°K.** O.LUTZ.
AGARDograph 15, 173-197, 14 refs., 1957.
Enthalpy charts have been constructed for combustion and flow problems of dissociating gases within the temperature range of 600 deg. to 4000 deg.K. From these it is possible to work out dissociation processes occurring at equilibrium and also the composition of the mixture. The charts are confined to the C, H, and O system, but can be extended to include N.

AG16 **Icing Problems and Recommended Solutions.** E.A.BRUN (Editor).
AD-200-674 AGARDograph 16, 264 pp., 1957.
N-62844 Various aspects of aircraft icing problems are discussed, by authors from different NATO countries and the whole text is in both English and French. Chapter headings are as follows: (1) General Survey, (2) icing conditions to be considered in the design of protection systems, (3) the measurement of icing conditions, (4) icing wind tunnel tests, (5) flight tests in simulated icing conditions, and (6) icing flight test concepts in the U.S.A. Abstracts of the individual papers are given in the succeeding items.

AG16/1 **General Survey.** E.A.BRUN.
AGARDograph 16, 7-69, 97 refs., 1957.
This is a general survey of icing conditions, the mechanics of icing, and the thermodynamics of the problem. Brief remarks are made on aeroplane icing and means of protection against this phenomena.

AG16/2 **Icing Conditions to be Considered in the Design of Protection Systems.** D.FRASER, K.G.PETTIT.
AGARDograph 16, 71-91, 14 refs., 1957.
Deals with the large-scale collection of data including icing parameters of interest, the measurement of these parameters, the results of statistical measurements, and details of icing requirements.

AG16/3 **The Measurement of Icing Conditions.** D.G.A.RENDEL, F.J.BIGG.
AGARDograph 16, 93-156, 40 refs., 1957.
Contents: the measurement of liquid water contents; measurement of droplet diameter; measurement of air temperature calibration of instruments; and positioning of instruments on the aircraft.

AG16/4 **Icing Wind Tunnel Tests.** R.B.MORRISON, J.A.NICHOLLS, R.E.CULLEN, H.E.STUBBS.
AGARDograph 16, 157-227, 19 refs., 1957.
An introduction deals with types of icing tunnels, economy of installation, and the nature of the tests; Details are then given of the conditions to be simulated in an icing tunnel, design considerations of the tunnel, and evaluation of test results. The two Appendices consider icing wind tunnel test facilities and refrigeration cycles.

AG16/5 **Flight Tests in Simulated Icing Conditions.** G.C.ABEL, J.K.THOMPSON.
AGARDograph 16, 229-246, 1957.
Two types of test facilities have been successfully used in this work:– the water spray rig which is mounted in front of the component to be tested in flight, and the tanker aircraft which is flown just in front of the test aircraft. Both types are described in this paper.

AG16/6 **Icing Flight Test Concepts in the U.S.A.** J.K.THOMPSON.
AGARDograph 16, 247-264, 1957.
Presents a general discussion on the subject with the intention of providing general guidance to the new engineer on such subjects as test directives and objectives, scope of the tests, instrumentation, and operational problems concerning the flight tests.

AG17 **Condensation Effects and Air Drying Systems for Supersonic Wind Tunnels.** J.J.SMOLDEREN.
AD-116-958 AGARDograph 17, 79 pp., 38 refs., 1956.
N-47980 Part one is devoted to a study of condensation effects and a criterion is presented for the complete removal of these effects. Conditions under which disturbances are sufficiently small are indicated. The second part studies drying processes in use and the third part surveys measuring devices for the determination of humidity.

AG18 **The Use of Rheoelectrical Analogies in Aerodynamics.** L.C.MALAVARD.
AD-121-447 AGARDograph 18, 175 pp., 67 refs., 1956.
N-49802 Rheoelectric analogy is based on the identity of the equations which govern certain fluid flows and those for the distribution of electric potential in a continuous conducting medium such as an electric tank or conducting paper. A review of the principle of the method is given, and aerodynamic applications are examined.

AG20 **History of German Guided Missiles Development.** T.BENECKE, A.W.QUICK (Editors),
N64-80060 W.SCHULZ (Managing Editor).
AGARDograph 20, 419 pp., 127 refs., 1957.
At a Symposium in Munich in April, 1956, twenty-six papers were given. This book contains these papers together with the more important discussions. Abstracts of the individual papers are given in the succeeding items.

AG20/1 **Summary of German Developments in Guided Missiles.** T.BENECKE.
AGARDograph 20, 1-7, 1957.
This is a general survey of the rocket and aircraft-type guided missiles developed by Germany during World War 2. It includes some details on their uses, trajectories, accuracies and guidance methods.

AG20/2 **Guidance and Control of the Henschel Missiles.** H.A.WAGNER.
AGARDograph 20, 8-23, 1957.
Deals with operational missiles; the beginning of the Henschel; description of Hs 293; method of attack; simulation; guidance and control; stability; accuracy of the airframe; Mach number; elevator servo; roll control; radio and wire links; tactical use; Hs 294; bar control; 'Zitterrochen'; Hs 117.

AG20/3 **Contributions to the Guidance of Missiles.** E.FISCHEL.
AGARDograph 20, 24-38, 7 refs., 1957.
Deals with the problems involved, the control of glider bombs, control of bombs by television including a training device, models for beam riding method and anti-aircraft rockets, course and range correction for the V1, ultra-violet light transmitting device, gyro-stabilized binoculars for bomb aimers, and theoretical work on target-seeking devices.

AG20/4 **Spoiler Control of Missiles.** G.ERNST.
AGARDograph 20, 39-49, 10 refs., 1957.
Deals with the spoiler and its operation, definitions of the spoiler, the spoiler in two-dimensional, three-dimensional and compressible flow, the spoiler on a flat plate and on an airfoil, application of the spoiler to flying bodies, construction of the flight control system, method of steering, and application of spinning flight control.

AG20/5 **The Aerodynamic Development of the V-2.** H.H.KURZWEG.
AGARDograph 20, 50-69, 15 refs., 1957.
Discusses the pioneer work which led to the development of this rocket missile. Descriptions include that of the aerodynamic department at Peenemünde, the sub- and supersonic wind-tunnels, free-flight models, instability regions of the A4 rocket, wind-tunnel model testing, and thermodynamic data.

AG20/6 **Development and Testing of the V-1 Auto-Pilot.** H.TEMME.
AGARDograph 20, 70-79, 1957.
The requirements in the development of the V1 are stated. One of these related to the accuracy which had to be achieved by an auto-pilot without additional radio control. This and the characteristics of the airframe led to some special requirements which the auto-pilot had to fulfil; these characteristics are discussed in this paper.

AG20/7 **The Control System of the V-2.** O.MÜLLER.
AGARDograph 20, 80-101, 1957.
Describes the control problem and the required control circuits, the control equipment for the standard series, the guide plane control of the special series, high precision control without radio, and special equipment of the control of the V2 which was in the course of development including the guide line control and improvement of the accuracy of the 'all-burnt' signal.

AG20/8 **Development and Field-Tests of a Radio-Controlled Aeroplane Model as Target Simulator for Anti-Aircraft Batteries.** W.KLOEPFER.
AGARDograph 20, 102-108, 1957.
Describes the principle of the radio control system, the technical details of the aircraft equipment, ground station, and the results of the field tests and plans for further development.

AG20/9 **Guided Missiles Radio Remote Control.** J.DANTSCHER.
AGARDograph 20, 109-124, 4 refs., 1957.
Deals with the principle of radio remote control, the Kehl/Strassburg system for the Fritz X free falling bomb and for the Hs 293 glider bomb, antennae, radio transmission jamming, testing of remote controlled missiles, and combat experience.

AG20/10 **Further Development of Remote Control Systems and the Remote Control of Air-to-Air Missiles.** J.DANTSCHER.
AGARDograph 20, 125-134, 1957.
Contents: Audio frequency line guidance system; direct-current line control system; bobbin arrangement for line control; line control of the X-4 air-to-air missile; survey of completed remote control system; and remote control receivers.

AG20/11 **A Guiding System Using Television.** F.MÜNSTER.
AGARDograph 20, 135-161, 10 refs., 1957.
The development of the Hs 293D which, until 1945, was the only television guided missile being actually tested, made clear the fundamental pecularities of this guiding method regarding tactical aspects, technical realization, and the requirements imposed upon the bomb aimer. In this paper, the stage of development is dealt with in which the actual testing of the Hs 293D was concerned. Also, planned improvements are discussed.

AG20/12 **Summary of the Development of High-Frequency Homing Devices.** G.GÜLLNER.
AGARDograph 20, 162-172, 1957.
These devices were designed to operate on either active or semi-active or passive principles. The first two worked as reflection devices which emitted radio frequencies from transmitters located in missiles or on the ground. The passive type was designed to operate against targets which themselves emitted high frequency energy. The description includes devices which were under construction during World War 2.

AG20/13 **The Guidance Systems HV and Hawaii II.** R.SCHÄFER.
AGARDograph 20, 173-186, 1957.
Contents: (i) The guiding of a flying object in a guide beam, (ii) the HV method, (iii) the Hawaii II method, (iv) the control of the V2, (v) the precision of the guide beam method, and (vi) guide beam test instruments.

AG20/14 **Guidance of Surface-to-Air Missiles by Means of Radar.** K.H.SCHIRRMACHER.
AGARDograph 20, 187-200, 1957.
After stating the problem of missile accuracy and the number to be fired simultaneously it is concluded that high-frequency techniques provide the only solution to the problem of guidance. Apart from the proximity fuse and the warhead the guiding equipment was composed of (i) target location, (ii) missile location, and (iii) guiding control proper. The paper deals with items (i) and (ii) and, where necessary, the links between (i) and (ii).

AG20/15 **The Physical and Technical Development of Infrared Homing Device.** E.W.KUTZSCHER.
AGARDograph 20, 201-217, 1957.
Describes the passive and active infrared methods, infrared radiation emitted by military targets, attenuation of infrared radiation, the infrared background radiation, infrared detectors, optical systems, range and accuracy, remarks about infrared homing devices, and discussion.

AG20/16 **Review of the Development of Proximity Fuses.** F. von RAUTENFIELD.
AGARDograph 20, 218-237, 12 refs., 1957.
Considers the problem and its requirements, physically feasible solutions and examples of German developments including electronic fuses, electrostatic fuses, magnetic fuses, acoustical fuses, and optical devices.

AG20/17 **Some Special Problems of Power Plants.** O.LUTZ.
AGARDograph 20, 238-252, 1957.
Deals with propellant problems and considers (i) monergols, lithergols, and hypergols, (ii) chemical means of increasing the output of cyclic power plants, and (iii) short remarks on special materials, compound materials, sweating materials, and compound ceramics.

AG20/18 **The Design and Development of the Solid-Fuel Rocket and its Performance.** H.VÜLLERS.
AGARDograph 20, 253-262, 8 refs., 1957.
Considers the problem of the conversion of the solid-fuel rocket from black powder propulsion to smokeless powder propulsion. Some of the more important data necessary to determine the dimensions of a solid-fuel rocket, the power out-put obtained and the general trend of development envisaged at the end of the war are described.

AG20/19 **Development of Hydrogen Peroxide Rockets in Germany.** H.WALTER.
AGARDograph 20, 263-280, 6 refs., 1957.
Contents: (i) the suitability of hydrogen peroxide for propulsion purposes, (ii) properties of hydrogen peroxide, (iii) fundamental problems of hydrogen peroxide propulsion sets, (iv) 'cold' power units, (v) 'hot' power units, and (vi) review.

AG20/20 **The Development of the V-2 Rocket Engine.** M.SCHILLING.
AGARDograph 20, 281-296, 1957.
Contents: (i) the choice of propellants, (ii) early determinations, (iii) rocket motor design features, and (iv) feeder systems.

AG20/21 **BMW-Developments.** H. von ZBOROWSKI.
AGARDograph 20, 297-324, 18 refs., 1957.
Describes the principles behind the development of aircraft and power plants produced by BMW. A few examples were discussed to demonstrate that even today these principles possess more than limited value, and that component developments, as for instance those for functional groups in the construction of rocket-engines, are dominated by the very same principles.

AG20/22 **History of the Air-Borne Towing Experiments with Large Size Ram-Jet Ducts in Germany During 1941-1945.** I.SÄNGER-BREDT.
AGARDograph 20, 325-351, 19 refs., 1957.
The history and the development work on ram-jet power plants are described including the towing tests on trucks and airborne towing tests on Dornier aircraft. Details are also given of precision measurements on the 1000 mm duct, wind tunnel tests, and co-operation with the industry on ram-jet projects.

AG20/23 **High-Velocity Free-Flying Ram-Jet Units (TR Missiles).** W.TROMMSDORFF.
AGARDograph 20, 352-374, 1957.
The idea of post-accelerated artillery missiles using a rocket propelling unit was developed, step-by-step into the use of high-velocity ram-jet units for missiles. This paper reconstructs the history of this development.

AG20/24 **On the History of the Development of the Schmidtrohr.** P.SCHMIDT.
AGARDograph 20, 375-399, 8 refs., 1957.
The author discusses the development of his invention of this type of pulse jet engine dealing with the principles of the ignition system and fuel system, the auxiliary equipment, and wind-tunnel tests.

AG20/25 **Development of the V-1 Pulse Jet.** F.GOSSLAU.
AGARDograph 20, 400-418, 1957.
The power plant and flight testing of the V-1 is described together with the fundamental working process of the pulse jets. Some general data is also provided for the last type of Argus pulse jet. These include design, dimensions, weights and performance curves.

AG20/26 **Research and Development of the Guided Missile 'Feuerlilie'.** W.WERNITZ.
AGARDograph 20, 419, 1957.
The idea of the 'Feuerlilie' research programme was born in 1941-1942. Its object was the determination of aerodynamic and stability data at high speeds, especially in the vicinity of the speed of sound. Until the end of the war the 'Feuerlilie' programme was led by the Research Department of the German Air Ministry.

AG21 **Second Guided Missiles Seminar: Guidance and Control.**
AD-154-130 AGARDograph 21, 391 pp., 73 refs., 1956.
N-58856 Twenty four papers are included, which consider the range of problems from the selection of a missile guidance and control system to its final flight testing. Abstracts of the individual papers are given in the succeeding items.

AG21/1 **Weapons System Philosophy.** G.H.CLEMENT.
AGARDograph 21, 1-10, 1 ref., 1956.
The philosophy is a point of view embracing a technique for ordering, classifying and analyzing a technically complex mechanism, organisation or process to bring each element into context. The approach is intended to give the optimum employment of resources.

AG21/2 **ORO Weapon System Philosophy.** H.C.MEAL.
AGARDograph 21, 11-28, 1956.
Describes the functions of operational research in attaining the optimum deployment of resources in a weapon system by using study of research, testing, construction of prototypes, training, development of tactical doctrine and other relevant factors as formulated by ORO (Operational Research Office, Johns Hopkins University). A continual renewal of analysis is necessary in the task.

AG21/3 **New Principles in the Design of Superior Communications, Navigation, and Missile Guidance Systems.** W.P.LEAR, Sr.
AGARDograph 21, 29-38, 1 ref., 1956.
Discusses the application of statistical concepts to the design of systems, with particular attention to the operational principles of the SCAN system. The possibility of using computers in this connection is pointed out.

AG21/4 **Guidance Techniques.** W.L.WEBSTER, Jr.
AGARDograph 21, 39-56, 1 ref., 1956.
The principles of guidance by command, beam rider, radio navigation, homing, and combined techniques are described. Choice of system depends on factors such as the accuracy, launching base, number of targets and missiles to be handled simultaneously and effective range required.

AG21/5 **Considerations in the Choice of a Missile Guidance and Control System.** R.W.MAYER.
AGARDograph 21, 57-66, 1956.
Firstly, the importance of thoroughly establishing requirements before making a choice is discussed. Then the criteria for judging a system are enumerated. The requirements for a better system of weighting criteria are noted.

AG21/6 **Inertial Navigation.** N.F.PARKER, C.P.GREENING.
AGARDograph 21, 67-86, 2 refs., 1956.
Inertial navigation is an application of Newton's second law of motion, which implies that acceleration relative to inertial space can be detected without reference to external information. The basic elements of a system are described; accelerometers, gyroscopes, and computers. The source and propagation of certain errors in the system are mentioned, with emphasis on misalignment of accelerometers as an example. Navigational errors resulting from errors in the accelerometers and gyroscopes are stated.

AG21/7 **Aiding the Inertial Navigation System.** W.F.BALLHAUS, F.STEVENS, Jr.
AGARDograph 21, 87-100, 1956.
Component errors and approximations may cumulate in a long-range guidance system and need to be aided to achieve the necessary terminal accuracy. Aiding techniques include the use of radar or visual checkpoints, the tracking of a radar beacon, star tracking, and computational damping from external velocity measurements. The use of two or more of these simultaneously is of great value.

AG21/8 **Linear Homing Navigation.** R.K.RONEY.
AGARDograph 21, 101-114, 2 refs., 1956.
Deals with the analysis of proportional navigation. The equations of navigation are developed and the effect of system dynamics and smoothing time on resulting trajectories and miss distances is discussed.

AG21/9 **Pitfalls in Missile Control.** R.L.JOHNSON.
AGARDograph 21, 115-138, 1956.
Some problems encountered in the design of past missiles include: static and dynamic aeroelasticity; structural feedbacks; cross-talk; nonlinearities; overloads; adverse effects of noise, drift, and tolerances; and such operational problems as environmental and safety considerations. The physics of typical examples is explained for each case.

AG21/10 **The Effects of Airframe Characteristics on Control System Design.** F.E.PERRY.
AGARDograph 21, 139-152, 1 ref., 1956.
Detailed consideration is given to stability, shift of aerodynamic properties with time of flight of the missile, nonlinearities, types of interaxis coupling and parasitic feedback.

AG21/11 **Geometrical Stabilization Based on Servodriven Gimbals and Integrating Gyro Units.**
C.S.DRAPER, R.B.WOODBURY.
AGARDograph 21, 153-182, 18 refs., 1956.
The general problem for land, sea, or air vehicles is described. A solution is described for stabilization by means of single-degree-of-freedom integrating gyro units carried by a three-degree-of-freedom servo-driven gimbal system. Functional and geometrical diagrams, system of concepts, terminology and symbols for formulation are presented and applied to an example. Design features and performance characteristics of suitable gyros are reviewed. The performance equation for motion about a single gimbal axis is set up for adaptation to a complete three-axes system. The use of gear-train drives is examined critically.

AG21/12 **Sampled-Data Systems.** J.R.RAGAZZINI.
AGARDograph 21, 183-228, 32 refs., 1956.
Basic theory, design and application of these systems to guidance and control are described, including mathematics of the sampling process, use of the Z-transform, system stability, and pulsed transfer functions. Advantages and disadvantages of this type of control are discussed.

AG21/13 **Digital Techniques in Missile Guidance Systems.** S.DARLINGTON.
AGARDograph 21, 229-248, 2 refs., 1956.
The considerable information fed into the system, such as trajectory data, tactics, numerical data from instruments can be handled and processed in a single digital computer. Characteristics of suitable computers are described in general terms. The mathematical programming is examined and its relation to full three-dimensional guidance.

AG21/14 **The Use of Digital Computer Techniques in Missile Design and Control.** D.H.GRIDLEY.
AGARDograph 21, 249-264, 1956.
Two examples of digital processing are discussed as they apply to the pre-flight and post-flight phases of missile system design and analysis. A third example relates to the control area and presents methods for analogue to digital conversion of quantities.

AG21/15 **The Application of Noise and Filter Theories to Guidance Problems.** R.J.PARKS, R.M.STEWART.
AGARDograph 21, 265-284, 2 refs., 1956.
This account of recent theories includes the application of the Wiener single multiple input filter theory to guidance system design where there is more than one source of guidance information with different characteristics and also when one or more sources is received in the form of sampled data. Typical practical applications are presented.

AG21/16 **Recent Developments in Fixed and Adaptive Filtering.** A.G.CARLTON, J.W.FOLLIN, Jr.
AGARDograph 21, 285-300, 1956.
Optimal filtering has been applied to problems in which the input characteristics are incompletely specified. The optimal filter and best input are determined by minimax principles. Two problems of time-varying filters are considered: (i) optimal settling to steady-state; (ii) design of adaptive filters which adjust to the environment.

AG21/17 **Practical Problems Encountered in Missile Guidance and Control Design.** R.E.WHIFFEN.
AGARDograph 21, 301-314, 1 ref., 1956.
The problems discussed are those to be overcome in designing, ground and flight testing of the missile. Emphasis is placed on reliability and the testing of the electronic guidance systems. The organization of the guided missile department, the rôle of a 'reliability group', meeting performance and manufacturing requirements, design limitations of available components, test equipment, and ground and preflight testing techniques are discussed.

AG21/18 **Application of Methods of Science to the Problem of Reliability.** C.R.KNIGHT.
AGARDograph 21, 315-330, 1956.
Discusses scientific methodology and statistics applied to the study of reliability problems. As an example an experiment conducted by Aeronautical Radio, Inc. to show the adverse effect of tube testing, as against marginal-testing of complete equipment, is described. Marginal testing is advocated only when carefully chosen in relation to characteristics of specific equipments. The organisational method of the experiment is however advocated.

AG21/19 **Reliability of Guided Missiles.** E.A.SPEAKMAN.
AGARDograph 21, 331-340, 7 refs., 1956.
The organisational pattern of the U.S. Department of Defense and the work it has promoted in industry to solve problems of reliability assessment and improvement are described. Recommendations are made for the following efforts: (i) reduce complexity; (ii) devise means for anticipating and determining adverse conditions encountered in missile production and operation; (iii) develop planned programmes of component testing to failure with conditions of maximum stress.

AG21/20 **Laboratory Vs Flight Evaluation of Airborne Guidance Components.** W.H.CLOHESSY.
AGARDograph 21, 341-346, 1956.
Defines evaluation to include system limits, reliability, and effects of non-standard environment. The organisation and facilities of the Test Division and Electromechanical Laboratories of White Sands Proving Ground are described. The factors favouring the two forms of subject testing are discussed and some current trends described.

AG21/21 **Trends in Field Testing of Guided Missiles.** E.A.STEINHOFF.
AGARDograph 21, 347-358, 1956.
Describes efforts to improve and adapt field instrumentation to automatic data handling and analysis by analogue and digital computers. Several projects are in the development stage for real time data reduction and data analysis. Savings in manpower and overall cost of missile testing are expected.

AG21/22 **Low Signal Level Missile Instrumentation.** L.G. deBEY.
AGARDograph 21, 359-374, 3 refs., 1956.
Recent trends in guided missile programmes show that future instrumentation systems will require to be operated at very low levels of radio signal energy. The probable revisions of current techniques to accomplish this are discussed, including improvements in system performance to cope with anticipated adverse conditions.

AG21/23 **On the Way to Automated Processing of Flight Measurements.** W.E.KLEMPERER.
AGARDograph 21, 375-386, 1956.
A survey of methods available for data acquired in three ways: from a ground station; from devices on the test missile; or from another aircraft. The methods available for each group are discussed separately.

AG21/24 **Paper on the Guidance and Control of Missiles.** S.WALDRON.
AGARDograph 21, 387-391, 1956.
A discussion of the reliability of electronic equipment as it concerns the reliability of guided missiles, reliability being defined as the probability of survival for a specified time. The stresses applied to the missile which affect reliability are discussed. It is concluded that a real gain in reliability requires investigation of failures which occur early in the missile flight.

AG22
AD-081-540
N-41550 **Mach Number Measurements in High-Speed Wind Tunnels.** J.A.F.HILL, J.R.BARON, L.H.SCHINDEL, J.R.MARKHAM.
AGARDograph 22, 113 pp., 81 refs., 1956.
Measurements of Mach numbers in air are discussed in relation to calibration of an empty wind tunnel, measurements of local Mach numbers around a model, and the simulation of free flight Mach number in the presence of wall interference. Errors of deduction and also measuring procedures are discussed.

AG23
AD-132-410
N-53410 **Optical Methods for Examining the Flow in High-Speed Wind Tunnel. Pt.1 – Schlieren Methods.** D.W.HOLDER, R.J.NORTH. **Pt.2 – Interferometer Methods.** G.P.WOOD.
AGARDograph 23, 148 pp., 168 refs., 1956.
Reviews the present state of knowledge in the use of schlieren, direct-shadow and interferometer techniques for visualising high-speed tunnel flow. Some details are given of methods in an early development stage or of limited use. Information is given on light sources and photographic materials.

AG24
AD-090-007
N-53172 **Fluctuations and Hot-Wire Anemometry in Compressible Flows.** M.V.MORKOVIN.
AGARDograph 24, 102 pp., 62 refs., 1956.
The system, as an information source, consists of the flow-field, the wire, and the associated instrumentation. A general formula is derived for the direct voltage sensitivities with respect to the fluctuation modes of vorticity, entropy, and sound. Empirical evidence on heat transfer to thin wires is analyzed. It is shown that the sensitivity expressions specialize for different speed ranges and serve as a basis for evaluating the performance of the hot-wire instrument. Procedures are outlined for the different speed ranges and their accuracy assessed. Illustrative examples are given.

AG25 Aviation Medicine: Selected Reviews. C.S.WHITE, W.R.LOVELACE, 2nd, F.G.HIRSCH (Editors).
AD-853-925 AGARDograph 25, 305 pp., 721 refs., 1958.
CN-67120 A collection of twelve papers which are abstracted separately in the following items.

AG25/1 Spirometric Methods. U.C.LUFT.
AGARDograph 25, 8-22, 57 refs., 1958.
Early methods used in respiratory physiology and metabolism are reviewed and the two techniques discussed: (i) direct spirometry and spirography, and (ii) indirect spirometry. For (i), methods of determining tidal volume, vital capacity, inspiratory capacity, oxygen consumption and similar parameters are described. In (ii), techniques for determining the functional residual volume and hence total lung volume are described, including dilution and clearance methods.

AG25/2 High-Speed Motion Picture Photography as an Aid in Bio-Medical Investigation. M.A.PALMER.
AGARDograph 25, 23-38, 41 refs., 1958.
After discussing some of the applications of high-speed photography, the author describes the characteristics of intermittent and continuous film cameras, giving as examples the Kodak and Fastax high-speed instruments. Problems of choice of field, illumination, film, exposure, speed and analysis, as they influence the desired data acquisition, are mentioned. Some examples of applications are given.

AG25/3 The Measurement of Atmospheric Ozone. I.G.BOWEN.
AGARDograph 25, 39-44, 12 refs., 1958.
Data are given for ozone concentration at different altitudes, also expressed in terms of partial pressure as a function of altitude. The partial pressure of ozone which might occur in the lungs is computed as a function of cabin pressure and altitude. Lack of an agreed opinion on the toxicity of ozone and its instability prevent the expression of an existing hazard. Measurement of ozone concentrations in aircraft cabins is suggested as an initial step in proving or disproving the existence of a toxicologic problem.

AG25/4 Methods and Apparatus for the Study of Stress Reactions and Metabolic Changes. B.B.LONGWELL.
AGARDograph 25, 45-58, 70 refs., 1958.
A study of the 'stresses' on the endocrine system and closely related metabolic processes. The endocrine glands and electrolyte and water balance studies are specifically discussed. Assay methods are described applicable to the thyroid, pituitary, adrenal cortex and adrenal medulla. Electrolyte variations in plasma and urine, blood volume changes, alterations in extracellular fluid, water balance, and the relations of these to hormonal control by aldosterone are covered.

AG25/5 Dosimetry of Ionizing Radiations. J.L.HOWARTH.
AGARDograph 25, 59-84, 79 refs., 1958.
The expanding activities in the field of nuclear energy is mentioned and the importance of measuring several varieties of radiations in aviation medicine is discussed. These include radiations from nuclear weapons, cosmic rays, nuclear power plants for aircraft, and radio-isotopes. The fundamentals of dosimetry, including definitions of physical and biological units, are discussed in detail. The general principles of ionization instruments are described.

AG25/6 Some Technical Developments Applicable to Problems in Pathology. T.L.CHIFFELLE.
AGARDograph 25, 85-112, 153 refs., 1958.
A broad survey is given with a detailed summary of some recent techniques, such as corrosion cast and injection procedures. Tissue disintegrators and the choice of tissue fixatives are discussed. Other topics include, freeze-drying, dye metachromasia, detection of lipoids and neutral fats, autofluorescence techniques, use of polarized light, electron microscopy, microradiography and X-ray microscopy.

AG25/7 Temperature Measuring Techniques for Aviation Physiological Research. F.G.HIRSCH.
AGARDograph 25, 113-124, 15 refs., 1958.
Temperature measuring techniques have been used in aviation biology to monitor environmental temperature exchange as a time function, the heat storage and loss with time, in the design of protective clothing and equipment. The principles of measuring devices are discussed and the devices themselves briefly described. These include thermocouples, thermistors, temperature sensitive paints and resistance thermometers.

AG25/8 The Analysis of Respiratory Gases. C.S.WHITE.
AGARDograph 25, 125-167, 95 refs., 1958.
The limitations of non-continuous and manual methods are pointed out and several automatic methods currently used are discussed in detail. These are based on (i) thermal conductivity principles, (ii) paramagnetic properties of gases, (iii) combinations of (i) and (ii), (iv) refractive index analyzers, (v) acoustic analyzers, (vi) critical flow methods, (vii) spectrographic techniques.

This last is dealt with in detail, especially the infra-red absorption of carbon dioxide and the use of emission phenomena.

AG25/9 **Aerosols: Physical Properties, Instrumentation and Techniques.** A.E.REIF.
AGARDograph 25, 168-244, 164 refs., 1958.
A review of the physical properties of aerosols, applications, theory and instrumentation for studying and treating them. Physical, electrostatic, optical and dimensional characteristics are considered.

AG25/10 **Pressure Transducers.** J.CLARK.
AGARDograph 25, 245-252, 3 refs., 1958.
Three pickups developed by the author are described: (i) a differential pressure-sensing instrument using two transformers on opposite sides of a diaphragm; (ii) and (iii) single-transformer instruments with flush-fitting diaphragms, one of sub-miniature size (0.10 in diam. by 0.25 in long), suitable for use in a catheter. Auxiliary electrical components are described and examples of applications of the transducers given.

AG25/11 **Spectrometric Methods: Gas Analysis By Quantitative Emission Spectroscopy.** C.S.WHITE, W.R.LOVELACE, 2nd.
AGARDograph 25, 253-268, 22 refs., 1958.
Reviews the history of the technique for analyzing nitrogen and describes a modification of the work of Lilly and Anderson. The complex spectral problem is reviewed. Calibration methods and techniques for obtaining quantitative results for respiratory experiments are described. The use of d.c. discharge tubes with broad-band pass filters, cutting off below 3000 and above 4000 A is discussed.

AG25/12 **Comparison of Rahn-Otis Technique with Other Methods of Intermittent and Continuous Sampling of Expired Air.** N.P.V.LUNDGREN.
AGARDograph 25, 269-276, 10 refs., 1958.
An arrangement is described for sampling end-expiratory air from the upper respiratory tract, allowing the use of automatic gas analyzers and Haldane analysis. Results agree with those from Rahn-Otis technique. When changing the content of inhaled gases a mixing delay was confirmed, of significance only in the first three minutes.

AG26 **Forward Scatter Communication Via Meteor Trails and Related Problems.** T.HAGFORS (Editor).
AD-159-935 AGARDograph 26, 69 pp., 23 refs., 1957.
N65-85351 A collection of 8 papers given at the Ionospheric Research Meeting, at the Hague, July 1957.
Abstracts of the separate papers are given in the succeeding items.

AG26/1 **Forward Scattering From Meteor Trails.** P.A.FORSYTH.
AGARDograph 26, 1-6, 1957.
Physical characteristics of meteors are reviewed, approximate particle density, ionization effects, reflectivity and transparency to radio waves and variation with density.

AG26/2 **Meteor Signal Characteristics of Importance in Communication.** P.A.FORSYTH.
AGARDograph 26, 7-14, 1957.
Factors determining the number of useful trails as a function of position or orientation are discussed, together with the effects of anisotropy, and diurnal variations. Some effects which influence the duration of individual echoes and echo characteristics are described. Examples are given of experimentally obtained fluctuations and variations in average rate of meteor incidence.

AG26/3 **Some Characteristics of Radio Communication Via Meteor Ionization Trails.** V.R.ESHLEMAN.
AGARDograph 26, 15-26, 15 refs., 1957.
By using meteor trails to reflect discontinuous VHF signals a lower transmission power and smaller antennae can be employed than when conventional scatter of continuous signals obtains. Consideration is given to the possibility of varying antenna beam bearings according to the diurnal variation in meteor radiants and also to monitor the changing radiant distribution to obtain optimum antenna bearings for communication.

AG26/4 **Some Statistical Results on Reflections from Meteoric Trails Obtained by Forward-Scatter Experiments in Norway.** T.HAGFORS.
AGARDograph 26, 27-38, 5 refs., 1957.
Results are given of an investigation of the meteoric component of the VHF scatter signal received over a 1200 km path. An analysis is made of (i) percentage of time for which the signal exceeds a fixed level; (ii) distribution of duration of the meteor bursts above a given level; (iii) distribution of the time intervals between meteor echoes. Deductions are made about the mass distribution of random meteors and the constant of molecular diffusion at the height of meteor reflections. The meteoric signal is compared with the signal due to turbulent fluctuations of electron density.

AG26/5 **Artificial Electron Clouds.** J.PRESSMAN, F.F.MARMO, L.M.ASCHENBRAND, A.S.JURSA, M.ZELIKOFF.
AGARDograph 25, 39-41, 1957.
Describes an experiment to produce artificial electron clouds by releasing nitrous oxide from a rocket at a height of 92 km. The electrons are produced by ionization of the gas by solar Lyman alpha radiation. The cloud formed acts as a reflector of electromagnetic waves.

AG26/6 **The Problem of Introducing Ionospheric Scatter Communication Systems into the European Frequency Region.** E.FITCH.
AGARDograph 26, 43-56, 3 refs., 1957.
Problems of interference in the system are enumerated. It is suggested that as high a frequency of operation as is technically feasible should be used.

AG26/7 **Operating Principles and Design Considerations of Janet Systems.** D.R.HANSEN.
AGARDograph 26, 57-61, 1957.
A number of design considerations are given. These include the gating of the systems, information storage elements, modulation method and antenna design.

AG26/8 **Some Operational Characteristics of the Canadian Janet System.** D.R.HANSEN.
AGARDograph 26, 63-69, 1957.
The system is described and parameters are given for a link to provide two-way teletype communication across a range of 2000 km. Some operational test results are given, including effects of diurnal and seasonal variations, error rates and auroral disturbances.

AG27 **Air Intake Problems in Supersonic Propulsion.** J.FABRI (Editor).
AD-853-933 AGARDograph 27, 82 pp., 36 refs., 1958.
N-64712 Design of air-intake must be matched with the engine for which it is intended. The problem of matching and also design characteristics of intakes are treated in separate papers which are abstracted in the succeeding items.

AG27/1 **Rôle of the Air-Intake in the Propulsive Balance of a Jet-Engine.** (In French.) P.CARRIÈRE.
AGARDograph 27, 1-20, 8 refs., 1958.
Aspects of the problem are analyzed by reference to a ram-jet of rotational symmetry. The parameters of flow coefficient, efficiency, additional drag and external drag are defined and their variations and orders of magnitude examined for various Mach numbers, shapes and diffuser exit conditions. The basic flow and thrust equations are derived. The case of an intake designed for a given Mach number and combustion rate is considered and also operation below design Mach number.

AG27/2 **A Review of Supersonic Air Intake Problems.** D.D.WYATT.
AGARDograph 27, 21-47, 25 refs., 1958.
Considers the problem of attaining high pressure recovery and examines critically methods of using various external and internal compression system to attain supersonic compression. The complication of fuselage boundary layer interference and boundary layer removal requirements are discussed. Pressure recovery losses of supersonic intakes during subsonic flight are indicated. Design requirements for minimizing drag, flow instabilities, and the effects of non-uniform discharge profiles are discussed. Finally the problem of matching intakes and engines and the use of variable geometries for this purpose is considered.

AG27/3 **Problems Related to Matching Turbojet Engine Requirements to Inlet Performances as Function of Flight Mach Number and Angle of Attack.** A.FERRI.
AGARDograph 27, 48-62, 1958.
Supersonic flight conditions are considered. Engine requirements as given by manufacturers are transformed into inlet parameters and associated flow and temperature functions. Parameter curves are derived for various Mach numbers; consequences of mismatching are presented. The need for varying the inlet parameter is pointed out and methods of achieving this discussed. Installations that increase or decrease angle-of-attack effects are described. Contraction ratio is derived as a function of inlet Mach number. It is concluded that up to Mach 1.6 a fixed geometry inlet can be used with suitable engine design and inlet matching.

AG27/4 **Interpretation of Tests on Supersonic Air-Intakes.** (In French.) L.VIAUD.
AGARDograph 27, 63-80, 3 refs., 1958.
Schematic models used in tests are described and definitions given for intake efficiency and drag. Difficulties of measuring internal mass flow rate on small models are discussed. The necessity for a standard air-intake definition is pointed out. A ram-type standard intake followed by a divergent section is advocated, the external drag being ignored in the first place.

AG28 **High Temperature Effects in Aircraft Structures.** N.J.HOFF (Editor).
N65-86169 AGARDograph 28, 357 pp., 466 refs., 1958.
Effects of heat on structures has become of importance with the development of supersonic flight and has rendered obsolete much of the design and performance predictions for subsonic vehicles. These aspects, and new and hitherto unpublished results as well as summaries of available information, are discussed in the 16 papers, which are abstracted in the succeeding items.

AG28/1 **High Temperature Effects in Aircraft Structures – Introduction.** N.J.HOFF.
AGARDograph 28, 1-13, 23 refs., 1958.
Includes: Aircraft development after World War 2; airplane and missile design; high temperature effects; heating effects at hypersonic speeds; ballistic missiles and satellites; concluding remarks.

AG28/2 **External Sources of Heat.** M.H.BLOOM.
AGARDograph 28, 14-40, 105 refs., 1958.
Discusses heat transfer processes; atmospheric conditions; equilibrium surface temperatures under the influence of radiation; flat surfaces; laminar heat transfer with pressure gradients; turbulent transfer with pressure gradients; and brief notes on transfer rates and experimental methods.

AG28/3 **Heat Transmission in the Structure.** F.V.POHLE.
AGARDograph 28, 41-57, 35 refs., 1958.
Includes: Modes of heat transfer; heat transfer by conduction – basic equations; boundary conditions; fundamentals of radiation; steady state solutions; transient solutions; analytical methods; applications to the supersonic wing; and numerical methods.

AG28/4 **Materials for High Temperature Aircraft Structures.** P.DUWEZ.
AGARDograph 28, 58-79, 11 refs., 1958.
Discusses: Three fundamental types of crystalline inorganic materials; physical properties of importance at high temperatures; aluminium and magnesium; titanium and its alloys; steels and related alloys; refractory metals; and non-metallic refractories.

AG28/5 **Non-Metallic Structural Materials at High Temperatures.** C.GURNEY.
AGARDograph 28, 81-109, 83 refs., 1958.
Discusses: High polymers – factors affecting the strength; transparent polymers; non-transparent polymers; reinforced polymers – properties of fibres and flakes; polymers for reinforced plastics; fibre-polymer structural materials; asbestos plastics; glass fibre plastics; polymer adhesives; ceramics; thermal and electrical properties of non-metallic structural materials.

AG28/6 **Glass-Like Structural Materials at High Temperatures.** I.PEYCHES.
AGARDograph 28, 110-132, 6 refs., 1958.
Topics include: composition of glass; physical and optical properties; electrical properties; mechanical properties; glass as an insulating material; glass as a reinforcement for plastics; Pyroceram.

AG28/7 **Creep and Relaxation in Metals.** N.P.ALLEN.
AGARDograph 28, 133-151, 21 refs., 1958.
Metals when stressed undergo an elastic strain, followed, if no fracture occurs, by an additional plastic strain which is irreversible. In the absence of further added stress the dimensions may remain constant. The addition of heat or large stresses may result in gradual change of dimensions called 'creep'. If the dimensions are held constant a relaxation of stress may occur. These phenomena are examined for a wide range of conditions for several metals.

AG28/8 **Creep and Stress Relaxation of Plastics.** W.N.FINDLEY.
AGARDograph 28, 152-170, 10 refs., 1958.
Discusses: the nature and structure of plastics; crystallization in polymers; mechanical models of time-dependent behaviour, based on Maxwell and Kelvin units; complex models, activation energy theory for stress and temperature influences, and the power law for time influences; the time-temperature superposition principle; and influence of varying stress.

AG28/9 **Fatigue of Structural Materials at High Temperature.** B.J.LAZAN.
AGARDograph 28, 171-187, 25 refs., 1958.
Includes: fatigue as a cause of service failure; fatigue life – statistical aspects, progressive fracture; fatigue strength at high temperature; dynamic creep in cyclic stressing; resonance fatigue and material damping.

AG28/10 **Thermal Stresses.** L.BROGLIO, P.SANTINI.
AGARDograph 28, 188-214, 20 refs., 1958.
General equations of thermoelasticity: reduction of thermal gradients to balanced systems of edge loads; minimal principles in thermal stress analysis; results of analyses; thermoelastic theory of beams, plates, shells; axisymmetric temperature distributions; inertia effects; and plastic flow.

AG28/11 **Buckling Caused by Thermal Stresses.** A.van der NEUT.
AGARDograph 28, 215-247, 16 refs., 1958.
Consequences of thermal buckling; thermal loading and buckling of solid, multicell, and sandwich wings, sandwich panels and circular frames; structures for high thermal performance and insulation systems; torsional buckling and rigidity; buckling of plates, analysis and solutions; post-buckling behaviour of plates; fields for future research.

AG28/12 **Stress Distribution in the Presence of Creep.** N.J.HOFF.
AGARDograph 28, 248-266, 31 refs., 1958.
Discusses: structural effects of creep; creep laws; multiaxial stress; variable stress; elastic deformations; elastic analogue; beam under constant bending moments; minimal principles; the plastic analogue; various solutions of creep problems.

AG28/13 **Creep Buckling.** B.M.FRAEIJS de VEUBEKE.
AGARDograph 28, 267-287, 30 refs., 1958.
Includes: creep buckling theories; creep buckling of linearly viscoelastic columns; buckling from secondary creep in metals; and from primary and secondary creep; inclusion of instantaneous plastic deformations; graphs and examples; comparison with experiments; creep buckling under general assumptions.

AG28/14 **Influence of Aerodynamic Heating on Aeroelastic Phenomena.** R.L.BISPLINGHOFF, J.DUGUNDJI.
AGARDograph 28, 288-312, 13 refs., 1958.
The practical effects are discussed. By use of piston aerodynamic theory, the influence of heating on divergence control and flutter is investigated. Examples relating to a thin solid lifting surface and a sheet panel are given to show the magnitude of the effects considered.

AG28/15 **Experimental Methods in High Temperature Structural Research.** J.TAYLOR.
AGARDograph 28, 313-322, 8 refs., 1958.
Discusses: techniques, loading systems, material properties, simple parts and complete structures under both steady-state and transient conditions; developments and trends, including the use of induction heating, digital computers, strain and temperature measuring.

AG28/16 **Models and Analogs.** R.R.HELDENFELS.
AGARDograph 28, 323-354, 29 refs., 1958.
Discusses: similarity parameters for model scaling: analogues for structural analysis, basic theory, stresses and electrical network laws.

AG29/1 **Polar Atmosphere Symposium: Pt.1 – Meteorology Section.** R.C.SUTCLIFFE (Editor).
AD-853-928 AGARDograph 29, Pt.1, 341 pp., 194 refs., 1958.
CN-62800 The papers clarify some of the problems of the polar regions, review current knowledge and offer interpretations of results of investigations of these regions. The importance of polar atmosphere in its influence to general circulation is emphasized. The separate papers of this symposium are abstracted in the following items.

AG29/1/1 **Arctic Geography and Climate.** F.K.HARE.
AGARDograph 29, Pt.1, 3-8, 8 refs., 1958.
The arctic and sub-arctic are more conveniently defined by certain geographical distributions in partial equilibrium with existing climates. These include: zonation of vegetation; occurrence of permafrost; distribution of ice in seas, lakes and rivers; continental glaciers; and the circulation of arctic and sub-arctic water masses. The mechanism of climate control over these distributions as known at present is shown in a map.

AG/29/1/2 **Similarities and Contrasts Between the Arctic and Antarctic Marine Climates.** R.M.HOLCOMBE.
AGARDograph 29, Pt.1, 9-17, 10 refs., 1958.
Discusses: the comparison of physical features; surface meteorological comparisons; upper air characteristics.

AG29/1/3 **The Recent Variations of the Climate at the Norwegian Arctic Stations.** T.HESSELBERG, T.W.JOHANNESSEN.
AGARDograph 29, Pt.1, 18-29, 1958.
Describes: the stations; climatic conditions; homogeneity of the observation material; serial observations; variations of temperature conditions; some consequences of an improved climate.

AG29/1/4 **A Brief Review of Research in Arctic Meteorology.** A.D.BELMONT.
AGARDograph 29, Pt.1, 30-36, 1958.
Briefly points out some past results, mentions work being done in U.S.A. and Canada to evaluate available research data and suggests two major problems which could be investigated with existing data.

AG29/1/5 **The General Circulation of the Lower Troposphere over Arctic Regions and its Relation to the Circulation Elsewhere.** J.NAMIAS.
AGARDograph 29, Pt.1, 45-61, 20 refs., 1958.
Includes: some comments on the synoptic approach; new data and comparisons with earlier estimates; relations of the arctic circulation to that elsewhere.

AG29/1/6 **Recent Studies on the Arctic Troposphere and its Teleconnections.** H.FLOHN, G.SEIDEL.
AGARDograph 29, Pt.1, 62-70, 7 refs., 1958.
Includes: permanent features of the general circulation; teleconnections of the arctic air cap in winter; contribution to the knowledge of the Siberian cold pole.

AG29/1/7 **Winds and Temperatures in the Arctic Stratosphere.** H.WEXLER, W.B.MORELAND.
AGARDograph 29, Pt.1, 71-84, 23 refs., 1958.
Discusses the contribution made by the acquisition of much aerological data in recent years and points out that earlier views, based on extrapolation from shallow soundings, require considerable modification, especially for the winter season.

AG29/1/8 **Canadian Studies of the High-Latitude Stratospheric Jet Stream in Winter.** W.L.GODSON.
AGARDograph 29, Pt.1, 85-86, 1958.
A research project has been organized to establish the existence of the jet and to study the hypothesis that its existence is controlled.

AG29/1/9 **The Problem of the Maintenance of the Low-Level Anticyclonic Circulation in the Arctic.** R.FJORTOFT.
AGARDograph 29, Pt.1, 87-92, 1958.
An examination of the normal pressure maps for November, together with the equations of the distribution of vertical motions and the field of horizontal divergence suggests the way in which the circulation is maintained.

AG29/1/10 **The Rôle of Tropospheric Cold-Air Poles and of Stratospheric High-Pressure Centers in the Arctic Weather.** R.SCHERHAG.
AGARDograph 29, Pt.1, 101-117, 9 refs., 1958.
Describes some of the work of the Meteorological Institute of the Free University of Berlin on conditions of the arctic atmosphere, especially in the regions of cold-air poles and high-pressure centers.

AG29/1/11 **Arctic Weather-Forecasting Problems of the Air Weather Service.** R.D.FLETCHER.
AGARDograph 29, Pt.1, 118-123, 1958.
Describes some of the forecasting problems of the Air Weather Service of the U.S. Air Force in predicting arctic winds and weather.

AG29/1/12 **Arctic Weather Analysis.** R.J.REED.
AGARDograph 29, Pt.1, 124-136, 9 refs., 1958.
The results of 63 vertical cross-sections along a line from Alert, Ellesmere Island to Kodiak, Alaska are summarized and sample cross-sections shown. The baroclinic structure is complex and not well represented by conventional frontal models; this is probably also true of middle-latitude systems. The results are from the Arctic Meteorology-Climatology Project, University of Washington, for the period February-June, 1955.

AG29/1/13 **The Quantitative Representation of the North Polar Pressure Field.** F.K.HARE.
AGARDograph 29, Pt.1, 137-150, 11 refs., 1958.
Includes: specification techniques; choice of functions; use of orthogonal polynomials; problem of co-ordinates and sampling grids and pressure sampling; variability of pressure within the Cartesian grid; computation – use of orthonormal coefficients; the Godson technique.

AG29/1/14 **An Empirical Method of Forecasting 24-Hour Movement and Change of Intensity of Sub-Arctic North Atlantic Cyclones.** J.J.GEORGE, P.M.WOLFF, W.L.SOMERVELL, Jr.
AGARDograph 29, Pt.1, 156, 1958.

AG29/1/15 **Solar Radiation Measurements in the Arctic Ocean.** S.FRITZ.
AGARDograph 29, Pt.1, 159-166, 6 refs., 1958.
Results are summarized of measurements on the ice-island T-3, by the U.S. Air Force Cambridge Research Center, for the year 1953, and compared with measurements in the antarctic and middle latitudes. A tentative explanation is given of the higher extra-terrestrial energy transmitted to the ground in the arctic than in Washington, D.C. The relation between measured solar energy and amount of ice melted is briefly discussed.

AG29/1/16 **Long-Wave Radiation and Turbulent Heat Transfer in the Antarctic Winter and the Development of Surface Inversions.** G.H.LILJEQUIST.
AGARDograph 29, Pt.1, 167-181, 7 refs., 1958.
Presents briefly an outline of the conditions connected with inversions.

AG29/1/17 **On the 'Arctic Whiteout'.** S.FRITZ.
AGARDograph 29, Pt.1, 182-186, 7 refs., 1958.
The 'whiteout' can only be fully explained by a psycho-physical investigation, but it depends largely on the threshold contrast between object and background. For invisibility, this is nearly zero, as it is in middle latitudes.

AG29/1/18 **On the Relation Between Meteorological Conditions and Total Amount of Ozone Over Tromsø.** H.JOHANSEN.
AGARDograph 29, Pt.1, 187-194, 1958.
The correlation between ozone content and elements such as, height of tropopause, upper temperature and pressure, shows an annual variation ... all correlation coefficients mid-winter and highest coefficients in April-May.

AG29/1/19 **Visual Range in the Polar Regions with Particular Reference to the Alaskan Arctic.** J.M.MITCHELL, Jr.
AGARDograph 29, Pt.1, 195-211, 14 refs., 1958.
Discusses: visual range aloft – arctic cloud systems, arctic haze; visual range near the ground – hyper extension of the range, blowing snow, coastal fogs; ice fog – causes, temperature, increasing air-base activity, diurnal variations, visual range; fog in the polar regions – remedial measures.

AG29/1/20 **Some Problems of Meteorological Observing in Polar Regions.** N.J.SCHUMACHER.
AGARDograph 29, Pt.1, 212-214, 2 refs., 1958.
The experiences and considerations derived from them relate to the station at Maudheim in the antarctic (71 deg.S, 11 deg.W) but probably have some validity for the arctic also.

AG29/1/21 **Lower Tropospheric Inversions at Ice Island T-3.** A.D.BELMONT.
AGARDograph 29, Pt.1, 215-284, 43 refs., 1958.
A record of two years of radiosonde observations from the Polar Basin is analyzed. A method of classification of the characteristics of inversions and their occurrence is also applicable to other portions of the radiosonde ascent. A new unit of inversion intensity is introduced, some relationships of inversion characteristics presented and a general qualitative theory suggested to account for discrepancies with previous theory.

AG29/1/22 **Current Status of Sea Ice Reconnaissance and Forecasting for the American Arctic.** C.C.BATES.
AGARDograph 29, Pt.1, 285-322, 14 refs., 1958.
A resumé is given of a typical monthly briefing of the Commander, Military Sea Transport Service (U.S. Navy) and his staff concerning the existing and probable future ice conditions to be encountered during annual re-supply of Northern Bases. The account illustrates the service provided.

AG29/1/23 **Meteorological Conditions and the Associated Sea Ice Distribution in the Chuckchi Sea During the Summer of 1955.** J.W.WINCHESTER, C.C.BATES.
AGARDograph 29, Pt.1, 323-334, 2 refs., 1958.
The behaviour of the polar pack's margin under abnormal meteorological conditions is described and sample verifications of ice forecasts given.

AG29/2 **Polar Atmosphere Symposium. Pt.2 – Ionospheric Section.** K.WEEKES (Editor).
AD-853-929 AGARDograph 29, Pt.2, 212 pp., 140 refs., 1957.
N69-76276 This second part of the symposium held in Oslo contains 21 papers, abstracts of which are given in the succeeding items.

AG29/2/1 **Theoretical Views on Drift Measurements.** I.L.JONES.
AGARDograph 29, Pt.2, 3-11, 6 refs., 1957.
Measurements of drift by observing the fading of a singly reflected wave at three closely spaced points on the ground are discussed. Variations in drift velocities in direction and magnitude are explained and the relation between true drift and that observed from anisometric ground patterns considered. The determination of true drift magnitudes and ground patterns from auto-correlation and cross-correlation functions, based on amplitude variations at three ground stations, is discussed.

AG29/2/2 **The Drift of an Ionized Layer in the Presence of the Geomagnetic Field.** K.WEEKES.
AGARDograph 29, Pt.2, 12-19, 7 refs., 1957.
Compares the relative efficiencies of movement by wind of given velocity and an applied electrical field which is a function of the same velocity.

AG29/2/3 **The Height-Variation of Horizontal Drift Velocities in the E-Region.** I.L.JONES.
AGARDograph 29, Pt.2, 20-22, 3 refs., 1957.
Drift measurements were made, using frequencies of 2Mc/s and 2.5Mc/s, with a reflection separation of about 5 km. It was found that during the winter months the phase of semi-diurnal component of velocity varied with height, the phase advancing with height. This is consistent with observations made on drifting meteor trails.

AG29/2/4 **Results of Ionospheric Drift Measurements in the United States.** V.AGY.
AGARDograph 29, Pt.2, 23-25, 1957.
No measurements have been made over the past few years. Of about three years data available, that for two years was obtained with 'Phillips' type equipment, giving time delays. The results are summarized. They agree with those made in Canada and England.

AG29/2/5 **Results of Ionospheric Drift Measurements in Norway.** L.HARANG.
AGARDograph 29, Pt.2, 26-32, 1 refs., 1957.
A survey is given of measurements made between 1953 and 1955. The mean seasonal and diurnal values of drift given are based on the assumption of an isotropic diffraction pattern at first. Then effects indicating anisotropic diffraction in the pattern are demonstrated.

AG29/2/6 **Large-Scale Movements of the Layers.** H.W.WELLS.
AGARDograph 29, Pt.2, 33-40, 1957.
Considers large-scale irregularities in the F-region, and their investigation. The material is based largely on investigations made by the Carnegie Institution of Washington and includes some results of back-scatter observations from the National Bureau of Standards.

AG29/2/7 **Movements of Ionospheric Irregularities Observed Simultaneously by Different Methods.**
I.L.JONES, B.LANDMARK, C.S.G.K.SETTY.
AGARDograph 29, Pt.2, 41-43, 4 refs., 1957.
Horizontal drift of irregularities has been measured by means of: (i) closely-spaced receivers with a common transmitter; (ii) widely-spaced transmitters with a single receiving station. Results from both methods are compared.

AG29/2/8 **Measurements of Irregularities and Drifts in the Arctic Ionosphere Using Airborne Techniques.**
G.J.GASSMANN.
AGARDograph 29, Pt.2, 44-51, 7 refs., 1957.
Discusses: the interpretation of h.f. records; the first ionospheric drift measurements at the North Pole.

AG29/2/9 **Turbulence in the Ionosphere with Applications to Meteor Trails, Radio Star Scintillation, Auroral Radar Echoes, and Other Phenomena.** H.G.BOOKER.
AGARDograph 29, Pt.2, 52-81, 43 refs., 1957.
Irregularities in electron density, causing scattering of radio waves, are attributed to isotropic turbulence in the neutral molecules and the effect of the Earth's magnetism on associated irregularities of density of the charged particles. The atmospheric model used is based on rocket observations. Formulae are deduced for the large eddies and standard turbulence theory used for small eddies. The possibility of using the incoherent scattering for radio communication is discussed.

AG29/2/10 **Electron Distribution in a New Model of the Ionosphere.** H.K.KALLMANN.
AGARDograph 29, Pt.2, 82-87, 13 refs., 1957.
From a theoretical analysis a model is derived for the regions between 80 and 300 km above the Earth's surface. It is based on pressure, density and temperature distributions obtained from rocket observations and solar radiation measurements. Calculated electron density distributions are compared with directly measured values.

AG29/2/11 **Prediction Techniques at High Latitudes.** J.H.MEEK.
AGARDograph 29, Pt.2, 101-107, 1957.
Discusses the method of h.f. prediction, developed by J.C.W.Scott in Canada and primarily designed for application to high latitude and polar communications circuits.

AG29/2/12 **Geographic Distribution of Geophysical Stations on the Polar Cap.** A.H.SHAPLEY.
AGARDograph 29, Pt.2, 108, 1957.
Points out that actual experience of existing stations in obtaining data on electromagnetic aspects of geophysics will soon be adequate to assist considerations of the density and distribution of stations in the networks. The fields studied will soon be on the same basis as synoptic meteorology.

AG29/2/13 **Statistical Results and their Shortcomings Concerning the Ionosphere Within the Auroral Zone.** R.W.KNECHT.
AGARDograph 29, Pt.2, 109-119, 3 refs., 1957.
Discusses the problem of obtaining representative values of ionospheric characteristics such as f_0F2, in and near the auroral zone. The first and probably most vital step is the determination of such parameters as the median values of these characteristics.

AG29/2/14 **Polar Disturbances.** J.H.MEEK.
AGARDograph 29, Pt.2, 120-128, 1957.
Indicates some of the significant work of recent years in ionosphere prediction, showing especially the type of work being done to solve the problem of polar geomagnetic disturbances.

AG29/2/15 **Polar Blackout Occurrence Patterns.** V.AGY.
AGARDograph 29, Pt.2, 129-134, 1957.
Discusses the difficulties in obtaining consistent correlation between magnetic disturbance and blackout, despite the obvious patterns of observations. The characteristics of the plotted observations are examined.

AG29/2/16 **Quantitative Measurements of Absorption in The Auroral Zone.** F.LIED.
AGARDograph 29, Pt.2, 135-146, 11 refs., 1957.
Although considerable statistical knowledge is available of the polar radio blackouts and ionospheric absorption disturbances, quantitative knowledge of normal absorption and similar disturbances is far from complete. Here available techniques which can be used to predict these phenomena are considered and a summary is given of published results of quantitative measurements from Canada and U.S.A. These are also compared with results from Norway.

AG29/2/17 **Forecasting of Disturbed HF Communication Conditions.** R.C.MOORE.
AGARDograph 29, Pt.2, 147-156, 1957
Four types of forecast are issued by the National Bureau of Standards centres in Virginia and Alaska, based on the 27-day recurrence tendency in solar-terrestrial effects, ionospheric responses to solar activity, normal persistence of ionospheric conditions and detailed knowledge of geomagnetic, ionospheric, and radio conditions. The forecasts are long-term (several days), medium term (24 hours), and short term (6 hours). The paper also discusses geomagnetic responses to solar phenomena in some detail.

AG29/2/18 **The Spectrum of the Electron Density Fluctuations in the Ionosphere.** R.M.GALLET.
AGARDograph 29, Pt.2, 165-170, 4 refs., 1957.
For the problems of radio-scattering, phase-fluctuations, and angular deviations, a detailed knowledge of the fluctuations of electron density is required. The general relationships between the unidimensional and the spatial spectrum, the physical factors limiting the amplitude at the largest dimensions and producing the cut-off at the smallest dimensions are discussed.

AG29/2/19 **A Theory of Long-Duration Meteor-Echoes Based on Atmospheric Turbulence with Experimental Confirmation.** H.G.BOOKER, R.COHN.
AGARDograph 29, Pt.2, 171-194, 21 refs., 1957.
Discusses: The effect of eddy-diffusion on the dispersal of meteor-trails; the relation between turbulence and incoherent scattering of radio waves by meteor-trails; calculation of incoherent echoing from a rough meteor-trail neglecting multiple scattering; experimental investigation of the decay of long-duration meteor-echoes; comparison with McKinley's observation of long-duration meteor-echoes; estimation of the line-density of intense meteor-trail; the spectrum of incoherent scattering associated with atmospheric turbulence; application to VHF scatter-transmission.

AG29/2/20 **Some Implications of Slant-Es.** E.K.SMITH, R.W.KNECHT.
AGARDograph 29, Pt.2, 195-204, 12 refs., 1957.
The phenomenon of slant-Es, which has been noted as an interesting anomaly on ionosonde records, seems to occur in two different forms; one in the arctic, the other near the magnetic equator. Examples of the phenomenon are given.

AG29/2/21 **Results of Scatter Measurements at 36 MC/S over a 1200 KM Path.** T.HAGFORS.
AGARDograph 29, Pt.2, 205-209, 5 refs., 1957.
Results published in 1952 of test transmissions using scatter effects in the ionosphere showed that the technique might be useful for arctic communications. Work on scatter propagation was taken up by the Norwegian Defence Research Establishment in 1955 in order to investigate the mechanisms involved in long distance ionospheric scatter propagation. Some of the results are described.

AG30
AD-853-930
CN-73684 **Medical Aspects of Flight Safety.** E.EVRARD, P.BERGERET, P.M. van WULFFTEN PALTHE.
AGARDograph 30, 308 pp.. 1959.
A selection of the most important reports presented at two Symposia of the AGARD Aeromedical Panel. The problem of aircraft accidents is considered from the physiological and pathological points of view. Abstracts of the individual papers are given in the succeeding items.

AG30/1 **Physiological Problems Posed by Safety in High-Altitude Flight.** (In French.) R.GRANDPIERRE, J.COLIN.
AGARDograph 30, 3-22, 1959.
Fields of research are discussed in the physio-pathology and physiology of protection against: low atmospheric pressure; intense light; spatial myopia; cosmic radiation; meteorite impact; extreme temperatures; effects of reduced gravity; high altitude escape hazards.

AG30/2 **Flight Safety: A New Approach.** D.R.H.URQUHART.
AGARDograph 30, 23-31, 1959.
The responsibilities of the R.A.F. Directorate of Flight Safety, which reports directly to the Air Council are outlined. They relate to both major accidents and air'incidents' in respect of the piloting, technical factors, scientific and statistical aspects, and education and propaganda by films, articles, posters, etc. Two accidents are described to illustrate the functioning of this Directorate. The importance of selection and training of personnel is emphasized.

AG30/3 **Naval Aviation Medicine Viewpoint on the Flight Safety Problem.** R.L.CHRISTY.
AGARDograph 30, 32-40, 1959.
Describes the organization and tasks of the U.S. Navy Safety Division which works with the Naval Center for Air Safety, Norfolk, Virginia. It is stated that 50 to 65% of air accidents are due to pilot-error and efforts are concentrated on the alleviation of this. The history of accident rates since 1955 is reported and an analysis given of the results of ejections from aircraft up to August 1956. Deductions are made regarding the improvement of ejection seats under conditions of high speed and low altitude.

AG30/4 **The Summation of Some Physiological Factors Leading to Incidents in the Air.** W.R.FRANKS.
AGARDograph 30, 41-51, 30 refs., 1959.
Syncope in flight can be distinguished from an epileptic fit by the anamnesis accompanying the former. It can be treated by pumping up the anti-g suit to a comfortable level and supplying oxygen for inhalation. The pilot should be very carefully instructed by ground base for landing after suffering a syncope. On the ground treatment consists in administering oxygen with 3.5% carbon dioxide.

AG30/5 **Some Practical Medical Aspects of Accident Prevention.** C.C.BARKER.
AGARDograph 30, 52-57, 1959.
The fighter aircraft is limited in performance by the human factor. The Aeromedical Group of AGARD assists in the development of improvements in this respect by studying such aspects of flying as crew equipment design, cockpit layout and management, crew comfort, etc.

AG30/6 **Some Possible Causes of Air Accidents.** (In French.) T.LOMONACO.
AGARDograph 30, 58-64, 1959.
Researches at the Centre of Studies and Researches in Aviation Medicine, Rome, confirmed that hyperventilation and noise cause a lag in reaction time and impairment of uniformity of response in a subject. Exhausting recreations and lack of sleep before flying duty also resulted in a lower resistance of the pilot to conditions of barometric depression. These factors can therefore impair physio-psychic efficiency.

AG30/7 **Blinking of Eyes, A Possible Cause of Air Accidents.** (In French.) E.EVRARD.
AGARDograph 30, 65-72, 9 refs., 1959.
An investigation to see whether the momentary blindness caused by blinking can cause accidents, in relation to the high speed of aircraft travel. Experimental sensory-motor tests in 50 pilots with an M.S.A. cockpit set-up gave figures for the onset of blinking. The Bourdon-Wiersma 'stipple-test', carried out on 449 subjects illustrates the change in rate of blinking over the time period of the test. It is concluded that only in very unusual circumstances can blinking be a factor in causing accidents.

AG30/8 **Spatial Disorientation in Operational Flight.** J.B.NUTTALL, W.G.SANFORD.
AGARDograph 30, 73-91, 5 refs., 1959.
This complex problem involves such factors as physiological status of the pilot, flying techniques, flight tatics, training and proficiency, cockpit layout and flight instrument design, which all collectively overshadow the pilot's 'vertigo', per se. Further studies are advised to evaluate the relative rôles played by all these factors in causing spatial disorientation to be a flight safety problem.

AG30/9 **Disorientation Due to Rapid Rotation in Flight.** G.M.JONES.
AGARDograph 30, 92-101, 4 refs., 1959.
The difficulties arising from loss of control in a single, rapid, rolling manoeuvre fall into three categories, those from (i) rates of change too rapid to be followed by a human operator; (ii) physical violence of a manoeuvre, and (iii) derangement of normal neuromuscular mechanisms as a result of vestibular stimulation. It is concluded that (iii) can jeopardize visual sensory efficiency and merits further investigation.

AG30/10 **Unconscious Episodes in Pilots During Flight (1956).** T.J.POWELL, T.M.CAREY, H.P.BRENT, W.J.R.TAYLOR.
AGARDograph 30, 102-115, 5 refs., 1959.
Eight cases were investigated in 1956 and five were diagnosed as 'physiological unconsciousness in medically fit aircrews'. The factors causing this were: previous or concomitant G; hypoglycaemia shortly after a light carbohydrate meal; hyperventilation (possibly associated with anxiety or anger); early slow EEG activity with hyperventilation. These may cumulate to bring about diminished cerebral activity.

AG30/11 **Obscured Losses of Consciousness; Causes of Unexplained Accidents.** (In French.) A.RÉMOND.
AGARDograph 30, 116-131, 1959.
Types of unconsciousness have been distinguished and related to the following causes: (i) abnormal sensory sensitivity; (ii) psychomotor epilepsy; (iii) syncopes and hypothymia; (iv) paroxysmal sleep; (v) paroxysmal coma concomitant with certain visceral diseases. Proposals are made for diagnosis and prevention of these states in aircrew candidates and for the possible use of warning devices to indicate onset of the states.

AG30/12 **Flight Safety and Air Accidents of Undetermined Origin in the French Air Force.** (In French.) P.BERGERET, R.MARCHESSEAU.
AGARDograph 30, 135-148, 1959.
Thirty-nine accidents from unknown causes, between 1948 and 1956, are considered. The statistical data on pilots' ages, experience, flying conditions, and types of aircraft do not lead to the cause of the acidents. Some of the aeromedical aspects of such accidents are reviewed. The principle that the 'man in the cockpit' should be studied by a flight surgeon during training with psychotechnical and psycho-physiological tests is advocated, together with more extensive psychological and physiopsychological indoctrination of flying instructors.

AG30/13 **Contribution to the Study of Accidents of Undetermined Origin, Stressing the Importance of the 'Pilot-Aircraft' Complex.** (In French.) R.SENEGAS, G.CANTONI.
AGARDograph 30, 149-154, 1959.
Detailed observations are given of 10 such accidents occurring over the past three years and involving single-seater jet aircraft. In a synthesis of these accidents the pilot-aircraft relationship is demonstrated with reference to different types of aircraft. The adaptation of man to machine is considered to remain as a perennial problem in aviation.

AG30/14 **Factors Related to Unexplained Accidents in the U.S. Air Forces in Europe.** J.M.TALBOT.
AGARDograph 30, 155-161, 3 refs., 1959.
A study based on the interrogation of 862 flyers of the U.S. Air Force reveals the aeromedical aspects of such accidents and including hypoxia, hyperventilation, explosive decompression, decompression sickness, and vertigo. Hypoxia and vertigo are always the foremost aeromedical factors in consideration of air accidents. The provision of sufficient and efficient protective flight equipment at air bases is also examined. Finally the place of aeromedical factors as primary or secondary causes in major unexplained accidents in 1955 and 1956 is analyzed and shown graphically.

AG30/15 **The Utilization of Pathology in Aircraft Accident Investigation.** F.M.TOWNSEND.
AGARDograph 30, 165-173, 15 refs., 1959.
The necessity for post-mortem pathological examination in investigations of unexplained accidents is discussed. Fields of interest for medical investigation are the prevailing environment of the pilot, possible traumatic factors, and the presence of pre-existing deficiencies in the pilot (such as coronary arteriosclerosis, third-ventricle cysts, or emphysema). The U.S. Air Force has a directive on the procedure to be used in the medical examination of accident victims, including toxicological and photographic techniques.

AG30/16 **The Unexplained Aircraft Accident: Some Problems in Post-Mortem Diagnosis.** J.K.MASON.
AGARDograph 30, 174-183, 39 refs., 1959.
It is pointed out that great caution is necessary in interpreting pathological findings in post-mortems on aircraft accident victims and in attributing pathological causes to accidents. This is because the total cases for investigation are few and control series in young adults are scarce.

AG30/17 **The Post Hoc Diagnosis of Loss of Useful Consciousness in the Air.** W.R.FRANKS.
AGARDograph 30, 184-194, 25 refs., 1959.
A review of the methods, and a commentary on them, used to ascertain (i) whether there has been a loss of consciousness, and (ii) what factors brought it about. The following conditions are considered: haemoglobin measurement, state of tissue irrigation, muscular tonus, diagnosis of hypoxia from lactic acid content of cerebral tissue, vomiting, incontinence, alcoholic or carbon monoxide intoxication, urine and skin secretion analysis. The necessity for caution in interpreting results is emphasized.

AG30/18 **The French Pressurized Suit.** (In French.) R.GRANDPIERRE, R.MUNNICH, J.COLIN.
AGARDograph 30, 197-207, 1959.
The work of the Aeromedical Training and Research Centre has resulted in the development of a suit which was satisfactorily tested in a low-pressure chamber to a simulated 60,000 ft altitude. It comprises a pressurized garment, pressurized helmet, and pneumatic valves.

AG30/19 **Trends in Personal Equipment.** E.L.COLE.
AGARDograph 30, 208-212, 1959.
Any leakage of a pressurized cabin may be fatal to an airman if he is not protected by a pressurized suit. Twelve photographs give details of several components of personnel protective clothing.

AG30/20 **Escape from Aircraft.** J.P.STAPP.
AGARDograph 30, 213-221, 13 refs., 1959.
With the aid of eleven diagrams the chief features and data for employment of an ejection seat, used in the U.S. Air Force are presented.

AG30/21 **U.S. Naval Aircraft Instrumentation Programme.** G.W.HOOVER.
AGARDograph 30, 222-229, 1959.
A break-through achieved during the past two years has resulted in a new instrument flight display, requiring little training and producing little disorientation; a flat C.R. tube for the presentation; a light-weight inexpensive universal computer for solving mission and flight mode problems; a new concept in designing a standard ejectable cockpit, adaptable to different aircraft configurations. The philosophy underlying the approach to problems is discussed.

AG30/22 **Future Trends in Protecting Aircrews.** D.FLICKINGER.
AGARDograph 30, 230-238, 4 refs., 1959.
With the performance capabilities of aircraft such as the F104 in mind, the author discussed human error or machine-operator malfunction. Two aspects are considered; the problem of obtaining more objective and usable data on the operator, through improved accident investigation techniques; and the design of operator-aircraft systems for optimal function and safety.

AG30/23 **Crash Injury Research, A Means for Greater Safety in Accidents.** A.H.HASBROOK.
AGARDograph 30, 241-252, 19 refs., 1959.
Discusses the necessity of investigation of injuries in non-fatal accidents together with relevant medical and pathological examinations. Results of inquests previously reported and used in the design of propeller transport aircraft and future jet aircraft are reviewed. Some recent investigations are discussed and the importance of the medical evidence pointed out.

AG30/24 **The Limits of Prediction Based on Psychomotor Tests.** (In French.) C.BOISBOURDIN, A. de B. De LAROCHE.
AGARDograph 30, 253-261, 1959.
Pilot selection is at present largely dependent on assessment of biographical data. Motivation, aptitude and environmental conditions of previous activities cannot be discriminated. Experimental methods can help to achieve economical training. Methods of training are considered to constitute the essential problem.

AG30/25 **Left-Handedness and Laterality in Pilots.** R.GERHARDT.
AGARDograph 30, 262-272, 7 refs., 1959.
The interest of the above characteristics in the study of flying proficiency is discussed. The importance of directionality is emphasized. Left-handedness without lateral aberration does not create the type of problem here considered. Directional aberrations in dextrous pilots may chance to be neglected.

AG30/26 **Training Performance as a Selection Device.** W.B.WEBB.
AGARDograph 30, 273-276, 1959.
The U.S. Naval School of Aviation Medicine at Pensacola uses a system of 'secondary screening' in selecting aircrew personnel. In a preflight period of 16 weeks the results obtained for the pupil are correlated with the initial entrance tests. In a second period those candidates showing failures are called before a 'disposition board' to see whether the cnadidate can be more favorably placed in service or continued in training. This helps to remedy any errors in the initial selection of candidates.

AG30/27 **The Significance of the Abnormal Electroencephalogram in Aircrew.** V.H.TOMPKINS.
AGARDograph 30, 277-284, 15 refs., 1959.
It is thought likely that a highly abnormal record of the paroxysmal type at rest is closely linked with physical or psychological breakdown and candidates with such records should not be accepted for training. However, any related symptoms are likely to have been revealed before completion of training. It is considered that certain factors in an EEG, which is clinically within normal limits, may be related to anxiety reactions which impair flying efficiency. These should be studied further.

AG30/28 **Electroencephalographic Evaluation of Naval Aviation Candidates.** R.E.LUEHRS.
AGARDograph 30, 285-289, 13 refs., 1959.
The methods used at the U.S. School of Aviation Medicine, Pensacola are described and commented on. At present no means have been established to provide valid selection criteria.

AG30/29 **The Significance of Nystagmus Observed in Routine Otologic Examination of Flight Personnel.** F.KIORBOE.
AGARDograph 30, 290-295, 1959.
In a three year period, out of 1338 subjects, 27 were confirmed as having nystagmus, which is a physiological reaction of the vestibulary organ to a non-physiological stimulus. Spontaneous and positional nystagmus found in second-year pilots could be attributed to alcoholism, infection, cranial trauma, Mênière's disease, disseminated sclerosis, labyrinthosis and stress, in the several cases examined. In two cases the causes were unknown. These are described in detail. It is recommended that nystagmus cases should not fly as first pilots even with cessation of the occurrence.

AG30/30 **The Significance of Nystagmus in Aviation Medicine.** A.GRAYBIEL.
AGARDograph 30, 296-304, 26 refs., 1959.
The significance is discussed in relation to clinical aspects, use of nystagmus as a test of fitness for flying, and its effect on visual perception in flight. It is concluded that nystagmus tests are of importance in the hands of medical specialists, but the low incidence of labyrinthosis in pilots does not justify a routine use. The tests are of importance in understanding the function of semicircular canals but of limited value in the selection of flyers. Its influence of perception during flight needs fuller investigation.

AG31
AD-227-760
N64-12125 **Explosions, Detonations, Flammability and Ignition: Pt.1 and 2.** S.S.PENNER, B.P.MULLINS.
AGARDograph 31, 287 pp., 1959.
Part 1 deals with selected analytical studies on explosions, detonations, flammability limits, and ignition of gases. Part 2 considers experimental and theoretical studies of flammability, ignitibility and explosion prevention. Individual abstracts to these two parts are given in the succeeding items.

AG31/1 **Selected Analytical Studies on Explosions, Detonations, Flammability Limits, and Ignition of Gases, and on Heterogeneous Burning.** S.S.PENNER.
AGARDograph 31, Pt.1, 1-107, 8 refs., 1959.
Discusses fundamentals of aerothermochemistry, elementary theory of explosions limits for premixed gases in closed vessels without surface reactions, the mechanism of complex reactions and explosion limits in reaction vessels, reactions in closed vessels, quenching, and combustion.

AG31/2 **Experimental and Theoretical Studies of Flammability, Ignitibility and Explosion Prevention.** B.P.MULLINS.
AGARDograph 31, Pt.2, 109-274, 81 refs., 1959.
The author considers flammability limits of homogeneous fuel-oxidant mixtures and fuel-diluent oxidant mixtures, flash points, flammability of heterogeneous fuel-air mixtures, spark and spontaneous ignition, combustion processes, and explosion prevention.

AG32
AD-233-171
N-79748 **Selected Topics on Ballistics.** W.C.NELSON (Editor).
AGARDograph 32, 280 pp., 202 refs., 1959.
This book is published to commemorate the centenary of Carl Cranz and contains papers read at the Cranz Centenary Colloquium held in West Germany. Abstracts of the individual papers are given in the following items.

AG32/1 **The Life and Work of C.Cranz.** (In French.) H.SCHARDIN.
AGARDograph 32, 1-17, 1959.
Includes a brief biography, and an account of his work in establishing the fundamentals of ballistics, use of graphics in trajectory determination and in internal ballistics, development of fuzes, derivation of the law of similarity in ballistics and numerous investigations and developments in instrumentation and recording of ballistic phenomena.

AG32/2 **Forty Years of British Aeroballistic Research.** J.W.MACCOLL.
AGARDograph 32, 18-35, 14 refs., 1959.
The following activities are described: organization of external ballistic research in the United Kingdom, aeroballistic research during World War 1, standard functions and drag data, measurement of loss of spin of projectiles, stability and damping of yaw, supersonic wind tunnel research and development, shadow photography of projectiles in flight, and application of numerical techniques.

AG32/3 **Exterior Ballistics Developments in the United States Since the Time of Cranz.** C.L.POOR.
AGARDograph 32, 36-45, 8 refs., 1959.
Exterior ballistics are described as the flight mechanics of weapons of ordnance, of shells, bombs, and of guided weapons. The history of rational flight mechanics is discussed, from 1920 to the present-day problems of ultra-high-speed flight. The value of this research is stated.

AG32/4 **Some Aerodynamic Effects on Long-Range Rocket Craft.** H.J.ALLEN.
AGARDograph 32, 46-58, 6 refs., 1959.
Discusses the loads and aerodynamic heating experienced by long-range ballistic rockets during their flight through the atmosphere and includes a discussion of the recovery of artificial satellites and spacecraft. The possibility of human habitation of satellites is treated from the point of view of decelerative loads during recovery and the role of aerodynamic lift is discussed.

AG32/5 **Ballistics of The Explorer.** J.E.FROEHLICH, A.R.HIBBS.
AGARDograph 32, 59-73, 1959.
After an introduction to the subject, the source of dispersions, and optimization of the launching trajectory is dealt with.

AG32/6 **Launching of Explorer 1.** R.F.HOELKER.
AGARDograph 32, 74-87, 1959.
Considers: historical development, missile description, performance of motors, flight performance, control, error analysis, apex prediction scheme, temperature, launch, actual performance, orbit, oblateness, lifetime, experiments and transmission.

AG32/7 **Meteorites and Ballistics.** J.S.RINEHART.
AGARDograph 32, 88-116, 93 refs., 1959.
Discusses recent studies in the interrelated areas, meteoritics, ballistics, and astroballistics, with specific reference to ablation fundamentals, the shapes and surface features of various meteorites, and the nature of impact craters.

AG32/8 **Projectile Aeroballistics.** R.SAUER.
AGARDograph 32, 117-124, 1959.
A survey is given of practical analytical and numerical methods of gas dynamics for problems of projectile aeroballistics. A brief review of the linearized theory of steady supersonic flow past projectiles is followed by exact numerical solutions and slender body approximations. Analogous solutions are considered for projectiles at incidence and for winged projectiles. The wing/body interaction problem and area rule are treated, and also linear methods for unsteady flow part oscillating projectiles are given. Non-linear methods are presented for computing the flow field between the projectile and shock in front of the projectile's nose.

AG32/9 **The Calculation of Stability and Damping of Spin-Stabilized Projectiles.** W.HAACK.
AGARDograph 32, 125-139, 8 refs., 1959.
The paper discusses (i) the calculation of the frequencies and damping coefficients and (ii) calculation of the projectile movement.

AG32/10 **Some Aspects of Stability and Controllability of Cross-Winged Guided Missiles.** S.F.ERDMANN.
AGARDograph 32, 140-144, 1959.
This discussion has shown that the rotation of the tailplane with respect to the crosswing from $\Delta\phi = 0$ deg to $\Delta\phi = 45$ deg can result in appreciable difficulties with respect to the controllability. In principle, however, through an enlargement of the rudder-area it is possible to eliminate the difficulties. This conclusion has been confirmed by experiments.

AG32/11 **The Rôle of Free Flight Ranges in Ballistic and Aerodynamic Research.** C.H.MURPHY, Jr.
AGARDograph 32, 145-167, 39 refs., 1959.
The three BRL free ranges are described in some detail together with some associated research programmes. The influence of range measurement on the development of a theory to describe the effect of nonlinear aerodynamic forces and moments is indicated.

AG32/12 **Electronic and Optical Means of Observation of Guided Missiles and Satellites.** L.A.DELSASSO.
AGARDograph 32, 168-182, 1959.
Contents:– (i) introduction, (ii) radar techniques, (iii) telemetering, (iv) radio Doppler, (v) optical methods, (vi) data processing, and (vii) satellite tracking.

AG32/13 **Special Ballistic Ranges and Gas Guns.** H.H.KURZWEG.
AGARDograph 32, 183-199, 10 refs., 1959.
Describes special ballistic ranges including pressurized and aerophysics ranges, and also gas guns.

AG32/14 **Preliminary Planning for a Hypervelocity Aeroballistic Range at AEDC.** E.J.STOLLENWERK, R.W.PERRY.
AGARDograph 32, 200-212, 4 refs., 1959.
Results of preliminary experiments aimed at defining the design of a hypervelocity aeroballistic range for the AEDC are reported and future possibilities discussed. As a first step toward telemetering from a projectile, an oscillator capable of withstanding a 200,000 g acceleration has been developed. Scale-up of a hypervelocity gun using spark-heated hydrogen or helium as the propellant is also in progress.

AG32/15 **Forty Years of British Internal Ballistic Research.** J.B.GOODE.
AGARDograph 32, 213-223, 1959.
Deals with, propellant aspects, experimental internal ballistics, internal ballistic theory, ballistic performance, special types of gun, and incidental effects. Problems requiring further study are stated to be the reduction of weight, gun heating, temperature ranges, ignition and burning, improved theory, and international standardization.

AG32/16 **A Brief History of Rocket Research and Development in The United Kingdom.** F.JAMES.
AGARDograph 32, 224-242, 11 refs., 1959.
This brief history is mainly a mention of the major problems of rocket development, roughly in the chronological order in which they were encountered in the United Kingdom. Subject to the limitations of security. Its usefulness is to invoke a perspective rather than to convey technical information.

AG32/17 **On The Secondary Jet Effects of Self-Propelled Missiles.** (In French.) F.TESSON.
AGARDograph 32, 243-261, 1959.
Gives a general analysis and also discusses the effect of the jet on the dynamic stability of the missile.

AG32/18 **Scaling Problems in Underwater Ballistics.** H.G.SNAY.
AGARDograph 32, 262-280, 9 refs., 1959.
The scaling requirements are difficult to satisfy for the underwater explosion bubble. If model explosions are made in a moving test tank during the period of acceleration, almost all the important effects can be scaled, including shock-wave phenomena. Two design studies of high gravity tanks are shown.

AG33 **The Construction of Research Films.** D.H.DENSHAM.
AD-227-759 AGARDograph 33, 104 pp., 1959.
CN-76588 The aim of this book is to help producers of research films to improve the style of their productions. The information given will apply equally to most types of short film production, including scientific films, training films, and documentary films.

AG34 **Sporadic E Ionization.** B.LANDMARK (Editor).
AD-227-763 AGARDograph 34, 204 pp., 111 refs., 1958.
N63-83755 Introductory papers deal with the world-wide occurrence of sporadic E and outline suggested theories. A number of papers are then given on experimental studies of sporadic E by means of various techniques, including h'(f) recordings, rocket soundings, scatter methods and studies of fading properties. Lastly the possible mechanisms of production are discussed. Abstracts of the individual papers are given in the succeeding items.

AG34/1 **Temporal and World-Wide Variations of Sporadic E.** E.K.SMITH, Jr.
AGARDograph 34, 1-22, 4 refs., 1958.
This is an attempt to portray the gross geographical and time variations of Sporadic E. The majority of the data used in the analysis is for the period 1947-1954. Some preliminary analyses of the IGY ionosonde data, notably from the close-space equatorial chain in South America are also included.

AG34/2 **Outline of Suggested Theories of Spora , E.** J.A.THOMAS.
AGARDograph 34, 23-31, 40 refs., 1958.
The various theories are briefly examined. The proposals for reflection mechanisms are outlined and these are followed by a short analysis of the suggested energy sources. Comment is made on the applicability of the various theories.

AG34/3 **Classification of Sporadic E. Pt.2.** J.A.THOMAS.
AGARDograph 34, 33-36, 1 refs, 1958.
The various approaches to the problem of classification are discussed, and inevitable defects of various local classifications when the problem is one of determining the world-wide behaviour of sporadic E are pointed out. The present IGY classification is gi"n, and a few comments are made on the analysis of the data so obtained.

AG34/4 **Slant Es Disturbance at Godhavn and its Correlation with Magnetic Disturbance.** J.K.OLESEN, J.RYBNER.
AGARDograph 34, 37-57, 11 refs., 1958.
Statistical material is presented which shows that 'slant Es condition' in the ionosphere normally occurs only during sunlit hours and is associated with a certain type of magnetic disturbance. There is a close correlation between the occurrences of the two phenomena, both diurnally and seasonally.

AG34/5 **Sporadic Ionization of the E-Region of the Ionosphere Above Lindau/Harz During the Past Year.** W.BECKER.
AGARDograph 34, 59-65, 1958.
This concept covers all ionization steps between 60 and 190 km height that are sporadic in time and hence not due to normal ultraviolet solar irradiation. A classification of these ionization steps is given, and a statistical investigation of echo traces presented. It is assumed that the different ionization mechanisms must be responsible for the observed sporadic ionization of the E-region.

AG34/6 **Correlation of Es Characteristics in Time and Space.** K.RAWER.
AGARDograph 34, 67-80, 10 refs., 1958.
The main parameters used to characterize an Es-layer are now precisely enough defined as foEs and fbEs. A better description can be given when the correlation functions in space and time are determined. This has been done provisionally; a correlation disturbance of about 200 km, and a correlation time of about 1 h for foEs and ½ h for fbEs has been found.

AG34/7 **Latitude Effects in Sporadic E Observations.** N.C.GERSON.
AGARDograph 34, 81-96, 1958.
Several conclusions have been drawn regarding the geographical distribution of sporadic E but, to determine the long term Es climatology, additional observations over many years are necessary.

AG34/8 **On the Origin of Sporadic E Echoes: Some Experimental Data Collected in France.** (In French.) D.LEPECHINSKY.
AGARDograph 34, 97-109, 10 refs., 1958.
Discusses the general statistical laws of occurrence of E echoes and distinguishes these echoes from other echo phenomena. The 'dynamic' theory of occurrence proposed by Gallet is examined and it is shown that the data here reviewed tend to confirm this theory. A table is included, showing the types of Es most frequently observed by the ten stations of C.N.E.T.

AG34/9 **Sporadic E as Observed by Backscatter Techniques in the United Kingdom.** E.D.R.SHEARMAN, J.HARWOOD.
AGARDograph 34, 111-128, 4 refs., 1958.
The advantages of using the rotating aerial back-scatter sounder for the observation of sporadic E clouds is discussed. This is followed by a discussion of results obtained during the I.G.Y. and also by earlier results using different techniques.

AG34/10 **Sporadic E Observed on VHF Oblique Incidence Circuits.** E.K.SMITH, Jr.
AGARDograph 34, 129-147, 8 refs., 1958.
Discusses the various circuits for the observation of sporadic E which were operated by the National Bureau of Standards. A rather crude method is shown by which it is possible to predict VHF field strength levels from vertical incidence data.

AG34/11 **Evidence About Es From N(h) Profiles.** K.WEEKES.
AGARDograph 34, 149, 1958.
It is found that the virtual height of the Es trace may be determined mainly by the gradient of the N(h) curve near Es, and not by the actual height of the Es-layer. On one occasion it was observed that, during an Es condition, a distortion was observed in the E-layer which might explain the Es condition by a redistribution process.

AG34/12 **Some Characteristics of Sporadic E Ionization as Determined by a Rapid Frequency Sweep Experiment.** B.H.BRIGGS.
AGARDograph 34, 151-161, 10 refs., 1958.
In the experiments described the frequency of a pulse transmitter was varied rapidly over a frequency range of ½ mc/s in about ½ sec, and a receiver was kept in tune by electronic means. The amplitudes of echoes from the Es-layer and the F-layer were recorded as functions of frequency. By comparison with the theory of reflection from a 'thin' ionized layer the thickness of the Es-layer is determined.

AG34/13 **Anisometry in the Fading Pattern of Sporadic E as Observed Near the Auroral Zone.** B.MAHLUM.
AGARDograph 34, 163-170, 4 refs., 1958.
The diffraction pattern formed over the ground from the sporadic E-layer has been studied at Tromsö (67 deg. Geom. Lat.). The irregularities in the diffraction pattern are found to be elongated in an east-west direction, and velocities of drift up to 1600 m/s of the irregularities have been observed.

AG34/14 **High Electron Density Gradients in the Ionosphere as Observed with Rockets.** J.C.SEDDON.
AGARDograph 34, 171-181, 7 refs., 1958.
Gives the results of day-time measurements of electron density profiles, made with rockets, during sporadic E conditions. Characteristics of sporadic E are considered. A night flight in Canada, is discussed, where two sporadic E regions existed. Evidence is presented that shows a spread-F condition existed above 190 km and that it probably consisted of many irregular turbulent high gradient regions.

AG34/15 **Measurement of Ionospheric Fine Structure by High Altitude Rockets.** W.PFISTER.
AGARDograph 34, 183-193, 2 refs., 1958.
In the United States, two methods are being used for the determination of electron density distribution from rocket experiments: the pulse delay method and the phase delay method. The results derived from both of these methods are discussed.

AG34/16 **Introduction to Discussion on Theoretical Explanation of Sporadic E.** K.WEEKES.
AGARDograph 34, 195-199, 1958.
The main forms of Es, that is those which usually give strong reflections, and exclude the persistent weak scattered echoes observable with high power equipment, are the subject of this discussion. Five types of Es which appear to be sufficiently distinct and to be likely to have different causes are distinguished.

AG35
AD-232-700
N-79746 **A Summary of Design Techniques for Axisymmetric Hypersonic Wind Tunnels.** YING-NIEN YU.
AGARDograph 35, 87 pp., 55 refs., 1958.
A family of perfect fluid co-ordinates of axisymmetric effusers with the exit Mach number range of 5 to 20 has been computed by the method of characteristics. A conical source flow front and a centre line Mach number distribution are used as initial conditions. Design techniques and other related problems of interest in the development of hypersonic facilities are summarized.

AG36
AD-233-126
N65-83972 **Aeronautical Preventive Medicine.** P.BERGERET, P.M. van WULFFTEN PALTHE, P.A.CAMPBELL, C.F.GELL, D.G.M.NELSON (Editors).
AGARDograph 36, 75 pp., 1957.
Six papers were presented at a symposium held by the AGARD Aeromedical Panel in 1957 emphasizing the importance of industrial medicine in the air operational system. Abstracts of the individual papers are given in the succeeding items.

AG36/1 **Aeronautical Preventive Medicine in the United States Air Force.** G.F.FISHER.
AGARDograph 36, 1-10, 1957.
The scope of interest of preventive medicine is in the health, welfare and well-being of all the personnel of the Air Force. These include not only the military components of all grades, but also their dependants and the large number of Federal Civil Service employees. The extent to which the programme is implemented varies with the availability of trained personnel and the limitations presented by the military budget.

AG36/2 **Aeronautical Preventive Medicine in the U.S. Navy.** A.SALAZAR, C.P.PHOEBUS.
AGARDograph 36, 11-19, 1957.
This presentation emphasizes those problems peculiar to air stations and includes a discussion of the problems resulting in operations aboard aircraft carriers or derived from actual flying of aircraft or resulting in medical problems of flying personnel.

AG36/3 **Organization of Preventive Medicine in the French Air Force and Aircraft Industry.** (In French.)
–.LABARTHE, –.BOURDON.
AGARDograph 36, 21-27, 1957.
An outline of the Preventive Medicine Service particularly in the big establishments of the 'Direction-Technique et Industrielle', naval dockyards, flight-test centres, motor and propeller test centres, and in aircraft factories.

AG36/4 **The Preservation of Health and Efficiency.** J.S.WILSON.
AGARDograph 36, 29-37, 9 refs., 1957.
Deals with the effect of stresses due to environment, noise and psychological effects, and outlines methods of dealing with them.

AG36/5 **Aeromedical Problems in Operating All-Weather Aircraft, Some Canadian Observations.** D.O.COONS.
AGARDograph 36, 39-47, 1957.
Discusses only the primary operations concerning all-weather operations of fighters under cold and hot environments, and concerns notes on aeromedical problems of the air and ground crews. Preventive measures are summarized.

AG36/6 **Changes in Elementary Neuron Activity Produced by Some Neurotropic Drugs.** R.MARGARIA, T.GUALTIEROTTI, D.SPINELLI, C.MORPURGO.
AGARDograph 36, 49-75, 20 refs., 1957.
The investigation was carried out in order to determine the effect of some well known neurotropic drugs, and to study whether and how these may counteract effects due to fatigue or hypoglycaemia or general stress.

AG37
AD-233-172
N-79747 **Advanced Aero Engine Testing.** A.W.MORLEY, J.FABRI (Editors).
AGARDograph 37, 298 pp., 1959.
This book embodies papers presented at the joint meeting of the Combustion and Propulsion Panel and the Wind Tunnel and Model Testing Panels in October, 1958. The three parts include papers on Engine Test Facilities, Engine Component Testing, and Flight Test Problems. Abstracts of the individual papers are given in the succeeding items.

AG37/1 **Propulsion System Problems Investigated in Wind Tunnel and Altitude Test Chamber Facilities.**
E.J.MANGANIELLO.
AGARDograph 37, 3-32, 47 refs., 1959.
The general classes of propulsion system problems investigated in the wind tunnels and altitude test chamber facilities of NACA Lewis Flight Propulsion Laboratory are outlined and some typical experimental results are given for illustrative purposes. Four categories of test facilities are considered – altitude test chamber facilities, free jet facilities, subsonic wind tunnels and supersonic wind tunnels. Both turbojet and ram-jet testing are considered.

AG37/2 **Some Selected Problems in Engine Altitude Testing.** B.H.GOETHERT.
AGARDograph 37, 33-78, 1959.
Considers the different methods of utilizing wind tunnels as engine test facilities, including altitude simulation, engine performance and flow problems.

AG37/3 **Full-Scale Propulsion Testing in Wind Tunnels.** R.W.HENSEL, H.K.MATT.
AGARDograph 37, 79-137, 40 refs., 1959.
Major facilities capable of handling full-scale engines are considered, the main emphasis being on continuous flow tunnels in the transonic and upwards range. Techniques for obtaining matched altitude conditions of Mach number, pressure and temperature are discussed together with such items as exhaust gas removal, wall interference and instrumentation peculiar to propulsion testing. Future trends are considered with emphasis on rocket testing.

AG37/4 **Measurements Relating to the Testing of Engines in the Large Wind Tunnels at Modane-Avrieux.** (In French.) M.PIERRE.
AGARDograph 37, 138-156, 5 refs., 1959.
Describes the engine tests carried out in the SIMA wind tunnel run by ONERA. The tests conducted since late 1952 have concerned: ram-jets, a complete target missile, medium and high power turbo-jets and ram-jet systems, a propeller power plant (600 cv Pratt-Whitney engine), and complete special engines.

AG37/5 **Model Testing of Turbines and Compressors.** S.F.SMITH, C.E.PAYNE.
AGARDograph 37, 159-176, 8 refs., 1959.
The merits of model testing as a means of evaluating the characteristics of turbines and compressors are discussed and some consideration is given to the correlation of model and full-scale results. Also included is a brief account of the construction of the models, the layout of the test plant and the instrumentation which have been evolved at Rolls-Royce.

AG37/6 **Some Experiences in Combustion Scaling.** A.H.LEFEBVRE, G.A.HALLS.
AGARDograph 37, 177-204, 39 refs., 1959.
It is suggested that scaling of combustion chambers is not a good proposition. An equation is presented which relates combustion performance to specific operating variables which should provide a basis for relaxation of the scaling rules by Stewart. The equation should be suitable for afterburners and combustion chambers. The problem of metal temperature is discussed and two possible solutions suggested.

AG37/7 **Laboratory and Flight Technique for the Measurement of the Temperature of Turbine Blading.** E.P.COCKSHUTT, G.G.LEVY, C.R.SHARP.
AGARDograph 37, 205-238, 1959.
The evolution of a flight-worthy instrumentation system for measuring turbine rotor blade temperatures in an Orenda 14 turbojet engine is described. The system comprises sheathed chromel-alumel thermo-couples installed in drilled turbine blades and used in conjunction with mercury slip rings mounted in the exhaust bullet of the engine.

AG37/8 **Applicability of Separate Component Test Results to Complete Propulsion Systems.** D.S.GABRIEL, L.E.WALLNER.
AGARDograph 37, 239-259, 3 refs., 1959.
Steady state and transient performance are discussed and the components considered are inlets, compressors, combustors, afterburners, turbines, and exhaust nozzles. Differences occur when testing isolated components which can result in misleading figures which during transient engine operation could prove to be dangerous.

AG37/9 **The Further Application of Generalized Parameters to Turbojet Performance Relationships.** E.MACIOCE.
AGARDograph 37, 260-269, 3 refs., 1959.
The non-dimensional treatment is extended to quantities which may be deduced from elementary turbojet performance data and which can be presented as functions of the same independent parameters. Further aspects of the performance of the engine can be examined by the method of generalized parameters.

AG37/10 **Flight Test Development of Supersonic Engines.** R.E.PRYOR.
AGARDograph 37, 273-290, 4 refs., 1959.
The reason for engine manufacturer flight programmes are discussed, along with an analysis of concurrent engine and aircraft development. Some typical problems are presented as a portion of a typical and representative development test programme. Finally, the contributions of this type programme are presented as conclusions to the paper.

AG38
AD-233-127
N-80083 **Design and Operation of a Continuous-Flow Hypersonic Wind Tunnel Using a Two-Dimensional Nozzle.** H.M.SCHURMEIER.
AGARDograph 38, 156 pp., 43 refs., 1959.
The design and operation of a conventional hypersonic wind tunnel using a two-dimensional nozzle requires the solution of many engineering problems associated with the high stagnation temperatures and pressures and critical dimensional tolerances. These solutions are outlined in some detail.

AG39
AD-242-985
N-87155 **Slip Flow Testing Techniques.** G.J.MASLACH, S.A.SCHAAF (Editors).
AGARDograph 39, 95 pp., 89 refs., 1959.
Methods developed to date are illustrated by various current flow systems which meet these requirements. Structural design and fabrication techniques for large dynamic vacuum systems are briefly reviewed. Instrumentation unique to low density aerodynamic research is described. The use of a free molecule probe is also discussed.

AG40
AD-238-942
N-84312

Avionics Research: Satellites and Problems of Long Range Detection and Tracking.
E.V.D.GLAZIER, E.RECHTIN, J.VOGE (Editors).
AGARDograph 40, 257 pp., 1960.
Nineteen papers published in this book were presented at a symposium organized in 1958 by the Avionics Panel. They show the importance of the study of physical environment in high atmosphere and space, they indicate basic physical research areas, and demonstrate how closely technology follows on the 'heels' of pure research. Abstracts of the individual papers are given in the succeeding items.

AG40/1

A Generalized Theory of Radar Observations. R.J.LEES.
AGARDograph 40, 1-5, 1960.
A radar receiver measures the amplitude and phase of a reflected signal at given time, frequency and position. Measurements of direction, range and velocity of a target are shown to be derived from the way in which the phase of the signal varies with the dimensions of position, frequency and time, while measurements of target shape, size and spin result in theory from measuring the way in which the amplitude varies with the same dimensions. The degree of resolution is shown to be governed by the extent to which the variations are explored, and ambiguities result if the exploration is not continuous.

AG40/2

The Calculus of Radar Observations. P.M.WOODWARD.
AGARDograph 40, 6-11, 3 refs., 1960.
Radar observation theory is presented as a question of least-squares fitting, in which the integrated squared deviations of the possible signals from the noisy signal actually received, form the basic starting point. The statistical treatment of these deviations is described in terms of a simple theory of weights, designed to disguise the specialized statistical theory which can be used for its justification. The rules of weight formation and combination are described and examples given. Incoherent detection, for instance, is presented as a problem of weight integration. The paper concludes by mentioning an interesting statistical problem, apparently unsolved.

AG40/3

Echoing Area Characteristics. J.S.HEY, H.GENT, P.G.SMITH.
AGARDograph 40. 12-28, 19 refs., 1960.
The echoing area properties of conducting objects of simple shape are summarized. The relationships between echoing area, size of object and radio wavelength are considered. The reflecting properties of ionized media are considered in relation to the radar detection of meteor trails. The paper then considers the echoing areas of the Moon and other astronomical bodies, concluding with a consideration of the possible echoing area of the sun.

AG40/4

Ground Scatter by Ionospheric Radar. W.DIEMINGER.
AGARDograph 40, 29-43, 8 refs., 1960.
In the history of radio propagation man experienced 3 great suprises: (i) the diffraction of long radio waves around the earth, (ii) the reflection of short waves in the ionosphere, and (iii) the scattering phenomena on short and very short wavelengths. Each of these phenomena opened a new field of application of radio waves, and for the scattering processes, one is just beginning to make use of it.

AG40/5

The Sun as a Noise Source in Radar Aerial Investigations. E.EASTWOOD.
AGARDograph 40, 44-56, 6 refs., 1960.
This paper describes experiments which utilize the quiet sun as a noise source at varying angles of elevation, in order to establish the vertical diagrams of high performance radars required to provide the operational environment demanded by modern military aircraft. The use of the solar noise signal for checking the azimuthal and elevation accuracies of microwave radars is indicated.

AG40/6

VHF Radar Propagation Research. B.C.BLEVIS, J.H.CHAPMAN.
AGARDograph 40, 57-67, 4 refs., 1960.
The experimental results to date have shown that there are important propagation factors which will affect long range VHF radars and on which further research is required.

AG40/7

The Electrostatic Field About an Ion Moving Slowly Through a Highly Ionized Gas. S.RAND.
AGARDograph 40, 68-74, 1960.
The Debye-Hückel field about an ion which is stationary in an ionized gas is well known. The purpose of this paper is to determine how this field becomes distorted when the ion under consideration moves with velocities small compared to the mean thermal velocity of ions in the gas.

AG40/8 **Plasma Motions Induced by Satellites in the Ionosphere.** L.KRAUS, K.M.WATSON.
AGARDograph 40, 75-91, 10 refs., 1960.
Electrostatic phenomena associated with a charged satellite in the ionosphere are investigated. The effect of the charge is to induce a hydrodynamic flow of the ionized gas (plasma), which is called 'electrohydrodynamic'. Using linearized flow theory the drag associated with this motion, as well as the wake behind the object, are discussed.

AG40/9 **Electrohydrodynamic Properties of Satellites.** L.KRAUS.
AGARDograph 40, 92-100, 5 refs., 1960.
The linearized theory of the interaction of a charged body in a plasma as described by Kraus and Watson indicates that for a small body moving at satellite velocities in the ionosphere, interesting electrohydrodynamic effects may be expected. The phenomena of interest are the drag, the increased ionization in the wake, and the angle of the wake. A parameter analysis of these phenomena permits us to assess these effects.

AG40/10 **Electromagnetic Waves and Satellite Echoes From Ionized Wakes of Satellites in H.F.** (In French.)
A.FLAMBARD, M.REYSSAT.
AGARDograph 40, 101-112, 1960.
Discussion of results obtained with 25 Mc/s transmission in detecting ionized wakes by the use of an oblique ionosphere probe. Hypotheses are given for the best conditions of detection with h.f.

AG40/11 **Observation of Re-Entry of an IRBM.** D.D.WOODBRIDGE.
AGARDograph 40, 113-124, 1960.
The purpose of 'Operation Gaslight', which concluded with the re-entry of the second Jupiter, was to investigate the physics associated with re-entry phenomena. Some of the difficulties in recording data are discussed. Although it appears that these difficulties were many, a considerable amount of usable data was obtained.

AG40/12 **Earth Satellite Observations made with the Millstone Hill Radar.** G.H.PETTENGILL, L.G.KRAFT, Jr.
AGARDograph 40, 125-134, 1960.
This paper is a general description of the facility of the Lincoln Laboratory (administered by the Massachusetts Institute of Technology).

AG40/13 **Radio Observations of the Russian Earth Satellites.** J.G.DAVIES.
AGARDograph 40, 135-139, 6 refs., 1960.
Gives results obtained by the 250 ft radio telescope at Jodrell Bank between October 1957 and April 1958.

AG40/14 **Radar Echoes Obtained From Earth Satellites 1957 Alpha and 1957 Beta.** A.M.PETERSON, R.L.LEADABRAND, W.E.JAYE, R.B.DYCE, L.T.DOLPHIN, R.I.PRESNELL, L.H.RORDEN, J.C.SCHLOBOHM.
AGARDograph 40, 140-155, 7 refs., 1960.
A description of the radar equipment used at the Stanford Research Institute and a short review of the radio-tracking method are presented.

AG40/15 **Sputnik Modulation Patterns.** W.E.BROWN, Jr.
AGARDograph 40, 156-173, 2 refs., 1960.
A preliminary catalogue and an anlysis are made of transmissions originating from Soviet satellites. The cataloguing is principally concerned with the type of modulation pattern and geographical location of the emission. Locating the transmission source leads to estimated ephemerides which in turn yield an estimated orbit injection point for the satellites.

AG40/16 **Satellite Tracking From Several Coordinated Doppler Receiving Stations.** W.S.McDONALD.
AGARDograph 40, 174-187, 3 refs., 1960.
This paper presents the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract No DA-04-498-Ord 18, sponsored by the Department of the Army Ordnance Corps.

AG40/17 **Vehicle Motions as Inferred from Radio-Signal-Strength Records.** W.C.PILKINGTON.
AGARDograph 40, 188-235, 3 refs., 1960.
The radio-signal-strength records from the Explorer satellites provided considerable information on staging, attitude, precession rate, spin rate, and ratio of moments of inertia. The records from the launching of each of the Explorers were investigated and gave information that could be used to explain the details of the performance.

AG40/18 **Forty Megacycle Satellite Images and Beyond-the-Horizon Propagation.** H.W.WELLS.
AGARDograph 40, 236-239, 3 refs., 1960.
Describes properties of the 'image' signals and includes discussions of mechanisms which may be effective. The results of all subsequent monitoring at 40 Mc/s in 1957 and 1958 are included together with description of beyond-the-horizon propagation demonstrating ionospheric dispersion of limited extent.

AG40/19 **An Interesting Propagation Effect of Sputnik I.** E.DEWAN.
AGARDograph 40, 240-257, 1960.
Examination of Brush pen recordings obtained by the AFCRC (Air Force Cambridge Research Center) revealed a remarkable phenomena: when the satellite came over the horizon and again when it went down towards the horizon in the opposite direction the signal occasionally had peaks as large as those observed when the satellite was at the zenith of its pass. A theory for this is given.

AG41
AD-263-859
N-102-012 **Fundamental Data Obtained From Shock-Tube Experiments.** A.FERRI (Editor).
AGARDograph 41, 415 pp., 571 refs., 1961.
This volume presents a collection of monographs in the fields of chemical, physical and thermodynamic problems investigated or investigable experimentally by shock-tube techniques. Abstracts of the individual papers are given in the succeeding items.

AG41/1 **Fluid Dynamics of Non Steady Flow.** A.FERRI, L.G.NAPOLITANO.
AGARDograph 41, 1-46, 62 refs., 1961.
The basic concepts underlying the theoretical treatment of unsteady, continuous one-dimensional (and quasi-one-dimensional) motion are reviewed. A short outline of the mathematical theory of characteristics of a system of quasi-linear first order partial differential equations is given in Appendix A. Thermodynamic properties of air in equilibrium at high temperature are reported in Appendix B.

AG41/2 **Flows With Discontinuities.** L.G.NAPOLITANO.
AGARDograph 41, 47-85, 25 refs., 1961.
The unsteady one-dimensional motion of an ideal, perfect fluid of constant composition in the presence of discontinuities is considered. Three different aspects of the problem are treated.

AG41/3 **Shock Tube Technology and Design.** H.T.NAGAMATSU.
AGARDograph 41, 86-136, 67 refs., 1961.
Discusses the production of high temperatures and hypersonic flow by the use of shock tubes, and includes the basic equations governing the flow and design features of a shock tunnel. Instrumentation is described, and also experimental results for high Mach numbers are correlated with analytical predictions.

AG41/4 **The Rate of Dissociation of the Halogens.** N.DAVIDSON.
AGARDograph 41, 138-154, 23 refs., 1961.
Ideal one-dimensional flow in a constant-area shock tube provides unique possibilities for the determination of fast chemical-reaction rates under controlled conditions of temperature and pressure. The use of the shock tube for the study of elementary processes is described and an introduction is provided to the techniques required for 'in situ' observations of fast chemical changes by the use of optical procedures.

AG41/5 **The Hydrogen-Bromine Reaction in a Shock Tube.** N.DAVIDSON.
AGARDograph 41, 155-160, 6 refs., 1961.
Application of the shock tube for the determination of rates in the simple chain reactions occurring in these mixtures forms the subject of this chapter. A comparison is made of the achievements described in chapters 4B and 4C.

AG41/6 **Kinetics Studies in a Single-Pulse Shock Tube.** A.HERTZBERG, H.S.GLICK.
AGARDograph 41, 161-182, 23 refs., 1961.
Describes the general features of the single-pulse shock tube method, using studies that have been performed on nitric oxide formation and aliphatic hydrocarbon decomposition as illustrative examples.

AG41/7 **Experiments on Carbon Formation from Hydrocarbons Behind Incident and Reflected Shock Fronts.** S.S.PENNER, E.N.BENNETT, F.HARSHBARGER, W.J.HOOKER.
AGARDograph 41, 183-220, 18 refs., 1961.
The problems involved in the determination of effective, overall reaction rates for carbon formation from hydrocarbons behind shock fronts constitute the subject of this chapter.

AG41/8 **Ionization Processes in Shock Waves.** V.H.BLACKMAN, G.B.F.NIBLETT.
AGARDograph 41, 221-241, 24 refs., 1961.
The electrical conductivity of shock-heated gases has been measured over a limited range of conditions and the results compared with theory. The approach to equilibrium ionization behind strong shock waves has been studied experimentally and theoretically, and finally the conducting plasma behind a shock wave has been used for magneto-fluid-dynamic studies.

AG41/9 **Vibrational Relaxation Times.** W.C.GRIFFITH.
AGARDograph 41, 242-260, 25 refs., 1961.
The theory of vibrational heat capacity and excitation rates is developed followed by a discussion on the speed of sound in a gas with lagging vibrational heat capacity; the structure of shock waves; the effect of vibrational lag on nozzle; bow-waves detachment distance in supersonic flows over blunt bodies; and the rôle of vibrational excitation as a step towards chemical dissociation.

AG41/10 **The Determination of Absolute Intensities and f-Numbers from Shock-Tube Studies.** S.S.PENNER.
AGARDograph 41, 261-290, 90 refs., 1961.
A survey of experimental and computational procedures which must be considered in order to obtain significant absolute intensity data.

AG41/11 **Equations of State and Thermodynamic Functions.** R.E.DUFF.
AGARDograph 41, 291-319, 31 refs., 1961.
Deals with theoretical possibilities and experimental attempts to determine equation of state and thermodynamic information about various materials from shock-wave measurements.

AG41/12 **Gaseous Detonations and the Structure of a Detonation Zone.** H.G.WAGNER.
AGARDograph 41, 320-385, 158 refs., 1961.
Deals with the theory of stable detonation, velocity and limits of detonation, comparison of experiments with analysis, the system C_2H_2—O_2, detonation spectra, spherical detonation waves, ignition by shock waves, initiation of a detonation, and spin phenomena.

AG41/13 **Atomic Line Profiles and Molecular Emission Spectra.** O.LAPORTE, E.B.TURNER.
AGARDograph 41, 386-404, 19 refs., 1961.
Mixing hydrogen in small quantities with the gas to be investigated provides a method of obtaining the temperature and ion density. Similarly, the addition of various hydrocarbons renders it possible to observe certain features of the flow in the light of the emission of the C_2 molecule. Such methods have a considerable potential for the purpose of rapidly scanning high-speed flows in shock tubes.

AG42 **The Upper Atmosphere Above F2-Maximum.** H.POEVERLEIN (Editor).
AD-255-176 AGARDograph 42, 355 pp., 279 refs., 1959.
N65-84829 This is a collection of 29 Papers presented at a Symposium of the Ionospheric Research Committee in Paris, May, 1959. Abstracts of the individual papers are given in the succeeding items.

AG42/1 **Information About the Gas Density in Space Derived From Radiation Measurements.** H.FRIEDMAN.
AGARDograph 42, 3-9, 6 refs., 1959.
Considers estimates of the distribution of hydrogen from observations of Lyman-α radiation in the night sky, and Bremsstrahlung from the Van Allen belts.

AG42/2 **Ionization Above the F2-Peak, as Affected by the Interplanetary Gas.** S.CHAPMAN.
AGARDograph 42, 11-18, 21 refs., 1959.
Evidence is presented favouring the view that the Earth's ambium consists of ionized solar atmosphere hydrogen. If this is so, the outermost part of the Earth's atmosphere is likewise hot and ionized. It must enclose an extensive layer of mainly neutral atomic hydrogen.

AG42/3 **The Structure of the Outer Atmosphere Including the Ion Distribution Above the F2-Maximum.** F.S.JOHNSON.
AGARDograph 42, 19-35, 21 refs., 1959.
It is indicated that ion distribution up to 550 km, is controlled by changes in the recombination coefficient, which is in probable agreement with diffusion theory. It is further suggested that the ion distribution above 550 km is controlled by diffusive equilibrium and not by recombination, although, above 550 km further changes in the recombination coefficient do occur. It is deduced that ions responsible for whistler propagation are terrestrial, and their source is the same as that for the F region.

AG42/4 **Motions in the Magnetosphere of the Earth.** T.GOLD.
AGARDograph 42, 37-45, 3 refs., 1959.
The conditions determining the dynamical behaviour of the ionized gas in the outer atmosphere of the Earth are discussed. This region is here called the 'magnetosphere'. A theory is given which

predicts that at the level of the F2-layer and above most motions will show strict symmetry between the two base points of a magnetic line of force.

AG42/5 **Summary of Results on the Trapped Particle Zone.** R.JASTROW.
AGARDograph 42, 47-54, 11 refs., 1959.
Data from satellite and space probe measurements are considered and the origin of the trapped particles, the geophysical effects and the origin of the Aurora are discussed.

AG42/6 **Properties of the Upper Atmosphere and Their Relation to the Radiation Belts of the Earth.** S.F.SINGER.
AGARDograph 42, 55-65, 16 refs., 1959.
A new theory has been developed and applied which gives the distribution of density with altitude for a planetary exosphere in the absence of thermodynamic equilibrium. The results differ considerably from those calculated on the basis of the hydrostatic equation.

AG42/7 **Measurement of Geomagnetically Trapped Particles of Natural and Artificial Origin.** L.ALLEN, Jr.
AGARDograph 42, 67-82, 3 refs., 1959.
The Air Force sounding rocket programme in connection with the 'Argus' experiment is described briefly. The payload consisted of eight Geiger counters and measurements were made of charged particles trapped in the geomagnetic field. Conclusions are drawn relating to the stability of trapped particles orbits. Some discussions of future planned experiments are given.

AG42/8 **Atmospheric and Magnetic Loss Mechanisms for Geomagnetically Trapped Particles.** J.A.WELCH, Jr.
AGARDograph 42, 83-94, 6 refs., 1959.
A theoretical formulation has been made for the history of an artificial shell of geomagnetically trapped electrons resulting from low-yield nuclear detonations in the exosphere. The formulation considers the spatial distribution of trapped electrons along the magnetic field lines, the drift rate around the world, and the configuration of the resulting shell. Jason rocket data and Explorer IV Satellite data have been compared with the theoretical results.

AG42/9 **The Determination of the Directional Distribution of Charged Particles Trapped in the Magnetic Field of the Earth.** R.D.SHELTON.
AGARDograph 42, 95-111, 8 refs., 1959.
The mathematical system for describing sampling of counters is formulated and applied in particular to Explorer IV. It is seen that the study of directional sampling is essential to a proper interpretation of the data. The basic theorems relating the spatial and directional distributions of the charged particle radiation are applied to a sample of data.

AG42/10 **Solar Flare Protons and Electrons and Their Interaction With the Geomagnetic Field.** J.R.WINCKLER.
AGARDograph 42, 113-138, 15 refs., 1959.
Discusses two types of phenomena which were observed during a series of balloon flights during the IGY. The first has been identified as X-rays arising from electrons present in visible auroral in the vicinity of the high altitude balloon, and the second as low energy cosmic rays generated largely by solar flares.

AG42/11 **Hydromagnetic Theory of Geomagnetic Storms.** A.J.DESSLER, E.N.PARKER.
AGARDograph 42, 139-149, 16 refs., 1959.
Stresses can be set up in the geomagnetic field by plasma from the solar wind. The sudden commencement is generated by the impact of a density increase in the solar wind on the geomagnetic field. The effect of the impact is carried to the Earth's surface by hydromagnetic waves. The hydromagnetic theory described here accounts for the average characteristics of a geomagnetic storm.

AG42/12 **VHF Radio Wave Absorption in Northern Latitudes and Solar Particle Emissions.** H.LEINBACH, C.C.REID.
AGARDograph 42, 151-163, 1959.
This paper is concerned mainly with the properties and an interpretation of absorption event, which probably has its origin in atmospheric ionization caused by protons emitted from the sun at the time of a solar flare. The interpretation of the long duration of the events is discussed, and some estimates of the energy of the protons, and of their number density in interplanetary space are made.

AG42/13 **Travelling Disturbances Originating in the Outer Ionosphere.** K.BIBL, K.RAWER.
AGARDograph 42, 165-174, 11 refs., 1959.
The vertical velocity component of 'travelling disturbances' which come from outside and are propagated through the ionosphere is determined as 115 ±35 m/s. Oscillation-like phenomena have a wide range of quasi-periods, between ¼ and 12 hours.

AG42/14 **On The Interpretation of Very High Aurorae.** A.OMHOLT.
AGARDograph 42, 175-181, 12 refs., 1959.
Summarizes the known facts about aurorae occurring in the upper part of the ionosphere. It is concluded that it is difficult to deduce any precise quantitative information about the upper atmosphere from the available observational data. Some estimates are made of the rates of ionization in the F-region of the ionosphere due to aurorae, and of the density in the beam of primary particles.

AG42/15 **Optical, Electromagnetic and Satellite Observations of High-Altitude Nuclear Detonations: Pt.1.** P.NEWMAN.
AGARDograph 42, 183-200, 18 refs., 1959.
Visual auroras were observed in the detonation area of the Argus tests. In the conjugate area, a brilliant aurora was observed in the third event. The ELF receiver employing loops, obtained strong signals in the second and third events. The frequency was approximately 1 c/s. A sporadic E cloud moving eastward was observed on ionosondes in the vicinity of the Azores shortly after the third detonation.

AG42/16 **Optical, Electromagnetic and Satellite Observations of High-Altitude Nuclear Detonations: Pt.2.** A.M.PETERSON.
AGARDograph 42, 201-209, 11 refs., 1959.
The radio effects of the Argus detonations were measured and the following results obtained: (i) auroral echoes in the vicinity of the launch point after all three shots and near the conjugate point after the first and third shot; (ii) sudden depressions of 6 to 12 db of the signal from England (19.6 Kc/s) observed at Madrid and the Azores; (iii) no ionospheric absorption or radio noise emission at the conjugate location on 30, 60, or 120 Mc/s.

AG42/17 **A Model of the F-Region Above $h_{max}F2$.** J.W.WRIGHT.
AGARDograph 42, 211-221, 14 refs., 1959.
A simple Chapman model (scale height 100 Km) of the ionosphere above the peak of the F-region is found to be in good agreement with the few observed profiles of this region. The model is used in conjunction with electron density profiles observed from the ground to construct meridional cross-sections along the 75 deg.W geographic meridian.

AG42/18 **Incoherent Scattering By Free Electrons as a Technique for Studying the Ionosphere: Some Observations and Theoretical Considerations.** K.L.BOWLES.
AGARDograph 42, 223-241, 15 refs., 1959.
Reports observations which confirm the existence of the incoherent scatter and shows that its intensity is essentially the predicted value. The observed Doppler broadening is considerably smaller than predicted. An explanation for this is offered.

AG42/19 **The Faraday Effect and Satellite Radio Signals Propagated Through the Ionospheres.** W.T.BLACKBAND, B.BURGESS, I.L.JONES, G.J.LAWSON.
AGARDograph 42, 243-262, 8 refs., 1959.
The total ionospheric electron content between the ground and a radio transmitter on an artificial satellite can in certain circumstances be determined from the Faraday fading effects. A theory of the method is presented together with a discussion of the interpretation of fading records. Experimental data are given, and compared with those obtained by other methods.

AG42/20 **Electron Density Beyond the F-Maximum Deduced from Satellite Emission.** E.J.VASSY.
AGARDograph 42, 263-270, 4 refs., 1959.
The method proposed by Alpert, et al., for the determination of this electron density is based upon the investigation of the refraction at the moment of radioelectric 'rise' of 'setting' of an artificial satellite. Alpert assumes an exponential decrease of electron density beyond F-maximum. Restriction of this assumption is suggested due to data provided by Pioneer III.

AG42/21 **High-Latitude Studies of F-Layer and Outer Atmosphere Ionization.** L.OWREN, H.BATES, J.POPE.
AGARDograph 42, 271-284, 7 refs., 1959.
Discusses experimental radio investigations of the F-layer and the outer ionosphere undertaken at the Geophysical Institute, Alaska. They include backscatter sounding at oblique incidence with sweep-frequency ionospheric recorder Doppler-shift measurements of signals from Russian satellites, and observations of nose-whistlers.

AG42/22 **Ionospheric Electron Content From Refraction Measurements on Cosmic Radio Sources.** M.M.KOMESAROFF, C.A.SHAIN.
AGARDograph 42, 285-289, 7 refs., 1959.
A brief description of a measuring technique of the total electron content of the ionosphere (including the upper F-region) is given. A theoretical analysis of the problem takes into account the effects of departures from spherical symmetry.

AG42/23 **Radar Studies of the Cislunar Medium: Pt.1.** V.R.ESHLEMAN, R.C.BARTHLE, P.B.GALLAGHER.
AGARDograph 42, 291-300, 11 refs., 1959.
The ionized medium between the Earth and Moon is being studied at Stanford University by means of lunar radar echoes. Several techniques based upon hf (3-30 Mc) Moon echoes for measuring the total integrated ion density, are described. The ionosphere part may be determined separately and subtracted from the total.

AG42/24 **Radar Studies of the Cislunar Medium: Pt.2.** P.B.GALLAGHER, R.C.BARTHLE, V.R.ESHLEMAN.
AGARDograph 42, 301-312, 1959.
The work described is concerned with properties of the ionized medium beyond the Earth's ionosphere, between the Earth and Moon. Special techniques are available in which the Moon is used as a passive reflector. The theory given describes some of these possible approaches, based upon how the cislunar ionized gases might be expected to interact with HF and VHF radio frequency waves propagated through it.

AG42/25 **Measurements of Ionospheric Electron Content by the Lunar Radio Technique.** S.J.BAUER, F.B.DANIELS.
AGARDograph 42, 313-319, 9 refs., 1959.
Measurements of Faraday rotation of lunar radio echoes are used to determine the time variation in the total ionospheric electron content. Absolute values are determined from measurements in conjunction with information on the electron content below the F2-peak. Diurnal, day-to-day, and seasonal variations in the total electron content are presented.

AG42/26 **Remark Concerning the Charge of a Satellite.** K.RAWER.
AGARDograph 42, 321-322, 1959.
A short note calling attention to the fact that the electric potential of a satellite depends on the ion and electron density found in its orbit, and that observation of this potential should be of interest.

AG42/27 **Hybrid Whistlers and the Problem of the Whistler Paths.** R.A.HELLIWELL.
AGARDograph 42, 323-332, 5 refs., 1959.
The purpose of this paper is to present an experimental test of the 'field-aligned duct' theory of multiple-path whistlers. Use is made of a new kind of whistler – the hybrid – consisting of the superposition of a 'long' and 'short' whistler excited by the same source.

AG42/28 **Low-Frequency Electromagnetic Radiation Associated with Magnetic Disturbances.** G.R.A.ELLIS.
AGARDograph 42, 333-344, 13 refs., 1959.
Discusses the results of continuous observations of the amplitude and spectrum of naturally occurring radiation in the band 2 to 40 Kc/s which were made during the period June to December, 1958 near Sydney, Australia.

AG42/29 **Transparency of the Ionosphere and Possible Noise Signals from High Altitudes at Extremely Low Frequencies.** H.POEVERLEIN.
AGARDograph 42, 345-354, 8 refs., 1959.
Propagation of extremely low frequencies in the ionosphere is studied on the basis of a recently developed wave theory with the inclusion of the effect of ions. Only vertical travelling waves are considered. The ordinary and the extraordinary waves appear separated.

AG43 **Data Handling.** E.D.JOHANN (Editor).
AD-254-470 AGARDograph 43, 600 pp., 91 refs., 1959.
N-95164 Thirty-six papers are included from the Data Handling Meeting of the Avionics Panel, Aachen, Germany, 1959. Abstracts of the individual papers are given in the succeeding items.

AG43/1 **Minitrack.** H.E.CARPENTER, J.J.MADDEN.
AGARDograph 43, 3-27, 1959.
This paper briefly reviews the interferometer concepts, the minitrack system, recording methods and preliminary data reduction accomplished at the individual tracking sites to prepare the data for transmission to the Network Control Centre.

AG43/2 **Space Track.** G.R.MICZAIKA.
AGARDograph 43, 29-33, 1959.
The purpose of Space Track is for tracking artificial satellites and space probes for space surveillance. Data from a variety of sources differ greatly, and its handling presents many problems if fully automatic data handling is desired. The situation is discussed.

AG43/3 **Some Aspects of Data Acquisition and Handling in 'Abie' Space Probes.** J.E.TABER.
AGARDograph 43, 35-43, 1959.
Discusses some of the aspects of the acquisition and handling of data obtained from NASA/AFBMD/STL space probes.

AG43/4 **Tracking and Data Handling for the Pioneer III and Pioneer IV Firings.** M.EIMER, R.STEVENS.
AGARDograph 43, 45-67, 1959.
The data here are analyzed to provide rapid and precise acquisition pointing information for the tracking stations and accurate determination of the vehicle paths.

AG43/5 **The Venus Radar Experiment.** R.PRICE.
AGARDograph 43, 69-86, 14 refs., 1959.
On February 10 and 12, 1958, the Millstone Hill radar site of the Lincoln Laboratory, M.I.T. was employed to obtain echoes from the planet Venus. The paper describes the way the experiment was done. Little has been determined, however, about the physical characteristics of Venus.

AG43/6 **Electronic Computers in Air Traffic Control.** J.F.GATTNARZIK.
AGARDograph 43, 89-93, 1959.
In order to understand the problems connected with the introduction of electric computer installations for the automatic supervision of aircraft traffic, this paper gives a short explanation of the usual type of work performed in an Air traffic control centre.

AG43/7 **An Experimental Automatic Radar Target Detection and Digital Coded Plot Extraction and Transmission System.** G.L.F.HINCKLEY.
AGARDograph 43, 95-110, 1959.
The system uses radar plot data available from two-dimensional search radars. Conversion from polar co-ordinates to Cartesian co-ordinates is effected and the encoded cartesian plot data is transmitted for remote use over long distances using a single telephone circuit. Full radar accuracy, resolution, and data rate are maintained. The remote coded plot data is suitable for decoding and display or for direct insertion into a digital computer.

AG43/8 **A High Speed Data Transmission System for Use Over Telephone Circuits.** A.P.CLARK.
AGARDograph 43, 111-139, 15 refs., 1959.
Discusses a system designed to transmit binary coded information at 750 bits per second over normally available telephone circuits. A typical design is considered for the logical circuits which are associated with signalling equipment and perform operations such as automatic error detection and correction.

AG43/9 **Operational Problem Areas in the Application of Data Processing to Air Traffic Control.** F.M.McDERMOTT.
AGARDograph 43, 141-145, 1959.
Outlines problem areas in the application of data processing to air traffic control. Methods of solving these problems are described in other presentations in this forum. The similarity in approach to the problems taken by different groups throughout the world, attests to the fact that we appear to be on the right track.

AG43/10 **The Present Plans for an Automatic Air Traffic Control Service in The Federal Republic of Germany.** K.HEIDELAUF.
AGARDograph 43, 147-157, 1959.
The workload on human controllers at Frankfurt is given as an example of the problem. This is followed by the system philosophy and objectives of a ten-year semi-automatic air traffic control system, and also a highly sophisticated automatic system.

AG43/11 **Electronic Computers Serving Air Traffic Control.** W.HILDEBRANDT.
AGARDograph 43, 159-170, 1959.
An account is given of research work concerning the automation of air traffic control with special regard to an improved discovery of possible conflict situations.

AG43/12 **The Co-ordinated Synthetic Presentation of Radar Data and Flight Progress Information.** C.D.COLCHESTER.
AGARDograph 43, 171-181, 5 refs., 1959.
Discusses the problem of presenting the information required for air traffic control, showing how this has led to the design of a synthetic plan display and a high speed character generator which are described briefly.

AG43/13 **Air Traffic Control With the Aid of a Bull Electronic Computer.** O.TOPPINO.
AGARDograph 43, 183-189, 1959.
Considers the work carried out in the field of Air Traffic Control by the 'Compagnie des Machines BULL' with a view to arriving at a method of calculation and type of procedure which will give maximum speed and efficiency.

AG43/14 **Semiautomatic Data Processing for U.S. Air Traffic Control – A Transition System.** D.S.KING.
AGARDograph 43, 191-196, 1959.
After describing the steps required in a manual air traffic control system a transitional system is described, in general terms, which uses automatic computers instead of the human operator, high-speed data transfer devices, and mechanical print-out devices.

AG43/15 **The Relation of System Philosophy to Operational and Technical Economics in the Transition and Terminal Area.** V.I.WEIHE.
AGARDograph 43, 197-201, 1959.
Description of the operational characteristics of the transition and terminal system is given. The author has covered in a general way the manner in which the human co-ordination load and the computing load will be shared between enroute control, transition control, and terminal control.

AG43/16 **Planning and In-Flight Control of Air Traffic.** R.F.HANSFORD.
AGARDograph 43, 203-220, 1959.
An outline survey is made of some of the major operational requirements of air traffic control and it is shown how these are strongly dependent on regional differences. It is shown that the air traffic control problem may be considered under the two broad categories of Flight Planning, and Flight Control.

AG43/17 **The Integration of Air Traffic Control and Air Defense.** D.R.ISRAEL.
AGARDograph 43, 221-242, 5 refs., 1959.
Describes the definite steps taken towards the integration of air traffic control with air defence by the Federal Aviation Agency and the United States Air Force.

AG43/18 **Automatic Data Processing in Air Traffic Control.** P.C.HAINES.
AGARDograph 43, 243-262, 1959.
Gives a description of the general approach being made by the United Kingdom to problems of data processing in Air Traffic Control, particular attention being paid to one aspect of this work related to the control of air traffic flying over the North Atlantic ocean. A description is given of a computer which is being designed for experiments in this field, and of the way in which it is intended to use the computer.

AG43/19 **A Digital Instrumentation System Embodying an 'On-Line' Digital Computer.** G.B.COLE, L.AIREY.
AGARDograph 43, 255-287, 8 refs., 1959.
Describes an on-line data handling system in use at the National Gas Turbine Establishment, Ministry of Supply, U.K. and discusses operating experience.

AG43/20 **Automation of Manned Air Vehicle Testing.** A.D.PHILLIPS.
AGARDograph 43, 289-312, 1959.
Deals primarily with the data handling problems associated with the Air Force conducted evaluations on aircraft as differentiated from developmental type testing conducted at the centre by resident contractor organizations.

AG43/21 **A Practical Philosophy of Automatic Data Processing as Applied to Aircraft-Gas-Turbine Component Evaluation.** P.A.VERRETTE.
AGARDograph 43, 313-330, 7 refs., 1959.
Describes the philosophy and the resultant working system in its essentials. Presents a brief discussion of the considerations leading to a philosophy which will meet the demands of increasingly complex component test programmes.

AG43/22 **Centralized Recording and Computation of Propulsion System Research Data.** R.E.TOZIER.
AGARDograph 43, 331-353, 6 refs., 1959.
The characteristic features and advantages of the NACA Lewis Flight Propulsion Laboratory's (now Lewis Research Center) data handling system are described.

AG43/23 **Some Developments in Techniques Related to Data Handling.** L.AIREY.
AGARDograph 43, 355-372, 5 refs., 1959.
Design and experimental work concerning (i) a linear coded digitizer involving moving brush gear, (ii) a high speed mercury switch, and (iii) simple devices to facilitate decoding of binary and binary-coded decimal numbers, is decribed.

AG42/24 **The Design of Data-Handling Systems for Wind Tunnels.** J.K.FRISWELL.
AGARDograph 43, 373-390, 4 refs., 1959.
Outlines some basic considerations affecting the design of digital data-handling systems for wind tunnels, as illustrated by experience with the punch-card systems installed for force and pressure measurement in the 3 x 3 ft and 8 x 8 ft supersonic tunnels at the Royal Aircraft Establishment, Bedford.

AG43/25 **Some Problems Arising From the Automatic Analysis of Dynamometric Measurements in Wind Tunnels.** R.MOREAU.
AGARDograph 43, 391-407, 1959.
Advantages and disadvantages are described of an automatic data processing system for force and moment wind tunnel measurements.

AG43/26 **On-Line Wind Tunnel Data Processing Using a Low Speed, Drum Storage, General Purpose Digital Computer and Suitable Peripheral Equipment.** J.M.LANGLEY, Jr.
AGARDograph 43, 409-422, 1959.
The data processing system currently in use at the Naval Supersonic Laboratory is discussed. The electro-mechanical analogue to digital conversion and recording equipment that produces a perforated raw data tape for computer input is described, as is the development of computer programme controlled digital to analogue conversion equipment that permits the automatic plotting of reduced data.

AG43/27 **The A.W.A. Wind Tunnel Data Handling System.** A.PENDLETON.
AGARDograph 43, 423-438, 3 refs., 1959.
Describes the system developed by Sir W.G.Armstrong Whitworth Aircraft Limited (A.W.A.) for use in their supersonic/transonic wind tunnel for automatically recording on punched paper tape all the data necessary to enable an electronic computer to calculate the aerodynamic coefficients, corrected angle of incidence and yaw, etc.

AG43/28 **Data Handling Practices in the Boeing Airplane Company Wind Tunnel Laboratory.** C.A.SAMSON.
AGARDograph 43, 439-460, 4 refs., 1959.
Present practices are described. Included is a brief description of the facilities involved, the major data systems provided, and a discussion of the economic factors and operating philosophies. Simple strip chart recorders driving analogue-to-digital converters which operate standard card punches are used. Analogue computers are provided for 'quick look', and final data are presented one day later, after processing by a Univac-1103A computer.

AG43/29 **Design Features and Performance of the Chance Vought Aircraft Wind Tunnel Data System.** E.C.VOGT.
AGARDograph 43, 461-478, 1959.
Description of a high speed data system is given. The data system chosen by Chance Vought Aircraft is compatible with the tunnel capabilities and data acquisition requirements. The versatility of the system is reflected in its use for force, pressure and dynamic testing. etc.

AG43/30 **A High Speed Data Handling System for the English Electric G.W. Division Intermittent Wind Tunnel.** E.PATTERSON, D.READSHAW.
AGARDograph 43, 479-491, 1959.
Outlines of the salient features of a high speed data handling system designed to read the analogue information from the force and moment strain gauge balances in a wind maquette model, the model being simultaneously pitched and rolled during the test run. Provision is also made for recording the pitch and roll attitude as measured by digital transducers.

AG43/31 **A System for Handling Wind Tunnel Data.** J.F.M.SCHOLES.
AGARDograph 43, 493-508, 5 refs., 1959.
A general description is given of a data-handling system which has been installed to serve the needs of several large wind tunnels at R.A.E., Bedford. Particular attention is given to the input end of the system and a typical data-recording sub-system is treated in some detail.

AG43/32 **Data Recording System at the Ballistic Research Laboratories Supersonic Wind Tunnels.** J.S.PEDGONAY.
AGARDograph 43, 509-534, 1959.
Described is a data recording system being shared by two continuous flow type wind tunnels which handles eight channels of information and is equipped to plot, indicate, type, punch tape as desired. It is designed to respond to 60 cycle or direct current transducer signals; one channel can be switched to follow accurately rotation of an exterior shaft for such controlled variables as angle of attack, survey rig position, and time.

AG43/33 **An Equipment for Automatically Processing Time-Multiplexed Telemetry Data.** J.H.RUSSELL.
AGARDograph 43, 535-545, 1959.
The requirement for the equipment is outlined and the reasons governing the choice of what is predominantly an analogue system are given. The equipment is described and the performance achieved and the methods of checking the data processing are indicated. The flexibility of the equipment is stressed and the future application of the equipment is discussed.

AG43/34 **Design for Reliability in Data Handling Systems.** A.DAVISON, R.THREADGOLD.
AGARDograph 43, 547-570, 10 refs., 1959.
The paper covers the various factors affecting the reliability of working of Data Handling Systems, and is divided broadly into two parts: one on the use of components in circuit design, and the second, the techniques of system design. Both refer particularly to systems which are mainly electronic.

AG43/35 **Some Practical Aspects of the Design of a Wind Tunnel Data Gathering System.** F.H.FELBERG, R.O.BURNETT.
AGARDograph 43, 571-582, 1959.
Discusses the system presently in use at the laboratory of the Southern California Co-operative wind tunnel, which was designed and is operated by the California Institute of Technology. Emphasis was placed on versatility, reliability, and data accuracy, and very careful attention was given to such matters as grounding and shielding, signal filtering, provision for checks and calibration, and component performance and reliability.

AG43/36 **Wind Tunnel Pressure Measurements Using Automatic Scanning Valves.** M.BAIN.
AGARDograph 43, 583-600, 1959.
Describes recent commercial developments in pressure scanning valves and discusses some of the systems being used in other wind tunnels.

AG44
AD-407-448
N63-17770 **The Use of Analogue Computers in Solving Problems in Flight Mechanics.** F.C.HAUS, J.CZINCZENHEIM, L.MOULIN.
AGARDograph 44, 551 pp., 30 refs., 1960.
The twenty-two Chapters in this publication deal with the equations of motion of an aircraft, principles of analogue calculation and their application to the mechanics of aircraft and aircraft guidance. Individual Chapters are abstracted in the succeeding items.

AG44/1 **Kinematics of the Aeroplane.** F.C.HAUS.
AGARDograph 44, 1-10, 1960.
Deals with reference trihedrals, the relative position of two trihedrals, the position and motion of the aeroplane in space, trihedrals depending on velocity, motions of the atmosphere itself, and angles of attack and sideslip.

AG44/2 **Dynamics of the Aeroplane with a Rigid Structure.** F.C.HAUS.
AGARDograph 44, 11-24, 1960.
Considers the structural deformation and configuration of the aeroplane, external actions (gravity, aerodynamic, and gyroscopic), general equations of motion, control surfaces, velocity and load disturbances, and equations of motion following a steady state.

AG44/3 **Transformation and Solution of the Equations of Motion of a Rigid Aeroplane.** F.C.HAUS.
AGARDograph 44, 25-55, 1960.
Non-dimensional expression of the disturbance velocities; determination of increments $\Delta x \Delta y \ldots\ldots \Delta N$ in the linear case; system of equations written in non-dimensional form; integration of linear systems; transformation formulae; further relations; block-diagrams; Laplace transformation and transfer functions; non-stationary effects; non-linearity and aerodynamic forces in relation to variables; usefulness of analogue computers; establishing of transformation formulae.

AG44/4 **Dynamics of the Non-Rigid Aeroplane.** J.CZINCZENHEIM.
AGARDograph 44, 56-84, 1960.
Discussion of the generalized co-ordinates and equations of motion is followed by the study of (i) motion of a rigid aeroplane with a movable control, and one controlled by an accelerometer, (ii) stability of an aeroplane with a flexible fuselage and (iii) influence of deformations in arbitrary modes. A functional diagram is given which corresponds to a non-rigid aeroplane.

AG44/5 **Principles of Analogue Computation.** L.MOULIN
AGARDograph 44, 85-93, 1960.
A brief discussion of the history of these computers and their drawbacks is followed by elementary operation details (sign inversion, multiplication by a constant factor, integration and summation).

AG44/6 **Solution of Linear Systems of Equations.** L.MOULIN.
AGARDograph 44, 94-99, 1960.
The solution of homogeneous systems of equations without a second member, and also non-homogeneous equations by the use of an analogue computer, is shown. Choice of set-up is briefly indicated.

AG44/7 **Non-Linear Function Generation.** L.MOULIN.
AGARDograph 44, 100-109, 1960.
A system of non-linear differential equations can be solved with an analogue computer provided a calculation block is available delivering an output voltage which varies according to the shape of the non-linear functions which are involved in the equations. It is shown that such blocks are available, and operations which they will perform are outlined.

AG44/8 **Special Features of Analogue Computation.** L.MOULIN.
AGARDograph 44, 110-120, 1960.
Two different methods are discussed for constructing an electric circuit to represent a given transfer function. The first shows an easy way to represent rapidly any given transfer function, while the second requires impedance calculations. Operational restrictions are also discussed.

AG44/9 **Problems in Kinematics.** F.C.HAUS, L.MOULIN.
AGARDograph 44, 121-126, 1960.
Studies the application of the analogue computer to the solution of the main problems related to the kinematics of aircraft motion by using Euler angles and direction cosines.

AG44/10 **Motion of an Aeroplane with Rigid Structure.** J.CZINCZENHEIM, F.C.HAUS.
AGARDograph 44, 127-155, 1960.
Considers linear problems and non-linear problems for use with analogue computers. They include longitudinal and lateral motion, permanent motion considered as helical motion, inertia coupling, aerodynamic non-linearities, and non-stationary aerodynamic actions.

AG44/11 **Motion of a Non-Rigid Aircraft.** J.CZINCZENHEIM.
AGARDograph 44, 156-163, 1960.
Results obtained with an analogue computer show the inertial effects during non-steady phase of the motion, and the loss of aileron efficiency during the steady phase. For an unswept wing, which is the only case covered by the equations, it is found that the non-steady phase depends on respective positions of the centre of torsion, the centre of gravity, and the secondary focus.

AG44/12 **Action of the Controls.** F.C.HAUS.
AGARDograph 44, 164-187, 1960.
Contents: Effort applied by the pilot; different types of controls; generators of 'artificial feel'; imperfections of the controls; response of aircraft to force exerted by the pilot; use of analogue computer – study of longitudinal motion of aircraft flying 'stick-free'; transfer functions of positioning servomechanisms; response of aircraft to pilot action in the case of servocontrols; and the use of the analogue computer.

AG44/13 **Automatic Control.** F.C.HAUS.
AGARDograph 44, 188-235, 1960.
The following are considered: Artificial stability; analogue study for the schematic case; physical action of elementary control equations; positioning of servocontrols and control inverting integration; analogue study of real cases; application to motion and automatic pilotage; partial simulation; use of manual control when auto-pilot is in action; aircraft response to human pilot; guidance following an alignment; auto control of flare-out; aircraft equipped with a gust damper.

AG44/14 **A Case of Aeroplane Guidance, as an Example of Analogue Computer Utilization: General Discussion.** F.C.HAUS.
AGARDograph 44, 325-327, 1960.
This is an introductory chapter to the eight following papers by the author dealing with the problem of guiding an aircraft during the approach stage of its landing.

AG44/15 **Equations of Motion of the Aeroplane.** F.C.HAUS.
AGARDograph 44, 328-334, 1960.
After the equations of motion have been written and simplified, the mechanical and aerodynamic characteristics of a 48,000 kg aircraft are considered for its flight in the approach phase.

AG44/16 **Automatic Guidance.** F.C.HAUS.
AGARDograph 44, 335-341, 1960.
Control equations consistent with the aeroplane flying along the line of intersection of the localizer and glide path planes are discussed, together with a criticism of these simplified equations. Some general remarks are made on the behaviour of the aeroplane flying with controls fixed, and elementary and generalized artificial stability. The calculations are for use with an analogue computer.

AG44/17 **Lateral Behaviour of the Aeroplane.** F.C.HAUS.
AGARDograph 44, 342-349, 1960.
Deals with the stability of an aircraft during the approach phase. Control problems investigated are: stabilization of a motion dependent on a fourth degree characteristic regardless of the aeroplane's course; stabilization of the course direction as determined by the fifth-order differential system; and the control of the aircraft along a path fixed in position and direction using a sixth-order differential system.

AG44/18 **Guidance in the Localizer Plane.** F.C.HAUS.
AGARDograph 44, 351-359, 1960.
For these approach problems only an analogue computer can be used. The contents of this chapter include: Control subjected to three error signals; a detail discussion of certain combinations; initial displacement of ψ; effect of a side gust; and a comparison with American research.

AG44/19 **Remarks on Lateral Motion.** F.C.HAUS.
AGARDograph 44, 360-364, 1960.
It is shown that the analogue computer permits a very precise study of lateral control, and that the introduction of servomechanisms opens up the field to new researches in the study of automatic approach.

AG44/20 **Longitudinal Behaviour of the Aeroplane.** F.C.HAUS.
AGARDograph 44, 365-371, 1960.
Considers stability with controls fixed; response to a step function; frequency response; different degrees of stability, long-period oscillation; and damping.

AG44/21 **Maintenance of the Glide Path.** F.C.HAUS.
AGARDograph 44, 372-384, 1960.
Use of the analogue computer is made in finding the combinations which lead to satisfactory holding of the required trajectory. Included are basic and complex conditions, power control, deflections, entering the glide path, and gusts.

AG44/22 **Remarks on the Longitudinal Motion.** F.C.HAUS.
AGARDograph 44, 385-393, 1960.
The possibilities offered by the analogue computer are clearly shown by this study of longitudinal control. The minimum requirements stated are (i) enough stability for the high gain case, in order to secure some margin of safety if the auto-pilot is switched off later than foreseen; and (ii) sufficient effectiveness for the low gain case. The proposed equations do not give adequate effectiveness in the latter case.

AG45 **Operations from Unprepared and Semi-Prepared Airfields.** G.BOCK (Editor).
AD-255-177 AGARDograph 45, 99pp., 60 refs., 1960.
N-95691 Discusses: classification and stabilization of unprepared landing areas; surface characteristics, vegetation and obstacles; design criteria for landing gears for unprepared surfaces, experience with such gears; a classification of aircraft suitable for use on unprepared airfields.

AG46 **Symposium on Vertical/Short Take-Off and Landing Aircraft. Parts 1 and 2.**
AD-255-178 AGARDograph 46, 621 pp., 179 refs., 1960.
N-95703 In compiling these proceedings, the aim was to present the contributions to the symposium in as
AD-255-179 complete a form as possible. All scheduled presentations and prepared comments have been
N-95703 included except where the material was of a classified nature; some of the non-scheduled contributions or comments have had to be condensed. The AGARDograph is presented in two separately bound parts; Pt. 1 includes papers relating to general studies and aerodynamic aspects, and engine configurations and engine installations, while Pt. 2 gives papers on ground proximity effects, safety and reliability, and flying qualities and vulnerability. Abstracts of the principal papers and prepared comments are given in the succeeding items.

AG46/1/1 **Capabilities and Costs of Various Types of VTOL Aircraft.** M.O.McKINNEY.
AGARDograph 46, Pt.1, 1-32, 1960.
The capabilities of various types of VTOL aircraft (particularly fighter-bomber aircraft and cargo transports) are discussed, and the mission areas for which they are most suitable are indicated. Capabilities are expressed in terms of: (i) ratio of useful load to gross weight, (ii) range, (iii) maximum and cruising speeds. The cost of various types of VTOL's in terms of size and/or number of vehicles, maintenance and operating expense are then considered.

AG46/1/2 **Evaluation of V/STOL Aircraft.** R.H.MILLER.
AGARDograph 46, Pt.1, 33-36, 1960.
A report of the work and findings of an Ad Hoc Group, formed at the request of the Director of Defence Research and Engineering, to study the state of the art in V/STOL aircraft in order to determine the requirements of the Military Departments, to find areas of similarity, and to recommend a research and development programme. The Group's conclusions and recommendations are given.

AG46/1/3 **Generalized Weight and Performance Studies on V/STOL Low-Level Strike Fighter Aircraft.** J.M.H. van VLAENDEREN.
AGARDograph 46, Pt.1, 37-54, 1960.
Calculations were made of the take-off (TO) distance over 50 ft of STOL strike-fighter aircraft for several values of thrust-weight ratio, unstick speed and thrust deflection angle. The minimum TO distance was plotted against the aircraft static thrust-weight ratio. The all-up weight for a given fixed weight was estimated as a function of TO distance and range for STOL aircraft, and as a function of range for VTOL aircraft.

AG46/1/4 **Operating Economics of VTOL and STOL Transport Aircraft.** A.W.R.GILCHRIST.
AGARDograph 46, Pt.1, 55-70, 1960.
A comparison is presented of the cost per ton-mile of a propeller-lift type VTOL transport, a turbine-engined transport helicopter, a pure STOL transport, and a conventional transport aircraft. The cost figures for the VTOL design when operated with a running take-off with an overload are also shown. Costs are given as a function of operating range.

AG46/1/5 **Parametric Investigation on 'STOL' Aircraft.** G.GABRIELLI.
AGARDograph 46, Pt.1, 71-140, 6 refs., 1960.
This parametric study consists of an evaluation of the minimum take-off and landing lengths as affected by some parameters (wing loading, maximum lift coefficient, engine thrust to aircraft A.U.W. ratio, thrust deflection angle) for a jet-propelled STOL aircraft capable of complying with any other requirement of G.O.R.2 (including mission profile, military loads, etc.). Aircraft with geometrically similar wings, and with two different propulsion systems are considered.

AG46/1/6 **The STOL Experimental Aircraft, Do 29.** S.DORNIER.
AGARDograph 46, Pt.1, 141-148, 1960.
Aerodynamic results which had an important bearing on the design of the Do 29 are first summarized. The following aspects of the Do 29 (a STOL aircraft with two pusher propellers behind the wing which can be tilted 90 deg. downwards) are then described: design characteristics, power plant tests, flight testing.

AG46/1/7 **Aerodynamic Aspects of Some Basic VTOL/STOL Systems.** J.WILLIAMS.
AGARDograph 46, Pt.1, 149-203, 67 refs., 1960.
The present state of knowledge on the aerodynamics of the following types of V/STOL systems is considered: direct jet lift (turbo-jet and turbo-fan), propeller lift (tilt wing and deflected slipstream), jet flaps, boundary layer control (blowing and suction).

AG46/1/8 **Prepared Comment on General Studies.** F.O'HARA.
AGARDograph 46, Pt.1, 205-206, 1960.
Brief comments are made on the preceding six papers dealing with the overall feasibility of V/STOL for operational application. The comments concern: the scope of the presentations made, the reliability of the estimates and comparisons given, and some of the implications.

AG46/1/9 **Comment on 'Capabilities and Cost of Various Types of VTOL Aircraft'.** (In French.) L.MINOR.
AGARDograph 46, Pt.1, 207-208, 1960.
The principal criticisms of the paper by M.O.McKinney are (i) that VTOL aircraft are not considered as an entirely separate category of vehicles but as modifications of STOL and even conventional aircraft, and (ii) the arbitrary character of the examples chosen.

AG46/1/10 **Contribution to the Question 'Short Take-Off or Vertical Take-Off'.** (In French.) G.EGGERS.
AGARDograph 46, Pt.1, 209-213, 1960.
The desirability of a VTO or STO capability is considered for fighter aircraft which is required to operate at a low altitude and at a high subsonic speed; the principal parameters considered are: the aerodynamic conception; the choice of powerplant; the thrust requirement.

AG46/1/11 **Comment on the Paper by M.O.MacKinney.** (In French.) R.DUMEZ.
AGARDograph 46, Pt.1, 215-217, 1960.
MacKinney in the first part of his paper presented a comparison of types of V and STOL strike aircraft, the basis of comparison being radius of action and weight. Here the proportion of the total thrust of the power plant that is usable in the normal aerodynamic flight of the aircraft is considered.

AG46/1/12 **On the Use of Jet Thrust for the Lift of STOL Aircraft.** (In French.) P.POISSON-QUINTON.
AGARDograph 46, Pt.1, 219-231. 2 refs., 1960.
Experimental studies carried out by O.N.E.R.A. in the Cannes wind tunnel are reported. After a study of the basic phenomena of two-dimensional flow, experiments were carried out on models of high-speed swept-wing aircraft. The results of these studies, out of ground effect, are presented and discussed.

AG46/1/13 **Possibilities and Problems of the Tilt Wing VTOL Aircraft.** W.Z.STEPNIEWSKI.
AGARDograph 46, Pt.1, 233-241, 4 refs., 1960.
The possibilities and problems of tilt-wing VTOL aircraft are indicated in the light of numerous design studies of operational machines and almost three years of actual flight test experience accumulated with VZ-2 (Vertol 76) flight research aircraft.

AG46/1/14 **Contribution to the Discussion of General Studies.** J.W.FOZARD.
AGARDograph 46, Pt.1, 242-244, 1960.
Work at Hawker Aircraft, Ltd. on V/STOL tactical strike aircraft is described with special reference to the P.1127 fitted with a large high-bypass ratio ducted fan motor with swivelling nozzles.

AG46/1/15 **Comments on 'Capabilities and Costs of Various Types of VTOL Aircraft' and on 'Supersonic Engines with Reference to V/STOL Aircraft'.** W.O.W.CHALLIER.
AGARDograph 46, Pt.1, 245-246, 1960.
The comments made relate to (i) the statement by M.O.MacKinney that the use of turbofan (or by-pass) engines for propulsion would greatly reduce the specific fuel consumption and the development of special light-weight lift engines would offer further substantial gains in performance; (ii) the effect of the simplifying assumptions made in Gosslau's paper.

AG46/1/16 **The Breguet STOL Aircraft.** (In French.) M.CZINCZENHEIM.
AGARDograph 46, Pt.1, 247-249, 1960.
Information is given relating to the design of STOL transport aircraft, based on the results obtained by the Breguet Co., after several years of study and two years of flight tests with the Breguet 940 Integral (an experimental STOL weighing 7 tons).

AG46/1/17 **The Hurel-Bertin HB-11 Convertible Aircraft.** (In French.) M.TAUREL.
AGARDograph 46, Pt.1, 251-253, 1960.
The HB-11 is a fan-in-wing aircraft which is powered by a Bristol Orpheus BOR 12 turbojet engine; in cruising-flight the aircraft functions as a conventional jet-propelled aircraft. Aerodynamic problems encountered in the development of this aircraft, and their solution, are described.

AG46/1/18 **The Doak Model 16 Aircraft.** N.E.NELSON.
AGARDograph 46, Pt.1, 255-256, 1960.
The Doak Model 16 tilting ducted fan aircraft is briefly described. The advantages of the ducted fan VTOL are indicated. Mention is also made of the design criteria for VTOL landing gear, and the desirability of automatic control and stabilization equipment being installed in such aircraft.

AG46/1/19 **Engine and Lifting Unit Configurations.** A.R.HOWELL.
AGARDograph 46, Pt.1, 257-288, 29 refs., 1960.
A general survey of engine configurations and lifting units suitable for V/STOL's employing jet lift, fan lift, tilting wing, deflected slipstream, and high lift systems including the jet flap. The merits of independent and combined lift and propulsion systems are discussed. The suitability of the ducted fan is emphasized.

AG46/1/20 **Supersonic Engines with Reference to Short and /ertical Take-Off of a Single-Seat Fighter.** F.GOSSLAU.
AGARDograph 46, Pt.1, 289-305, 1960.
This paper is concerned with the effect of specific engine weight on the development of V/STOL aircraft, rather than with the powerplants themselves. It is shown that the powerplant requirements for high altitude supersonic flight are compatible with VTOL requirements.

AG46/1/21 **Contribution Made During Discussion of 'Engine Configurations and Engine Installations'.** J.FLETCHER.
AGARDograph 46, Pt.1, 307-308, 1960.
It is pointed out that in Howell's paper insufficient attention has been paid to the problem of the total installed weight of the lifting power units. The need for further research into intake and exit design in order to decrease this factor is stressed.

AG46/1/22 **Comparison of Different Ways of Grouping Engines.** (In French.) W.SEIBOLD.
AGARDograph 46, Pt.1, 309-314, 1960.
A comparison is made of the various ways of positioning the power-units in a single-seat aircraft that is capable of vertical take-off and landing and of flying at a high subsonic speed at low altitude. The comparison is limited to those configurations in which the propulsive jet is directly applied (i.e. it excludes ducted fan types).

AG46/1/23 **Ejectors (Trompes) Applied to Vertical Flight.** (In French.) J.BERTIN.
AGARDograph 46, Pt.1, 315-323, 1960.
The application of ejectors for lifting and control purposes in flying platforms and V/STOL aircraft, and when incorporated in a wing structure, is considered. One important advantage obtained from the use of these ejectors is the dilution and dispersion of the direct lift jet, and consequ it lessening of the damage due to vibrations and interactions when these vehicles are operated ry close to the ground.

AG46/1/24 **Note on the Thrust Response Rates of Jet Lift Engines.** G.L.WILDE.
AGARDograph 46, Pt.1, 325-328, 1960.
Three methods for effecting control of an aircraft supported by jet lift or fan lift engines are described. The thrust response rates of various sizes of jet engines to throttle movement are then discussed, as this response rate will affect critically the safe operation of the aircraft.

AG46/1/25 **Adaptation of Existing Engines for Vertical Take-Off.** (In French.) M.ERNST.
AGARDograph 46, Pt.1, 329-330, 3 refs., 1960.
The following problems associated with adapting existing turbo-jet engines for VTOL applications are discussed: intake of air; vertical operation; safety regulations; restriction of air-flow (for control purposes); jet deflection; special test rigs. The paper is based on experience gained with S.N.E.C.M.A.

AG46/1/26 **Introduction to the S.N.E.C.M.A. JTF-10 Engine.** (In French.) S.BOUDIGUES.
AGARDograph 46, Pt.1, 331-334, 1960.
Brief descriptions, and performance details are given of three versions of the Pratt & Whitney JTF-10 engine which has been adapted by S.N.E.C.M.A. to meet their requirements; the three versions are (i) the basic turbo-jet engine, (ii) the turbine with heated secondary gas flow, and (iii) the turbine with heated secondary flow and reheat of the primary flow. The engine has a wide field of application including V/STOL.

AG46/1/27 **Summary of Comments on the General Electric Lift Fan.** A.P.ADAMSON.
AGARDograph 46, Pt.1, 335, 1960.
A very brief description is given of the G.E. lift fan arrangement which consists of a combination of a turbo-jet gas generator and a tip turbine-driven lift fan. The arrangement may be used for a wide variety of VTOL aircraft ranging from transports to supersonic interceptors.

AG46/1/28 **Comments on the Paper 'Engine and Lifting Unit Configurations'.** H.PEARSON.
AGARDograph 46, Pt.1, 337-338, 1960.
Additional remarks, rather than criticisms, are made to the paper by Howell concerning engine configurations and lifting units suitable for V/STOL aircraft. It is suggested, inter alia, that when jet engines of very low weight are considered, fan engines will not be of such comparable low weight.

AG46/1/29 **Comments on the BE 53 Engine.** S.HOOKER.
AGARDograph 46, Pt.1, 339-340, 1960.
The Bristol Siddeley BE 53 ducted fan by-pass engine, as used in the Hawker Aircraft P.1127 VTOL single-engined strike aircraft, is briefly described. The advantages of ducted fan engines for VTOL applications are discussed.

AG46/1/30 **Comments on Engine Configurations and Engine Installations.** J.A.O'MALLEY, Jr.
AGARDograph 46, Pt.1, 341-354, 1960.
The optimum characteristics desirable in VTOL powerplants are discussed with reference to knowledge gained through research at Bell Aircraft Corp. The importance of the mission-capability of the aircraft in assessing its powerplant requirements, is stressed.

AG46/2/1 **Terrain for Landing or Take-Off of V/STOL Aircraft.** (In French.) J.P.VESIGOT, E.GIRE.
AGARDograph 46, Pt.2, 355-370, 1960.
A report of experimental investigation into the effects of jet streams (from V/STOL aircraft) on the following types of landing surface: existing runways; entirely natural terrain; partly protected terrain; specially constructed surfaces.

AG46/2/2 **Flow Phenomena Experienced with VTOL Aircraft in Ground Proximity.** J.A.O'MALLEY, Jr.
AGARDograph 46, Pt.2, 371-408, 22 refs., 1960.
Summarizes experimental data from two U.S. research programmes into the nature of the induced flow fields developed by lifting jets impinging on the ground surface during take-off. Deals mainly with the aerodynamic effects of the secondary flow fields, but also considers the interrelationships with jet temperature effects on the thrusting engine.

AG46/2/3 **Ground Interference Effects with Jet Lift V/STOL Aircraft.** J.FLETCHER.
AGARDograph 46, Pt.2, 409, 1960.
A classified paper; an abstract only is given. Some results of research into ground interference effects (e.g. changes of total lift, and the effect of ground erosion and debris, the effects of jet efflux recirculation) are presented with special reference to the SC.1. Schemes for minimizing ground interference effects are briefly indicated.

AG46/2/4 **Comments on the AGARDograph 'Operations from Unprepared and Semi-Prepared Airfields'.** G.BOCK.
AGARDograph 46, Pt.2, 411-413, 1960.
Reference is made to an AGARDograph in preparation dealing with the take-off and landing of conventional aircraft from unprepared and semi-prepared airfields. Pt.1 comprises 'unprepared landing areas, their classification and temporary stabilization'; in Pt.2, the design of landing gears for operation under such conditions is treated.

AG46/2/5 **Comments on Ground Proximity Effects.** J.G.McHUGH.
AGARDograph 46, Pt.2, 415-416, 1960.
The U.S. Army's downwash impingement study (relating to helicopters and VTOL aircraft) is briefly described. A truck-mounted mobile test apparatus capable of operating a 5 ft diameter open propeller or a 2 ft ducted propeller is used in the experimental investigations. The first phase of the test programme (dealing with the determination of the flow field) is near completion.

AG46/2/6 **Contribution to Discussion on Ground Interference Effects with Jet Lift Aircraft.** F.B.GREATREX.
AGARDograph 46, Pt.2, 417-418, 1960.
It is stressed that ground erosion in itself is not a problem; what is important is whether erosion harms the aircraft or engines. Two take-off techniques suitable for take-off from unprepared ground are briefly described; one of these has been used with the Meteor and the SC.1.

AG46/2/7 **Simulated VTOL Exhaust Impingement on Ground Surfaces.** C.A.GROTZ.
AGARDograph 46, Pt.2, 419-426, 1960.
Describes a test programme carried out by Boeing Airplane Co. to: (i) investigate the ground surface environment which might result from various types of engines used to provide lift during the vertical mode of flight; (ii) test various types of natural ground surface materials such as sand, gravel, and sod; (iii) evaluate synthetic materials that might be used to cover the ground plane and prevent debris being thrown into the air.

AG46/2/8 **Effect of Ground Proximity on the Aerodynamic Characteristics of V/STOL Aircraft Using Jets.** (In French). P.POISSON-QUINTON.
AGARDograph 46, Pt.2, 427-435, 4 refs., 1960.
Two examples are given of the unfavorable effects of ground proximity on STOL configurations fitted with blown flaps; a brief summary is then presented of a preliminary study of a GETOL configuration using the 'platform' effect for take-off and landing.

AG46/2/9 **Contribution to the Discussion on Ground Proximity Effects.** R.S.HOOPER.
AGARDograph 46, Pt.2, 437-439, 1960.
Experience gained on such effects during the development of the Hawker P.1127 VTOL aircraft is summarized. Factors discussed include: free-air lift loss of the hovering aircraft due to its immer-

sion in its own induced down-flow; adverse heating effects; debris ingestion and transient effects. The way these adverse effects have been circumvented is described.

AG46/2/10 **Preliminary Tests on the Ground Proximity Effect on the Lifting Thrust of Reaction Jets for a Particular Configuration.** (In French.) M.BURET.
AGARDograph 46, Pt.2, 441-451, 1960.
This note concerns tests on models of a V/STOL configuration using a single Bristol BE 53 engine ejecting through four rotable nozzles; the object was to evaluate, to a first approximation, the effect of the pressure due to the impact on the ground of these four lifting jets. Two sets of tests were carried out, one in a fixed rig, and the other in a wind tunnel.

AG46/2/11 **The Safety and Reliability of V/STOL Aircraft-Engines, Autostabilizers and Associated Equipment.** D.LEAN, T.F.HARLE.
AGARDograph 46, Pt.2, 453-477, 6 refs., 1960.
Deals with some of the problems to be faced in obtaining an acceptable level of safety and reliability (without defining this level). Three main aspects are considered: powerplant; systems and equipment (particularly those peculiar to V/STOL, autostabilizers, fault detection); operation.

AG46/2/12 **Some Dynamic Problems of Light-Weight Propeller Blades.** J.R.RICHARDSON.
AGARDograph 46, Pt.2, 479-486, 6 refs., 1960.
The design parameters of ground resonance and stall flutter are examined from the view-point of their importance in the design of light-weight propeller blades for VTOL's. The effect of blade configuration is also examined.

AG46/2/13 **Some Considerations on Airworthiness Requirements for the Landing Gear of Tilt-Wing V/STOL Aircraft.** S.BERNSTEIN.
AGARDograph 46, Pt.2, 487-498, 1960.
The design criteria for VTOL landing gear are considered with reference to small propeller-lift configurations. The unique feature is the requirement to absorb energy under emergency descent after engine failure in hovering or low-speed forward flight.

AG46/2/14 **Comments on the Paper 'The Safety and Reliability of V/STOL Aircraft Engines, Aircraft Engines and Associated Equipment'.** (In French.) L.MINOR.
AGARDograph 46, Pt.2, 499-503, 1960.
The probability of failure and the reliability of configurations employing a single engine and those having multiple powerplants are discussed. General criteria of safety applicable to conventional and V/STOL aircraft are then given.

AG46/2/15 **Influence of the Number of Engines on Safety.** (In French.) W.SEIBOLD.
AGARDograph 46, Pt.2, 505-508, 1960.
Considers the effect of the number of engines on the safety of a high-speed aircraft flying at low altitude and landing vertically. It is shown that, for the mission considered, two engines give the greatest probability of safety if the configuration is such that the aircraft can land vertically with one engine not functioning.

AG46/2/16 **Comment on Safety and Reliability Problems.** R.BEAR.
AGARDograph 46, Pt.2, 509-510, 1960.
Factors having a bearing on the safety and reliability of a single-seat strike VTOL aircraft which are discussed include attaining an engine of the required specific weight (0.06 to 0.08); the degree of reliability and safety of a number of small engines; liability of small engines to failure; cost of the overall aircraft programme, taking into account the utilization of the vehicle. An engine qualification test is recommended.

AG46/2/17 **Handling Qualities Criteria for V/STOL Aircraft.** S.B.ANDERSON.
AGARDograph 46, Pt.2, 511-531, 23 refs., 1960.
A recent NASA study was undertaken to determine the modifications and additions necessary to the stability requirements of conventional aircraft and helicopters, in order to make them suitable for V/STOL. The flight experience and reasoning, and the research leading to these special requirements are discussed.

AG46/2/18 **Stabilization in Vertical Flight of VTOL Aircraft.** (In French.) G.ERNST, J.JARDINIER.
AGARDograph 46, Pt.2, 533-549, 5 refs., 1960.
Piloting problems raised by VTO aircraft at low speeds, and their solution; the need for angular stability, and methods of achieving it; choice of a contemplated stabilizing system, and its handling safety; control instruments for piloting VTO aircraft.

AG46/2/19 **Blind Flying of V/STOL Aircraft with Particular Reference to Take-Off and Landing.** J.K.B.ILLINGWORTH, J.S.SHAYLER.
AGARDograph 46, Pt.2, 551-573, 2 refs., 1960.
The flight régimes in which the instrumentation and guidance requirements of V/STOL aircraft differ from those of conventional aircraft are considered, together with stability and control requirements for these régimes. Blind take-off is briefly discussed, and blind landing treated in more detail. For blind approach, methods are discussed for providing a co-ordinate system to locate accurately the aircraft and to provide the necessary guidance relative to the selected approach path.

AG46/2/20 **Studies on Survivability of Aircraft and the Effect of the Results on Aircraft Design.** W.S.GEDDES.
AGARDograph 46, Pt.2, 575, 1960.
A classified paper; an abstract only is given. Some resolutions from a continuing study to establish quantitative measures of the vulnerability of aircraft to fire from ground-based weapons are presented. The variables considered include size and type of aircraft, type of weapon and detection system, altitude speed, manoeuvre, etc. The object is to guide the formulation of future aircraft requirements.

AG46/2/21 **Prepared Comment on V/STOL Blind Flying with Particular Reference to Take-Off and Landing.** R.BIGNAMINI.
AGARDograph 46, Pt.2, 577-578, 1960.
Agreement is expressed with the main points of the paper of Illingworth and Shayler concerning blind landing. The presentation of altitude and position information is briefly mentioned, and the military requirements for a guidance system are listed.

AG46/2/22 **Studies on The Transition of VTOL Aircraft.** S.GÜNTER.
AGARDograph 46, Pt.2, 579-589, 1960.
A formula for the admissible $W/(SC_L)$ for short take-off over a given obstacle is first established. Flight paths of the take-off transition at constant altitude of the aircraft and constant speed of turning the engines are then given for aircraft with various jet engine combinations of rotatable and fixed engines. Parabolic and straight flight paths at low excess thrust are shown. Finally the landing transition with a horizontal approach flight is investigated.

AG46/2/23 **Comments on the Landing Technique used by S.N.E.C.M.A.** (In French.) M.DUMEZ.
AGARDograph 46, Pt.2, 591-593, 1960.
Describes the landing technique developed by S.N.E.C.M.A. on the following machines: ATAR Volants C.400 P.1, C.400 P.2, C.400 P.3 and the C.450 aircraft. The technique comprises stabilizing the machine at an altitude of about 0.4 m and cutting the thrust at the moment when the pilot judges the vertical and horizontal speeds to be zero.

AG46/2/24 **Comments Regarding Flying Qualities.** J.A.O'MALLEY, Jr.
AGARDograph 46, Pt.2, 595-602, 1960.
A review of work carried out at the Bell Aircraft Corp. on VTOL flying qualities, which included a theoretical study on stability and control, and experimental investigations of control functions using an Air Test Vehicle and aircraft, including the X-14.

AG46/2/25 **Comment on Autostabilizers.** H.G.CONWAY.
AGARDograph 46, Pt.2, 603-604, 1960.
In commenting on the need for stabilization on operational VTOL a brief specification is given for an automatic landing system; the guidance elements and the control elements are described. Comment is also made on the subject of auto-pilot authority, with reference to the SC 1.

AG46/2/26 **Notes on Control Power Requirements and Thrust Allowances of Jet Lift VTOL Transports.** P.L.SUTCLIFFE.
AGARDograph 46, Pt.2, 605-606, 1960.
A report of recent studies at Hawker Siddeley Aviation in which some of the controllability requirements and thrust allowances for jet-lift VTOL transports were determined. The aircraft considered was a high-winged transport provided with VTO capabilities by a bank of small lightweight lift engines on each wing.

AG46/2/27 **Adaptive Flight Control for V/STOL's.** W.N.LUNDAHL.
AGARDograph 46, Pt.2, 607-613, 1960.
Discusses: automatic control requirements, the fundamentals of the MH (Minneapolis, Honeywell) adaptive control, blending of aerodynamic and reaction controls, mechanization of pitch axis to provide the functions of pitch damping and pitch attitude control, and adaptive redundancy.

AG46/2/28 **Non-Technical Comments.** R.COCHRANE.
AGARDograph 46, Pt.2, 615-616, 1960.
In these brief comments on the symposium on V/STOL Aircraft it is pointed out that the conference has done much to clarify the requirements for military V/STOL aircraft both for strike fighters and tactical transports.

AG46/2/29 **Summary of the V/STOL Symposium.** A.J.MARX.
AGARDograph 46, Pt.2, 617-621, 1960.
In this brief summary, the penalties incurred by the incorporation of the V/STOL capability are first discussed. The various factors treated in the symposium papers which affect the formulation of the requirements of V/STOL strike and transport aircraft are then briefly reviewed.

AG47 **Gas Sampling and Chemical Analysis in Combustion Processes.** G.TINÉ.
AD-256-972 AGARDograph 47, 94 pp., 127 refs., 1961.
N-97040 A review of the experimental technique as applied to combustion phenomena of interest in aeronautics. The procedures described and the comments on them are based on visits by the author to thirty laboratories in several NATO countries.

AG48 **Bio-Assay Techniques for Human Centrifuges and Physiological Effects of Acceleration.**
AB-261-880 P.BERGERET (Editor).
N64-13451 AGARDograph 48, 176 pp., 1961.
A collection of monographs discussing various aspects in the study of the human centrifuge and the physiological effects of acceleration. Abstracts of the individual papers are given in the succeeding items.

AG48/1 **The Human Centrifuge and its Application to Pilot Selection.** S.RUFF.
AGARDograph 48, 1-13, 3 refs., 1961.
A short survey is given of the special technical devices of the human centrifuge constructed for the Institute für Flugmedizin der Deutschen Versuchsanstalt für Luftfahrt. The use of the centrifuge as a selection instrument is then considered.

AG48/2 **Some Recent Definitions of the Acceleration Problem.** W.R.FRANKS.
AGARDograph 48, 14-22, 23 refs., 1961.
Accumulated experience with accelerations, and means of protection against these, have served to define more closely some of the limiting factors concerned with this variant of modern man's environment. It is pointed out that as individuals vary in this respect, there is still room for selection and training for specialized assignments.

AG48/3 **A Review of the Physiological Effects of Angular Accelerations.** W.H.JOHNSON, N.B.G.TAYLOR.
AGARDograph 48, 23-34, 8 refs., 1961.
The known and possible physiological effects of angular accelerations are reviewed in relation to the production of motion-sickness, spatial disorientation and 'blackout' by centrifugal acceleration. The characteristic accelerations of physiological significance produced by swings, turntables, centrifuges and linear vertical accelerators are described. A preliminary report is given of some recent experiments on cats to clarify the function of the utricle and saccule.

AG48/4 **Human Tolerance and Limitations to Acceleration.** R.N.HEADLEY.
AGARDograph 48, 35-41, 8 refs., 1961.
Human tolerance and limitation to some of the accelerations anticipated in manned space travel are discussed. The need for increased knowledge of the physiological and psychological sequence of events occurring during these accelerations is stressed.

AG48/5 **Instrumentation and The Human Centrifuge.** G.H.BYFORD.
AGARDograph 48, 42-51, 7 refs., 1961.
The forces producing the acceleration are defined, and the experimental conditions are specified. The following instrumentation techniques are reviewed: closed circuit television, electroencephalography, blood tests, magnetic band measurements, and computers. The mathematical analysis of the results is also described.

AG48/6 **Centrifuge Methods and Techniques in the U.S. Navy.** F.K.SMITH.
AGARDograph 48, 52-58, 6 refs., 1961.
Characteristics of the N.A.D.C. (Johnsonville, Pa.) centrifuge when used as a flight simulator; terminology; testing, mounting, and means of restraint; physiological measurements; performance evaluation.

AG48/7 **End Points for Acceleration Tolerances on the Centrifuge.** M.G.WEBB.
AGARDograph 48, 59-64, 16 refs., 1961.
It is emphasized that the ultimate purpose of those working in the field of acceleration studies is to be able to test on the centrifuge the ability of man to perform his total task in his total environment.

AG48/8 **A Discussion on Restraint and Protection of the Human Experiencing the Smooth and Oscillating Accelerations of Proposed Space Vehicles.** C.C.CLARK, R.F.GRAY.
AGARDograph 48, 65-95, 8 refs., 1961.
It is postulated that it is not the forces resulting from acceleration that are harmful to man, but the asymmetrical reactions on the body resulting from the lack of equilibrium in the action of these forces. With adequate external protection, the tolerance of human subjects depends mainly on the effects of local compression or expansion on the tissues, rather than on the results of displacements or distortion of tissues and organs.

AG48/9 **The Effects of Forward Acceleration on Respiration.** W.G.BLANCHARD.
AGARDograph 48, 96-100, 3 refs., 1961.
Various aspects of the respiratory abnormalities caused by headward and transverse acceleration have been studied. Quantitative measurements were made of the degree of respiratory impairment, and a radiographic study made of the abnormal intrathoracic organ relationship. The results are presented and discussed.

AG48/10 **The Physiological Effects of Acceleration on Respiration and Protective Measures.** A.S.HYDE.
AGARDograph 48, 101-106, 11 refs., 1961.
Recent, current and near-future experiments defining respiratory physiology during forward acceleration are reviewed. Areas where more work is required are indicated. It is emphasized that a rational, orderly, continuing research programme is necessary for the amelioration of the respiratory effects of acceleration.

AG48/11 **Effects of Repeated Positive Accelerations of Weak Intensity and Long Duration. Anatomical Study of a Dog's Kidney.** (In French.) R.SENELAR, R.LOUBIÈRE, F.VIOLETTE.
AGARDograph 48, 107-118, 17 refs., 1961.
Repeated exposures of dogs to an acceleration of 2 to 5 g per day, up to a total of 10 to 60 hr produced macroscopic and microscopic injuries in the kidneys (venous and capillary congestion, glomerular congestion and tubular vacuolization, with infiltration of iron ochre pigment from the blood). Three months later an invading sclerosis was observed which led eventually to the disappearance of the glomerule.

AG48/12 **Cardiovascular Effects of Forward Acceleration.** G.C.E.MUELLER.
AGARDograph 48. 119-129, 21 refs., 1961.
During forward acceleration, the venous return afforded by body-positioning is sufficient for the heart to perform adequately. Other cardio-vascular effects are described; it is pointed out that pulmonary blood flow is probably one of the most critical factors limiting tolerance to such accelerations. Defects in pulmonary diffusion may also be disabling. Trends for future research are indicated.

AG48/13 **Host Factors in Resistance to Acceleration Stress.** E.R.STIEHM.
AGARDograph 48, 130-139, 17 refs., 1961.
Reticulo-endothelial stimulation is a simple, relatively safe method of increasing acceleration tolerance without radical alteration in physiology. This method is discussed and a common mechanism for increased acceleration tolerance is proposed, involving alterations in steroid metabolism mediated via the hypophyseal-adrenal channel.

AG48/14 **Points of Interest and Limits of Researches Carried Out on Animals and on Man By Means of Centrifuges.** (In French.) R.GRANDPIERRE, F.VIOLETTE, R.FLANDROIS, J.B.TOSAN.
AGARDograph 48, 140-146, 1961.
Following a brief history of the centrifuge since Darwin (1794), the use of the centrifuges for studying long duration g is discussed, and the technical limitations, especially for cases of extremely rapid acceleration, are considered. The limitations of the evaluation of data obtained are emphasized.

AG48/15 **Medical Machine Record Cards – Their Development and Use in the Astronaut Selection Program.** A.H.SCHWICHTENBERG, D.D.FLICKINGER, W.R.LOVELACE, 2nd.
AGARDograph 48, 147-172, 4 refs., 1961.
Under the auspices of U.S.A.F., special mark sense type Machine Record Cards were developed to record complete medical history, physical examination and various specialist examinations, radiological and laboratory tests, as well as physiological data. The potentialities of this system are indicated.

AG49 Transonic Wind Tunnel Testing. B.H.GOETHERT.
AD-271-130 AGARDograph 49, 397 pp., 1961.
N62-10280 An historical review of transonic wind tunnel testing, and a discussion of the flow around aircraft in free-flight are followed by a detailed consideration of a very wide range of subjects associated with transonic wind tunnel testing including interference effects, experiments in slotted tunnels, boundary layer growth, power requirements, etc. Transonic tunnels on which information is available are listed.

AG50 Niobium, Molybdenum, Tantalum and Tungsten. R.P.SYRE.
AD-274-036 AGARDograph 50, 130 pp., 1961.
N62-10975 Describes the physical and mechanical characteristics and oxidation behaviour of the metals and their alloys. The present state of knowledge is considered, and recommendations made for research and development. Protective coatings, joining, fabrication, phase diagrams, impurities, diffusion couples and high temperature behaviour are also discussed.

AG51 An Initial Assessment of Graphite as a Structural Material in Conditions of High Thermal Flux.
AD-262-488 A.J.KENNEDY.
N64-33057 AGARDograph 51, 39 pp., 45 refs., 1960.
The state of fundamental knowledge on graphite and the graphitization process is reviewed. The present state of development of four principal methods of manufacture is examined. The erosion of graphite, the use of coatings, the addition of vaporizing compounds and the development of new graphites are discussed. Considerations relating to thermal shock, creep and fabrication are surveyed.

AG52 Escape and Survival: Clinical and Biological Problems in Aerospace Medicine.
AD-261-881 P.BERGERET (Editor).
N64-13493 AGARDograph 52, 117 pp., 1961.
Twelve papers on various aspects of this subject are presented. Abstracts of the individual papers are given in the succeeding items.

AG52/1 Biological Problems of Escape at High Altitudes. H.L.ROXBURGH.
AGARDograph 52, 1-4, 4 refs., 1961.
The various conditions and effects that a pilot is likely to experience when escaping from his aircraft at high altitudes, and particularly when using an ejection seat, are discussed. A recent escape from a Canberra at 54,000 ft is described to exemplify the problems.

AG52/2 Escape from Aircraft at High Speeds and Low Altitudes. F.G.CUMMING.
AGARDograph 52, 5-9, 1961.
Recent experimental research on escape at low altitudes is described. The problem of opening the parachute at high speeds is a fundamental difficulty at speeds below 600 m.p.h. Questions relating to protection against blast and strong deceleration forces are then studied for speeds up to 800 m.p.h.

AG52/3 Parachutist's Spin Problem. O.WALCHNER.
AGARDograph 52, 10-17, 1961.
The hazardous flat spin conditions that a parachutist is likely to encounter during free-fall from high-altitude were investigated by a study of the autorotation characteristics inherent in various configurations including man. The tests described indicated that the spin can be controlled, for instance by proper orientation and attitudes of the feet or other limbs.

AG52/4 Medical Aspects of Ejections Carried Out in France on Different Types of Ejection Seats. (In French.) J.FABRE.
AGARDograph 52, 18-29, 1961.
A review of 100 ejections, which considers the effects of altitude and speed, and the percentage of facilities, major and minor injuries, and cases in which the pilots were unhurt, and their relation to the types of seats used, and the improvements that have been made to them. The specific traumatology (i.e. injuries of the spine) of ejection is then discussed.

AG52/5 Fundamental Concepts in R.C.A.F. Arctic Survival Training. S.E.ALEXANDER, J.G.FRASER.
AGARDograph 52, 30-45, 5 refs., 1961.
Contents: Implications of a pilot survival experiment; principles of training; 'ten-day survival' concept; response to the survival situation; preparatory 'set' (i.e. mental preparation); some common fears; the Eskimo way of life.

AG52/6 **Aviation Medicine Consultation Problem Cases.** C.A.BERRY.
AGARDograph 52, 46-62, 13 refs., 1961.
During the period 1956-58, 1159 problem aeromedical cases were examined by the U.S.A.A.F. In 51% of these cases a return to flying duties was recommended. The distribution of diagnoses was: cardiovascular problems 34%, neuropsychiatric 18%, ophtalmological 12%, otolaryngological 11%, no diagnosis 9%, pulmonary 6%. The author presents case studies in the following fields: dysbarism, ulcers, migraine, syncope, pneumothorax.

AG52/7 **Early Diagnosis of Hydrops of the Labyrinth.** R.N.KRAUS.
AGARDograph 52, 63-81, 17 refs., 1961.
Although no definite conclusions can be drawn from the case histories presented, it is clearly shown that: (i) the hearing defect due to hydrops of the labyrinth can be accurately differentiated from other hearing defects; (ii) defective hearing is frequently observed before vertigo occurs; (iii) the early diagnosis is of particular importance to aviation medicine.

AG52/8 **Therapy of Spontaneous Pneumothorax in R.C.A.F. Flying Personnel.** G.N.BURGESS, D.G.M.NELSON.
AGARDograph 52, 82-88, 11 refs., 1961.
Presents a discussion of spontaneous pneumo-thorax with special reference to its therapy in R.C.A.F. aircrew. Includes a review of current surgical opinion in the literature, and a study of the results of therapy by chemical pleurodesis in R.C.A.F. personnel.

AG52/9 **A Brief Survey of the Rôle of Elective Surgery in a Modern Air Force.** J.W.GARRAWAY.
AGARDograph 52, 89-93, 1961.
The problem of the way in which a population which is virtually non-expendable in peace-time can be conserved in functional adequacy by the quickest possible means for the longest possible time as occasion demands, is considered. The rôle of elective surgery is discussed with reference to varicose veins, peptic ulceration, thyreotoxicosis, urinary lithiasis, syndrome of prolapsed intervertebral disc, and malignant disease.

AG52/10 **The Choice of Gas Mixture for Breathing in High Performance Aircraft.** J.ERNSTING, G.J.R.McHARDY, H.L.ROXBURGH.
AGARDograph 52, 94-103, 5 refs., 1961.
Examines the ideal pressure environment of the lung alveoli, considering both the cabin pressure and the gas breathed; discusses methods of ensuring the efficiency of the human operator, particularly after failure of a pressure cabin.

AG52/11 **Animal and Man in the Space Environment.** J.E.PICKERING.
AGARDograph 52, 104-107, 1961.
This discussion of environmental hazards concentrates on radiations, and particularly solar cosmic rays and the trapped particles of the Van Allen Belts. These radiations have the most pronounced effect on two types of tissue: (i) epithelial cells, bone marrow, and certain tissues of the reproductive systems; (ii) nerve tissue.

AG52/12 **Bio-Astronautics Research: What Shall We Simulate?** B.H.LOWI, T.H.GALLAGHER.
AGARDograph 52, 108-114, 1961.
This general discussion of simulation techniques, seeks to establish the reputability of simulation as a logical extension of the classical scientific method. The effect of the attitude of the operators on the performance of their tasks is also considered.

AG53 **Radiowave Absorption in the Ionosphere.** N.C.GERSON (Editor).
AD-274-536 AGARDograph 53, 379 pp., 1962.
N62-11615 Papers are included which were given at the Fifth Meeting of the AGARD Ionospheric Committee during June, 1960. The papers were concerned with the theory, measuring techniques, Luxembourg effect, absorption in middle latitudes, absorption in high latitudes, Polar cap absorption, D and E region effects, absorption anomalies, and atmospheric pr rties. Abstracts of the individual papers are given in the succeeding items.

AG53/1 **General Absorption Theory.** N.C.GERSON.
AGARDograph 53, 1-7, 17 refs., 1962.
The classical procedures underlying the development of the magneto-ionic theory of electromagnetic propagation in an ionized medium is reviewed, on the assumption that a time-invariant, homogeneous and isotropic medium are involved. Equations for the real and complex refractive index and the absorption are derived.

AG53/2 **Theoretical Computation of Ionospheric Absorption at Low Frequencies.** J.J.GIBBONS.
AGARDograph 53, 8-12, 10 refs., 1962.
The differential equation for the reflection coefficient in the deviative region is solved approximately. The expression is tested on cases of known reflection coefficient and then applied to recently proposed models of the E and D layers.

AG53/3 **The Dependence of Ionospheric Disturbances on Large Solar Flares.** T.B.HARTZ, J.L.McALPINE.
AGARDograph 53, 13-28, 15 refs., 1962.
It is shown that those flares that are accompanied by major noise bursts at frequencies below 200 Mc/s are followed in a period of less than four days by noticeable ionospheric disturbances, while no such association is found for those flares not accompanied by major bursts at the lower radio frequencies. For the burst-accompanied flares, it is shown that the magnitude of the terrestrial disturbance depends strongly on the location of the flare on the sun. The nature of this dependence is discussed in terms of a model of the solar magnetic field.

AG53/4 **The Effect of Solar X-Rays on the Ionosphere** D.W.SWIFT.
AGARDograph 53, 29-56, 20 refs., 1962.
This investigation is concerned with the mechanism whereby electrons are produced by soft X-rays originating from the sun. It is also concerned with the processes that these electrons undergo from the time they are produced until they again become part of a neutral molecule. Attention is focussed upon what is called the D region (the altitude range from 60 to 95 km) for it is here that the high frequency radio waves are absorbed during a SID. There are many areas in which further study is needed.

AG53/5 **Anomalies in the Measurements of Ionospheric Absorption.** (In French.) G.PILLET.
AGARDograph 53, 57-67, 9 refs., 1962.
Attention is drawn to the difficulties encountered in interpreting absorption measurements made by the classical vertical-incidence, pulse-amplitude method. As a result of recordings made near Paris, it is concluded that ionospheric focussing, when present, affects second-order amplitudes much more than anticipated. The effect probably arises from the longer optical path of these echoes. Because of this effect, absorption measurements should be made, preferably, by a comparison of the first-order amplitudes with the standard constant I_0.

AG53/6 **Short Wave Fadeouts, Their Modes and Complete Characterization.** H.SCHWENTEK.
AGARDograph 53, 68-84, 3 refs., 1962.
Field strength records are presented showing typical deviations from the normal diurnal pattern caused by ionospheric disturbances. An attempt has been made to characterize these effects exactly and completely. To enable a global comparison of fadeouts, their maximum absorption is reduced to absorption at vertical incidence and a frequency of one Mc/s. The fadeout duration, as a solar quality, must be determined from a study of the most sensitive transmission path. The influence of the sun's zenith angle has been considered. The tabulation used at Lindau (Harz) is reproduced. Finally, it is pointed out how transmission paths must be chosen to insure reliable recordings of fadeouts.

AG53/7 **A New Principle of the Measurement of Ionospheric Absorption.** (In French.) E.VASSY.
AGARDograph 53, 85-91, 1962.
It is proposed to use omnidirectional antennae and a classical receiving device to record field intensities of a radio wave transmitted from an artificial satellite. Formulae, developed in this paper, allow the absorption coefficient of ionospheric regions located below the satellite to be deduced.

AG53/8 **Observations of the D Region from a Study of Ionospheric Cross Modulation.** B.LANDMARK, F.LIED.
AGARDograph 53, 92-100, 5 refs., 1962.
Results from observations of ionospheric cross modulation using pulse techniques, carried out at Kjeller, are presented. An interpretation of the results is attempted. Electron density profiles were deduced for day and night observations during all seasons.

AG53/9 **Preliminary Results of Experiment Luxemborg.** G.C.RUMI.
AGARDograph 53, 101-105, 3 refs., 1962.
A cross modulation experiment was conducted at College, Alaska for a few weeks during 1960. From the results, it was possible to deduce collision frequencies and electron densities at rather low altitudes. At 48 km the electron density was found to be 12 cu/cm.

AG53/10 **Ionospheric Absorption Investigations at Hawaii and Johnston Island.** A.FREDRIKSEN, R.B.DYCE.
AGARDograph 53, 106-112, 3 refs., 1962.
Discussion of the irregular component of absorption at certain tropical latitudes during evening hours. An attempt is made to find a correspondence between hourly averages of the apparent absorption with other ionospheric parameters. Both night time and day time absorption observations were made.

AG53/11 **Radio Wave Absorption at Long Distances.** N.C.GERSON.
AGARDograph 53, 113-125, 39 refs., 1962.
A summary of past experiments on circumferential propagation around the Earth is given, and the various possible propagation modes discussed. These modes include multihop, M type reflections, migrating reflections, shallow reflections and ionospheric trapping. Of these possibilities, considerations of absorption tend to the conclusion that an ionospheric channelling mechanism (which includes trapping and migrating reflections) probably is the effective mode. The propagation of satellite signals to great distances with small attenuation also leads to the belief that some type of low loss channelling mechanism is involved. Absorption over these distances when propagation conditions over shorter paths were disturbed is also discussed.

AG53/12 **Cosmic Noise Absorption Measurements.** B.LUSIGNAN.
AGARDograph 53, 126-136, 9 refs., 1962.
Results of cosmic noise absorption measurements at 27.5 Mc/s made at Stanford, California, and Pullman, Washington, during 1958 are presented. A method introduced by Mitra and Shain for extracting F layer absorption from total absorption, and an extension of this method to remove D layer absorption are described. Subtracting these two components from the total absorption leaves an extra component of absorption. The diurnal and annual variation of all these components is presented graphically and discussed. Errors in the cosmic noise curves are discovered and corrected. The cause of these errors and its relation to assumptions of the cosmic noise absorption method are discussed.

AG53/13 **Fading and Attenuation of High Frequency Radio Waves Propagated Over Long Paths Crossing the Auroral, Temperate and Equatorial Zones.** K.C.YEH, O.G.VILLARD, Jr.
AGARDograph 53, 137-154, 22 refs., 1962.
This investigation is primarily concerned with the fading and attenuation of high-frequency radio signals propagated over a long path crossing the auroral zone. The fading of high-frequency signals propagated over non-auroral paths of comparable length has also been studied, and some new results are obtained. The principal fading and attenuation measurements on which these conclusions are based were carried out in August, 1957.

AG53/14 **A Study of 2 Mc/s Ionospheric Absorption Measurements at High Latitudes.** K.DAVIES.
AGARDograph 53, 155-169, 20 refs., 1962.
The seasonal and diurnal variations are considered. The diurnal variations indicate that the dependence of absorption on solar zenith angle decreases with increase of latitude. The distribution of midnight absorption with latitude shows that, although the maximum occurs in the auroral zone, high absorption is also encountered over the polar cap. A study of the duration of long lasting blackouts shows that in summer the duration is longer as the latitude increases.

AG53/15 **Absorption Measurements Near the Auroral Zone.** A.KAVADAS.
AGARDograph 53, 170-176, 5 refs., 1962.
The Institute of Upper Atmospheric Physics is using the cosmic noise method to investigate the structure and morphology of absorbing regions in the ionosphere. A high resolution antenna (6.5 deg. beamwidth) has been used to look alternately at regions on either side of the zenith. Simultaneous measurements have been made at several frequencies in the lower VHF band. The measurements have been augmented by information from VHF scatter circuits, all-sky cameras, magnetometers and Earth current recorders.

AG53/16 **The Ionospheric Blackouts Observed in Terre Adélie in 1957 and 1958.** D.LEPECHINSKY, S.CARTRON, A.FREON, J.P.LEGRAND.
AGARDograph 53, 177-190, 14 refs., 1962.
From an examination of the numerous ionograms, the occurrences of complete blackouts were noted at Terre Adélie, which is well within the southern auroral zone and only a few hundred kilometres from the south magnetic pole. Correlation of these high absorption periods was sought with other geophysical phenomena; e.g. local and planetary magnetic indices, cosmic ray fluctuations, proton events, solar radio and ultraviolet bursts and with ionospheric blackouts found at northern high latitude stations. Suggestions are made regarding the probable mechanism responsible for producing the polar high absorption periods and their precursors.

AG53/17 **The Absorption Effect in the Arctic During a Severe Ionospheric Storm.** P.PENNDORF, G.E.HILL.
AGARDograph 53, 191-201, 3 refs., 1962.
A complete set of ionospheric data for the northern hemisphere has been analyzed for September 11-14, 1957 during a period when a severe ionospheric and magnetic storm occurred. Synoptic charts were constructed at three hour intervals for f_{min}, f^0Es and f^0F2. The analytical method used allowed the transformation of blackout data into f_{min} data, so that reliable charts of equal f_{min} could be obtained.

AG53/18 **Worldwide Patterns of Ionospheric Blackout Occurrence.** V.AGY, K.DAVIES.
AGARDograph 53, 202-205, 17 refs., 1962.
The results to-date of statistical studies of polar blackout occurrence are discussed briefly. A chart summarizing blackout activity in both northern and southern hemispheres was prepared, using IGY data from sixty ionosonde stations. This chart and the detailed sequence of events occurring in the northern hemisphere during five periods when blackouts extended over large areas of the earth was presented.

AG53/19 **Study of Polar Cap and Auroral Absorption at HF and VHF Frequencies.** D.H.JELLY, A.G.MATTHEWS, C.COLLINS.
AGARDograph 53, 206-215, 11 refs., 1962.
Summarizes results from a study of 'polar blackouts' (as observed on HF ionosonde equipment) in relation to polar cap absorption (as observed on riometers at 30 Mc/s). Criteria are established for selecting those blackouts which correspond to polar cap absorption events. On the basis of these, a study of ionosonde data covering an eleven year solar cycle reveals some 40 events. The distribution of these events shows a close association with the mean sunspot number.

AG53/20 **Morphology and Interpretation of the Great Polar Cap Absorption Events of May and July, 1959.** G.C.REID, H.LEINBACH.
AGARDograph 53, 216-228, 9 refs., 1962.
The Alaskan riometer chain is briefly described. An account is given of the type of information which may be obtained from high latitude riometer measurements of Polar Cap Absorption. This type of absorption is attributed to the ionization produced in the lower ionosphere by low energy, solar produced, cosmic rays. The two great events which began on May 10 and July 10, 1959 are described in detail, with special emphasis given to the absorption variations in time and in latitude.

AG53/21 **Analysis of Riometer Observations Obtained During Polar Radio Blackouts.** C.HOLT, B.LANDMARK, F.LIED.
AGARDograph 53, 229-243, 2 refs., 1962.
Presents a partial analysis of riometer observations undertaken in Norway for about two years. Two networks, each containing five stations, were established one after the other. The data allowed a study of polar radio blackouts, particularly the daily absorption referred to that for magnetically quiet days. The study included the temporal and latitudinal variation in absorption, its relationship to geomagnetic and auroral activity, and typical structure and size of the absorbing clouds.

AG53/22 **Absorption in the D and E Regions and its Time Variation.** K.BIBL, A.PAUL, K.RAWER.
AGARDograph 53, 244-259, 9 refs., 1962.
Considers deviative absorption, the influence of blanketing Es, the seasonal variation of absorption and the sunset value of absorption.

AG53/23 **The Absorption of Short Radio Waves in the Ionospheric D and E Regions.** J.A.FEJER.
AGARDograph 53, 260-274, 23 refs., 1962.
After an historical introduction of ionospheric absorption investigations, methods of calculating this absorption at normal incidence are discussed, followed by a consideration of methods used in experimental studies of the E and D regions.

AG53/24 **Some Observations of 2.89 Mc/s Equivalent Antenna Temperatures at the Auroral Zone.** C.G.LITTLE, G.M.LERFALD, R.PARTHASARATHY.
AGARDograph 53, 275-286, 12 refs., 1962.
From the observations it is concluded that during much of the observed period, propagated cosmic noise furnished a significant proportion of the energy at 2.89 Mc/s incident on the receiving antenna. The lower temperatures (below 280 deg. K) recorded during November are believed to be essentially ionospheric in origin.

AG53/25 **The Sunrise Absorption Effect Observed at Low Frequencies.** A.C.[illegible]KIN.
AGARDograph 53, 287-300, 10 refs., 1962.
A theoretical determination is made of the electron density distribution in the region between 60 and 100 km for times around sunrise, and an attempt is made to explain the observed phenomena.

AG53/26 **The Winter Anomaly in Ionospheric Absorption.** L.THOMAS.
AGARDograph 53, 301-317, 16 refs., 1962.
Data obtained during the IGY are used to make a preliminary examination of the extent of the anomaly in the Northern Hemisphere. More complete data available for Europe are used to study the phenomenon in more detail and to investigate month-by-month changes in the degree of anomaly at different latitudes. Data from Slough are re-examined for long term association with geomagnetic activity.

AG53/27 **Observations of Electron Density and Collision Frequency During Polar Radio Blackout Conditions.** O.HOLT, B.LANDMARK, F.LIED.
AGARDograph 53, 318-329, 4 refs., 1962.
Results are presented from observations of electron density and collision frequency in the D region during polar radio blackout conditions. Measurements of ionospheric cross-modulation and partial reflections from the lower ionosphere were carried out near Tromsö, close to the auroral zone.

AG53/28 **Variable Atmospheric Properties Derived from Rocket and Satellite Observations.** H.K.KALLMANN BIJL.
AGARDograph 53, 330-337, 26 refs., 1962.
Upper air densities obtained in the region from 100 km to about 800 km are presented. An attempt has been made to determine pressure scale height and temperature in certain regions of the atmosphere on the basis of presently available data.

AG53/29 **Re-Evaluation of Ionospheric Electron-Densities and Collision Frequencies Derived from Rocket Measurements of Refractive Index and Attenuation.** J.A.KANE.
AGARDograph 53, 338-347, 12 refs., 1962.
Measurements were made of the refractive index and attenuation coefficient for a 7.75 Mc/s radio wave through the D region of the ionosphere. Electron densities and collision frequencies were derived by the Appleton-Hartree formalism and the latter is compared with that of the Boltzmann transfer equation.

AG53/30 **Determination of the Electron Content of the Outer Ionosphere from Measurements of Cosmic Radio Noise Absorption.** A.P.MITRA, K.A.SARADA.
AGARDograph 53, 348-357, 11 refs., 1962.
Simultaneous use of ionograms and observations of cosmic radio noise taken at New Delhi (22.4 Mc/s) have yielded approximate values of the electron content of the outer ionosphere. It has been assumed that the electron density falls off exponentially from the level of maximum ionization. The value of the exponent was determined to be about 6×10^{-3}/km.

AG53/31 **General Remarks on Absorption.** W.DIEMINGER, C.W.BERGMAN, G.C.RUMI, I.RANZI, L.THOMAS.
AGARDograph 53, 358-362, 1 ref., 1962.
The above authors spoke respectively on (i) low frequency observations, and oblique incidence absorption; (ii) ionospheric tilts; (iii) meteors and absorption; (iv) coastal influence on ionospheric echoes, and (v) magnetic activity and absorption.

AG53/32 **Concluding Remarks.** W.T.BLACKBAND, K.RAWER, E.T.VASSEY.
AGARDograph 53, 363-366, 1962.
General impressions of the Conference on Radiowave Absorption in the Ionosphere are briefly given.

AG54 **Wind-Tunnel Calibration Techniques.** A.POPE.
AD-294-167 AGARDograph 54, 131 pp., 69 refs., 1961.
N63-80505 Discusses air-flow and temperature measuring instruments, their use, and the presentation of data obtained when calibrating low-speed, nearsonic, transonic and hypersonic wind tunnels.

AG55 **Navigation Systems for Aircraft and Space Vehicles.** T.G.THORNE (Editor).
AD-652-919 AGARDograph 55, 550 pp., 1962.
N62-16398 Contains thirty-four papers presented at the AGARD Avionics Panel Meeting, October, 1960, Istanbul. The papers give a broad review of navigation systems and techniques including navigation aids for aircraft, air traffic control, automatic landing, and navigation and control of space vehicles. Abstracts of the individual papers are given in the succeeding items.

AG55/1 **Radio Aids to Aeronautical Navigation: A Review of Current Practice and Future Trends.** C.WILLIAMS.
AGARDograph 55, 5-23, 10 refs., 1962.
Discusses the following: (i) Basic principles of radio navigation; (ii) present techniques including radio Doppler self-contained system, ground-supported systems, direction finding, bearing-distance systems, hyperbolic systems, and long range navigation; (iii) very short range navigation; (iv) new techniques including integrated radio and inertial, high stability frequency sources Dectra, VLF global, and radio sextants and direction finders using artificial satellites.

AG55/2 **Radio Navigation Systems for Aviation and Maritime Use: A Comparative Study.** G.ULBRICHT.
AGARDograph 55, 24-35, 1962.
As a result of the work of a German commission to examine and compare the present-day long and medium wave navigation systems, a book has been produced bearing the above title. Two sections of this book are described in detail which deal with (i) accuracy and range of radio navigation systems, and (ii) tables comparing these systems. The book is not intended to help the reader in choosing a system, but to assist him by presenting, in an objective manner, the maximum amount of information on the various systems.

AG55/3 **The Testing and Evaluation of Radio Navigation Systems.** D.F.H.GROCOTT.
AGARDograph 55, 36-55, 1962.
Describes methods and instruments used at the Aircraft and Armament Experimental Establishment in the U.K. to evaluate navigation systems with particular attention to the problem of datum accuracy. As an illustration, the conduct of flight trials of a Doppler system and the Dectra system are described broadly.

AG55/4 **The Optimum Choice and Display of Air Navigation Aids.** D.O.FRASER.
AGARDograph 55, 56-64, 2 refs., 1962.
Draws attention to the increased loads on flying crews imposed by navigation requirements of new aircraft. Suggestions are made regarding dividing the tasks between the air crew and automatic devices although this has its limitations.

AG55/5 **Digits, Decisions and Displays: The Airborne Computer Concept as Applied to the VTOL Aircraft.** D.W.RICHARDSON.
AGARDograph 55, 65-70, 1 ref., 1962.
Describes an airborne central computer system that will allow a tactical mission to be accomplished reliably and simply on VTOL aircraft. The system integrates the basic control functions of the aircraft into one centralized system, allowing emergency or standby modes in the case of malfunction. It also eliminates the necessity for a separate air data computer and autopilot.

AG55/6 **The Effects of the Ionosphere on V.L.F. Navigational Aids.** W.T.BLACKBAND.
AGARDograph 55, 71-80, 11 refs., 1962.
Deals with the mechanisms of propagation, attenuation of signals, diurnal changes in phase over a given path, the effects of ionospheric disturbances, and, to assess the potentialities of v.l.f. navigation, brief conclusions are drawn on airborne measurements. It is suggested that there is a need for an extensive and world-wide monitoring of the phase stability of v.l.f. transmissions over long paths during both normal and disturbed ionospheric conditions.

AG55/7 **On L.F. Ionospheric Phenomena in Radio Navigation Systems.** J.R.JOHLER.
AGARDograph 55, 81-133, 33 refs., 1962.
Summarizes some of the recent advances in the theory of propagation of l.f. ionospheric modes, and applies these theories to the classical theory. New and unpublished aspects of the theory are detailed for purposes of computation. The theory is applied to experimental and geophysical data, and the propagation prediction procedure for the operation of Loran-C on ionospheric modes is illustrated.

AG55/8 **A Survey of Recent Research in the Propagation of V.L.F. Radio Waves.** J.R.WAIT.
AGARDograph 55, 134-155, 326 refs., 1962.
A brief description of recent advances of ground wave propagation is followed by sections on ray and mode concepts of ionospheric propagation. Research dealing with the wave form of atmospherics is also considered. Finally, some recent applications of v.l.f. propagation are described.

AG55/9 **The Loran-C Navigation System.** W.N.DEAN, S.HOROWITZ.
AGARDograph 55, 156-171, 7 refs., 1962.
Loran is a radio position fixing system in which a mobile receiver measures the difference of time of arrival of pulse signals from a number of synchronized transmitting stations. A pair of Loran transmitters produces a family of hyperbolic lines of position; a second pair of transmitters generating intersecting lines will produce a fix. The system has been demonstrated to have a wide usefulness as a long-range precision navigation system.

AG55/10 **The Dectra System.** C.POWELL.
AGARDograph 55, 172-189, 8 refs., 1962.
The Dectra navigational aid, designed primarily to cover long air routes, has been in operation in the North Atlantic since 1957. It has been subjected to an intensive programme of flight tests and sea trials, the results of which are summarized. Also dealt with are the lines along which technical development is proceeding in the light of performance observations. A brief outline of the principles and characteristics of the system is given by way of an introduction.

AG55/11 **Mobile Interference Fringes.** (In French.) L.DUMAS.
AGARDograph 55, 190-203, 1962.
The increased accuracy of radio location systems employing the moving interference fringes created by two signals of slightly different frequency is discussed. Such systems are termed 'isophase', and continuous signal and discontinuous systems are considered. Their applications (e.g. to navigation, air traffic control and distance measurement) are described.

AG55/12 **Marine and Aviation Radiolocation.** (In French.) —.LE FUR.
AGARDograph 55, 204-206, 1962.
The requirements of marine radiolocation systems are summarized, and the analogy between marine and aviation systems indicated. Two French marine radiolocation systems 'Rana' and 'Derveaux' are then discussed and the advantages of each are indicated.

AG55/13 **The Doppler Twin Beacon and its Application to Radio Navigation.** E.KRAMAR.
AGARDograph 55, 207-219, 5 refs., 1962.
Twin-array Doppler installations are suggested which offer new ways of solving various problems. Of particular significance is the fact that no new airborne equipment is required because the existing V.O.R. receiver may be used.

AG55/14 **Performance of Doppler Navigation Equipments at Various Altitudes.** T.G.THORNE.
AGARDograph 55, 220-233, 2 refs., 1962.
Frequently modulated systems, pulse systems and continuous wave systems are considered for achieving accurate and satisfactory performance at all heights up to 50,000 ft. The CW system is shown to give satisfactory results with certain limitations regarding aerials; however this can be overcome by isolating the aerials in separate radomes.

AG55/15 **Methods of Overcoming Altitude Gap Errors in an F.M.C.W. Doppler System.** G.E.BECK.
AGARDograph 55, 234-245, 1962.
Discusses the magnitude of these errors and describes the design methods available to reduce them to an acceptable level. The work done on the Marconi AD 2300 equipment to reduce these errors and the flight results obtained are also dealt with.

AG55/16 **The Combination of Doppler Navigator and Ground-Aided Navigation Systems.** T.GRAY.
AGARDograph 55, 246-254, 1962.
Describes the Decca-Doppler hybrid system. Points in favour of such a system are outlined, and it is shown that both systems are very largely complimentary and so are specially suitable for combination.

AG55/17 **Design and Performance of an I.C.W. Doppler Sensor and Digital Navigation Computer.** J.V.HOLDAM.
AGARDograph 55, 255-272, 1962.
Discusses the AN/APN 105 self-contained Doppler navigation equipment, its system philosophy, the design and function of each of the system's physical components, and details of the inputs and outputs. The performance of the system and the methods employed in ascertaining, interpreting and evaluating this performance, are also discussed.

AG55/18 **Celestial Route Guidance Systems.** (In French.) R.GENTY.
AGARDograph 55, 273-283, 1962.
A celestial guidance system suitable for supersonic transport aircraft flying at high altitudes is proposed. The system incorporates a telescope, supported on a platform which is maintained in the horizontal by a gyroscope and constantly oriented in direction by a gyromagnetic compass, which is driven by two motors which communicate to the telescope the height and azimuth of a selected star as a function of the latitude and longitude of the geographical co-ordinates of the point of observation and of the declination and angle of the star.

AG55/19 **Radar Navigation and Automatic Flight Control.** (In French.) L.GÉRARDIN.
AGARDograph 55, 288-313. 1962.
Problems of aerial navigation; radar and navigation; the need for automatic systems; plane or volumetric radars; automatic radar control system; extraction of plane information; runway tracking; performance of automatic radars; identification of objectives; parasitic echoes.

AG55/20 **Research Methods in Air Traffic Control.** T.K.VICKERS.
AGARDograph 55, 314-333, 1962.
The development of simulation techniques has enabled the planning of air traffic control facilities to be placed on a scientific basis, with large savings in time and costs. Methods used in the U.S.A. are outlined, and some typical examples of graphical simulation are described.

AG55/21 **The Improvement of Air Traffic Flow in the Terminal Area.** T.K.VICKERS.
AGARDograph 55, 334-351, 1962.
Discusses the amount of separation needed to prevent collisions between aircraft, approach systems, and present and future air traffic control techniques. The idea of the dual approach system is outlined and is shown to be feasible by simulation studies and flight tests at Chicago airport.

AG55/22 **The French Solution for Regional Control by Radar.** L.MILOSEVIC.
AGARDograph 55, 352-375, 1962.
Aerial navigation in France, since 1958 has been controlled by four regional radar centres (Paris-Orly, Bordeaux-Merignac, Aix-en-Provence, and Lyon). The performance requirements of these radars are first presented and then the equipment utilized is described.

AG55/23 **The Avoidance of Collision in the Air.** S.RATCLIFFE.
AGARDograph 55, 376-399, 1962.
Two main classes of collision avoidance in the air are (i) techniques based on a knowledge of the intended path of neighbouring aircraft relative to the earth's surface, and (ii) techniques in which sufficiently detailed knowledge of future intentions is not available, and the emphasis is on observed and relative motion. The main topic of this paper is on the second of the two classes. Two appendices deal with the change of airspeed produced by change of height and the choice of point at which escape manoeuvre is initiated.

AG55/24 **All Weather Landing Developments.** J.L.ANAST.
AGARDograph 55, 400-406, 1962.
Reviews past developments in the U,S.A. since the inception of the first organized attack in 1946. Some indications are given of the Federal Aviation Agencies concepts and its steps to provide a limited all-weather landing system within five years. A brief description is also included on the development programme for the REGAL (Range and Elevation Guidance for Automatic Landing) system.

AG55/25 **Problem of Approach in Bad Visibility.** (In French.) M.J.GREMILLET.
AGARDograph 55, 407-413, 1962.
Conventional ILS systems define the 'localiser axis' with respect to the runway axis with an accuracy of ±1/3 deg., and because of the weak signal received under certain conditions, are subject to interference effects from signals reflected by other aircraft. The Compagnie Générale de Télégraphie CSF system is designed to have greater accuracy and to avoid the possibility of unwanted interference. The principles of the CSF system and its use for all-weather landing are described. An account is given of the actual equipment, and further possible uses are indicated.

AG55/26 **An Automatic Landing System Developed by B.L.E.U. with Particular Reference to the Radio Aids.** J.S.SHAYLER.
AGARDograph 55, 414-431, 17 refs., 1962.
The broad considerations that have influenced the choice of this automatic system are discussed briefly. This is followed by a general description of the system, its practical performance, radio aids, and its application to civil aviation. The system gives a performance adequate for blind landing, and a consistency of touchdown better than achieved by the average pilot landing manually in good visibility.

AG55/27 **A New Radioaltimeter for High Altitudes.** (In French.) M.J.GREMILLET.
AGARDograph 55, 432-441, 1962.
Analysis of the operation and applications of CRT radioaltimeters; development of the CSF Type AM 230 radioaltimeter; accuracy of the equipment; installation in the aircraft; conclusion.

AG55/28 **Space Vehicle Attitude Control.** N.SIRRI.
AGARDograph 55, 446-468, 1962.
Some of the general problems of space vehicle attitude control are considered, followed by two aspects of control which are considered in more detail. They are: sensing, which refers to the process of identifying and acquiring certain reference directions and then providing signals proportional to variations of the vehicle attitude from this reference frame; and actuation, which refers to the process of applying torques to correct deviations. The application to a space vehicle on its journey from the earth to the moon is given, together with details of the Ranger attitude control system.

AG55/29 **Attitude Control and Orbit Correction Systems for Earth Satellites.** E.FTHENAKIS.
AGARDograph 55, 469-489, 1962.
Discusses the relative merits of a number of methods used for controlling the attitude of earth satellites or space vehicles as well as means for correcting the eccentricity and period of satellite orbits.

AG55/30 **Timing and Space Navigation with an Existing Ground-Based System.** G.HEFLEY, R.F.LINFIELD, R.H.DOHERTY.
AGARDograph 55, 490-506, 7 refs., 1962.
Describes a technique for determining the position of space vehicles by the long base line inverse hyperbolic system. Its accuracy is primarily a function of time synchronization of the receiving stations and geometrical considerations. Included in the description is the Loran-C clock which is the heart of the time synchronization system.

AG55/31 **Earth Based Radio Navigation for Lunar Vehicles.** C.R.GATES.
AGARDograph 55, 507-516, 1962.
The paper, which is largely tutorial, deals with the problem of guiding the vehicle to the moon. It tackles the problem from the following categories: (i) injection guidance, (ii) mid-course guidance, and (iii) terminal guidance. The primary concern is mid-course guidance, including particularly the use of radio which appears to have great utility.

AG55/32 **On the Use of Precision Frequency Signals in Space.** W.E.FRYE.
AGARDograph 55, 517-527, 21 refs., 1962.
A review of the use of the Doppler effect for orbit determination and terrestrial navigation in conjunction with earth satellites. Also, an examination is made of the application to space navigation and guidance of new developments in the generation of very stable and precisely known frequencies, and the detection and amplification of weak signals.

AG55/33 **The Transit System.** R.B.KERSHNER.
AGARDograph 55, 528-536, 1 ref., 1962.
The system provides a world-wide navigational aid by using artificial satellites of the earth. It is an all-weather system with true global coverage, and requires relatively simple receiving equipment on the part of the user. Its concept, use, and accuracy are discussed.

AG55/34 **Doppler Tracking of the Transit Navigational Satellite and its Extension to Problems in Geodesy.** R.R.NEWTON.
AGARDograph 55, 537-544, 3 refs., 1962.
Parameters that determine Doppler shift; determination of parameters from analysis of the Doppler shift; experimental considerations; geodetic problems.

AG56 **Several Techniques for Flight Flutter Testing.** M.O.W.WOLFE (Editor).
AD-294-147 AGARDograph 56, 83 pp., 1960.
N63-80160 Three papers are given which review the state-of-the-art in the United States, France and the United Kingdom. Abstracts of the individual papers are given in the following items.

AG56/1 **A Review of Flight Flutter Testing Techniques in Great Britain.** M.O.W.WOLFE, W.T.KIRKBY.
AGARDograph 56, 7-35, 18 refs., 1960.
Introduction; historical survey; response to turbulence and gusts; continuously forced oscillation techniques; decaying oscillation techniques, instrumentation of aircraft; flight test procedures; conclusion.

AG56/2 **Utilization of Electrodynamic Vibrators for in-Flight Measurement of the Response of an Aircraft Wing to Harmonic Excitation.** G. de VRIES.
AGARDograph 56, 37-56, 6 refs., 1960.
Introduction; basic mathematical assumptions in calculation and interpretation of calculated results for the reduction of in-flight data; basic principle on which O.N.E.R.A. in-flight excitation equipment is designed; some results.

AG56/3 **Some Recent Developments in the Art of In-Flight Vibration Testing.** W.R.LAIDLAW, W.T.BUTTERWORTH.
AGARDograph 56, 57-81, 11 refs., 1960.
Introduction; structural dynamics; basic excitation methods; simple harmonic excitation; pulse excitation; airborne instrumentation; data system and analysis; flight test techniques; conclusions.

AG57 **Microminiaturization.** G.W.A.DUMMER (Editor).
N62-12297 AGARDograph 57, 355 pp., 1962.
Presents a record of the proceedings of the AGARD Conference on Microminiaturization held in Oslo in July, 1961. Includes papers on the three main systems of microminiaturization devices – micromodules, microcircuits, and solid circuits. Abstracts of the individual papers are given in the succeeding items.

AG57/1 A Review of British Work on Microminiaturization Techniques. G.W.A.DUMMER.
AGARDograph 57, 1-23, 1962.
Reviews the history of these techniques in the U.K., political decisions on systems, and their film techniques in making microcircuits.

AG57/2 Microelectronics: From Feasibility to Use. H.B.PARKER.
AGARDograph 57, 24-31, 1962.
Outlines some military and industrial factors related to the use of microelectronics, and points out management problems incident to the introduction of new technologies.

AG57/3 Microminiaturization and Molecular Electronics. R.D.ALBERTS.
AGARDograph 57, 32-44, 1962.
The thought leading up to microminiature circuits and components is outlined together with a brief description of fabrication problems and reliability.

AG57/4 Methods of Optimisation Applied to Microminiaturization. (In French.) J.BERTRAIS.
AGARDograph 57, 45-64, 6 refs., 1962.
With special reference to dissipative elements a method of study is proposed to define the ultimate in miniaturization for a given state-of-the-art. Examples are given. Factors of merit are derived permitting classification of the materials and definition of improvements to be expected.

AG57/5 Some Recent Developments in Integrated Electronics and Microsystems. H.KIHN.
AGARDograph 57, 65-95, 13 refs., 1962.
Describes briefly some of the steps in the development of microsystems leading to the process of integrated electronics, and also some working devices which have been developed at the Radio Corporation of America (RCA) under an integrated electronics programme.

AG57/6 The Micromodule Approach to Microminiaturization. S.F.DANKO.
AGARDograph 57, 96-114, 3 refs., 1962.
The interest shown in practical miniaturization by the U.S. Army Signal Corps has led to studies of the micromodule system. This is considered to have less problems in production and to be the best vehicle to carry electronics from today's microminiaturization capabilities to future technologies.

AG57/7 The Design of a Standard Micro-Element. S.C.DUNN.
AGARDograph 57, 115-120, 1962.
Requirements of a standard component are outlined and the construction of the proposed standard element described. This is of flat circular disc form with different terminations for different components (transistors, capacitors, etc.). The present status of the programme activities, which includes a mechanical assembly mechanism, is given.

AG57/8 A Flexible Approach to Micromodular Construction. H.T.PRIOR.
AGARDograph 57, 121-135, 9 refs., 1962.
The paper is primarily concerned with assemblies of individual components. Factors limiting the degree of miniaturization are explored, and temperature rise is said to be the biggest problem; the solution to this is discussed for a wide range of components. By having good flexibility in the range of components and method of assembly, application both inside and outside the aviation field should be attainable.

AG57/9 A Concept for Microsystems Electronics. B.G.BENDER.
AGARDograph 57, 136-143, 1962.
In developing a concept for microsystems, size and weight reduction are not the only considerations. Strength, reliability, flexibility of circuit design, repairability, heat drain, and costs must also be considered. Means for automatic insertion of devices and simplicity of interconnection should also be provided. The methods used by Hughes Aircraft Company for overcoming these influences are described and as particular examples, the development of the Microseal diodes and transistors are described. These devices are 0.030 in. thick and the diode is 0.062 in. diameter, the transistor being egg-shaped and 0.070 in. at its greatest breadth.

AG57/10 Micromodules for Computers. (In French.) A.P.BOBENRIETH.
AGARDograph 57, 144-158, 1962.
The methods being developed by the French Thomson-Houston Co. in their Semiconductor Division to develop circuits for reliable, lightweight numerical calculators, for use over a wide range of temperatures are described. Resistance to shock and a diversity of atmospheres is also required. The circuits comprise only transistors and low capacity resistances. The methods are not too advanced but allow scope for competent manufacture and reasonable selling price in the future.

AG57/11 **Microcircuitry: Special Considerations for Military Quality Systems.** G.J.SELVIN.
AGARDograph 57, 159-173, 1962.
Presents design objectives and engineering solutions to the problems of building military quality electronic systems composed of semiconductor microcircuitry. Development of a method is described for providing true hermetic protection for each individual circuit stage, interconnection of stages. plug-in capabilities of logical blocks, growth potential in operating temperatures to over 500 deg.C, and adaptability to production automation. Data are provided on module thermal dissipation limits, and ranges of suitable electronic component values.

AG57/12 **Preliminary Considerations for the Design of a Microminiature Telecommunications Equipment.** T.M.GOSS.
AGARDograph 57, 174-183, 1962.
Describes some of the problems anticipated in the design of a microminiature telecommunications equipment, and some preliminary work on these problems. It is aimed to improve the reliability and to effect a reduction in volume by a factor of ten as compared with current equipment of similar performance. A low-power v.h.f. transmitter was selected as a vehicle for these considerations.

AG57/13 **A System of Tantalum Film Microcircuitry.** H.A.STONE. Jr.
AGARDograph 57, 186-196, 4 refs., 1962.
Work is described, conducted by Bell Telephone Laboratories, which has as its objective a process for fabricating groups of thin film resistors and capacitors of high electrical quality, and interconnections, using as a basis a pattern of tantalum on an inorganic substrate.

AG57/14 **Recent Progress in Microelectronics.** M.APSTEIN.
AGARDograph 57, 197-213, 10 refs., 1962.
Describes the D.O.F.L. (Diamond Ordance Fuze Laboratories) methods of preparing, assembling and testing components. Individual components are assembled as desired into a functional module in which the size of the substrate is not fixed. A relatively large number of components are applied to a single wafer to form a functional unit. Improvements in digital unit switching speeds are described. Efforts are being made to accomplish the transition from digital to linear systems. The design of a 400 Mc/s command receiver of very low volume is described.

AG57/15 **The Microcircuit Concept.** D.I.GAFFEE.
AGARDograph 57, 214-227, 7 refs., 1962.
After discussing the need for microminiaturization and outlining the three main approaches, the author considers the problem of making a highly reliable microminiature digital integrator using transistors. Circuit reliability considerations are analyzed. Design of substrates, resistors, conductors and capacitors and their properties are described and a brief outline given of the special problems of interconnection and encapsulation.

AG57/16 **Thin Film Microcircuit Networks.** W.N.CARROLL.
AGARDograph 57, 228-238, 1962.
Describes the fabrication and operational testing of several types of thin film circuit networks, fabricated by vacuum-evaporation techniques with multi-layer deposition. Data are given on the fabrication process, component stability and reproducibility and circuit operational performance.

AG57/17 **Miniature Magnetic Memories.** (In French.) P.LEDUC, P.MARTINELLI.
AGARDograph 57, 239-251, 1962.
The use of thin films of iron-nickel as elements of magnetic memories necessitates knowledge of their chemical composition. Two methods of analysis may be used; (i) by colorimetry, (ii) by X-ray fluorescence. The second method comprises exciting the K-radiation of the iron and the nickel, and making a spectrometric analysis of this radiation. A formula is established giving the composition of nickel from the measurements.

AG57/18 **An Evaporated Film 135-Cryotron Memory Plane.** C.J.KRAUS.
AGARDograph 57, 252-261, 2 refs., 1962.
The design, operation, and fabrication of a computer memory plane made entirely of evaporated thin films is described. By applying the principles of superconductivity to the design and operation of this memory plane, reductions of physical size, space and power requirements have been made. Three major aspects are dealt with (i) principles of super-conductivity, including a description of the operation of the basic cryotron device, (ii) fabrication and testing of a complete 135 cryotron memory plane, (iii) the unique applications of this technology.

AG57/19 **Solid State Integrated Circuits Development, Manufacture and Application.** J.R.BLACK, H.W.WELCH, Jr.
AGARDograph 57, 262-281, 1962.
The following applications technologies are first considered: (i) selection and construction of functions to be performed by the integrated circuit; (ii) selection and application of the form of the electro-magnetic energy processing to be used in the integrated circuit; (iii) development of design theory and strategy applicable to integrated circuits; (iv) evaluation of performance and reliability of integrated circuits under expected environments. Process technologies that are discussed include; (i) semiconductor crystal growth and deposition; (ii) solid state device technology; (iii) thin film technology; (iv) electronic ceramic and substrate technology; (v) surface passivation and encapsulation technology.

AG57/20 **The Background to Integrated Single Crystal Circuit Fabrication.** D.H.ROBERTS, B.L.H.WILSON, J.M.ALLEN.
AGARDograph 57, 282-296, 19 refs., 1962.
It is first explained why silicon rather than germanium is selected, and it is then shown how it is quite simple conceptually to make a whole range of active and passive circuit elements by solid state diffusion of impurities into silicon. The background research and technique studies of the Plessey Co. are also described.

AG57/21 **Semiconductor Networks.** W.ADCOCK, J.S.WALKER.
AGARDograph 57, 297-316, 1962.
Microminiaturization techniques in which both active and passive components are integrated into one element, using a semiconductor, are discussed; the advantages of these techniques over other methods of microminiaturization are indicated.

AG57/22 **Micrologic Elements.** R.H.NORMAN, J.R.NALL.
AGARDograph 57, 317-333, 5 refs., 1962.
Micrologic elements fall into the class of devices known as integrated circuits, i.e. the complete logic circuit including resistors and transistors is formed by selective diffusion and deposition on a continuous semiconductor (silicon) substrate. The advantages of such elements, not only from the point of view of size, but also cost and reliability, are indicated.

AG57/23 **Molecular Electronics and Microsystems.** J.P.STELMAK.
AGARDograph 57, 334-348, 2 refs., 1962.
The following are considered; microminiaturization through molecular electronics (basic materials, unique effects in a semiconductor functional block); functional block design and development (single- and multi-stage amplifiers); system integration.

AG58 **Low Noise Electronics.** K.ENDRESEN (Editor).
AD-290-064 AGARDograph 58, 359 pp., 1962.
N62-14643 This work contains edited versions of the papers presented to the Fifth AGARD Avionics Panel Conference, Oslo, 1961. The most recent scientific progress in low noise devices is covered with full literature references. Abstracts of the individual papers are given in the succeeding items.

AG58/1 **The Physical Effects of Low Noise Electronics.** H.HEFFNER.
AGARDograph 58, 3-12, 2 refs., 1962.
Reviews some of the properties of noise and signal in low noise amplifiers when quantum effects are taken into account, and shows how these quantum effects limit the noise performance of the amplifiers. An appendix tabulates the best noise performance (at given frequencies) of eight parametric devices, and gives brief comments on the characteristics of these devices.

AG58/2 **Using Low Noise Amplifiers.** F.G.SMITH.
AGARDograph 58, 13-21, 2 refs., 1962.
The usefulness of a low-noise amplifier depends upon the noise environment in which it is used, and upon the way in which it is used. Noise received by the aerial originates in extraterrestrial sources, in the atmosphere, and from the ground. Frequencies in the range 1000 to 5000 Mc/s may give the lowest effective temperatures from the combined galactic and atmospheric contributions; the ground contribution is a matter of aerial design, especially in far-out sidelobes. Some measurements of aerial noise at 408 Mc/s are presented and compared with simple theory. Discussion.

AG58/3 **Low Noise Possibilities of Certain Semiconductor Amplifying Systems.** R.E.BURGESS.
AGARDograph 58, 25-30, 8 refs., 1962.
Consideration is given to three schemes of semiconductor amplification, and factors determining their noise performance are discussed. The schemes involve travelling-wave amplification arising

from transmission through a medium of negative conductance and are exemplified by a transmission line structure with appropriate metallic electrodes and semiconductor dielectric. The application of a d.c. potential difference sets up the shunt negative conductance by the process of either (i) electron tunnelling between superconductors, (ii) space-charge waves or (iii) 'top-heavy' population of the conduction band relative to the donor levels.

AG58/4 **Relation Between Amplification and Bandwidth of Parametric-Travelling-Wave Amplifiers using Varactor Diodes.** W.HEINLEIN.
AGARDograph 58, 31-38, 8 refs., 1962.
Parametric travelling-wave amplifiers whose wave-guide has the character of a band-pass filter are considered. For two band-pass structures of practical importance which contain as lumped capacitances merely the basic capacitances of varactor diodes, the maximum product is estimated of the gain per diode at the mid-band frequency and the relative bandwidth that can be attained with parametric travelling-wave amplification. A maximum of about 2 dB per diode results for the aforementioned product which is termed 'effectiveness'.

AG58/5 **Proposal for a Gain-Equalizing Technique for Travelling-Wave Parametric Amplifiers.** E.V.SØRENSEN.
AGARDograph 58, 39-51, 12 refs., 1962.
The purpose of this article is to suggest a way for eliminating the band-edge instability problem and realizing a flat gain-frequency response while preserving a reasonably high gain per section in travelling wave parametric diode amplifiers of the band-pass (or coupled-cavity) type. Discussion.

AG58/6 **Wide-Band Parametric Amplifier for Trans-Horizon Links.** (In French.) R.BAUD.
AGARDograph 58, 52-59, 1962.
The low thermal noise of parametric amplifiers emphasizes their usefulness in trans-horizon links employing tropospheric diffusion. A study of a reflection-type parametric amplifier for use in the frequency range 830 to 960 Mc/s is reported. The noise temperature and the product of the gain and bandwidth (3 dB) are calculated for this amplifier under optimum conditions. Experimental values obtained for these properties agree well with the calculated values.

AG58/7 **Parametric Phenomena in a Wave Propagation System.** (In French.) G.PIRCHER.
AGARDograph 58, 60-82, 7 refs., 1962.
Previously published considerations of parametric amplifers have treated them by using equivalence techniques. Here the characteristics of parametric amplifiers are calculated using the concepts of propagation and matrix diffraction for treating the problems relating to microwaves, and the laws of black-body radiation.

AG58/8 **Optimization of the Noise Temperature and Calculation of the Pass Band of a Diode Parametric Amplifier as a Function of the Diode Characteristics for Systems Operating at Very High Frequencies.** (In French.) M.CHAUSSEDOUX.
AGARDograph 58, 83-94, 7 refs., 1962.
The temperature and pass band characteristics of a diode (type L.S.U.C.) parametric amplifier with circulator are calculated as a function of the diode characteristics and of the ratio of the idling frequency to the signal frequency. The optimization of the noise temperature of the amplifier by selecting optimum values of the circuit elements is treated; the corresponding pass-band is then determined.

AG58/9 **Characteristics of Diode Parametric Amplifiers: Study and Measurement.** (In French.) I.D'ESCRIVAN.
AGARDograph 58, 95-110, 1962.
It is pointed out that the performance of diode parametric amplifiers is conditioned, at the outset, by the nature of the diode, and its utilization. The performance of a direct amplifier with imposed signal frequency is examined. The following are studied: diode characteristics (in the passive state and with pumping), the circuit parameters, quantitative amplification characteristics, measurement of performance.

AG58/10 **Measurement of Characteristics of Parametric Amplifier Diodes.** G.W.ROSENBERG, T.SCHAUG-PETTERSEN, A.TONNING.
AGARDograph 58, 111-128, 2 refs., 1962.
Methods of static and dynamic measurements of diodes are discussed. The static measurements involve measurement of impedance over a wide frequency range and the data obtained are used for computing the parameters of the equivalent circuit of the diode. The purpose of the dynamic measurements is to determine a certain characteristic frequency f_d which is shown to define the performance of the diode in a parametric amplifier. Methods are discussed for obtaining f_d as a function of absorbed pump power. Discussion.

AG58/11 A Microwave Adler Tube. T.J.BRIDGES.
AGARDograph 58, 129-134, 4 refs., 1962.
A description is given of an Adler tube operating at 2700 Mc/s. This is a sealed-off version of a previously described demountable experiment at 4000 Mc/s. Gain of 24 dB can be obtained and the double channel effective input noise temperature is 96 deg.K (noise factor 1.24 dB), as measured at the input terminal of the tube. By correcting for circuit losses the effective beam temperature is given as 62 deg.K. A band-width of 10 Mc/s is obtained at points where the minimum noise temperature is doubled. Improvements which may reduce the noise temperature even further are described.

AG58/12 Experiments on the Noise Performance of a D.C. Pumped Quadrupole Amplifier. J.C.VOKES, T.J.BRIDGES.
AGARDograph 58, 135-141, 6 refs., 1962.
Details of the design of an experimental 400 Mc/s d.c. pumped quadrupole amplifier using an expansion gun are given and some results quoted. It was originally thought that by using an expansion gun the beam temperature (which is equivalent to the noise temperature) could be reduced from that of the cathode to as low as 16 deg.K, resulting in a very low noise tube. Recent theories show that the expansion gun (in its original form) does not reduce the noise on the beam. Experimental results obtained confirm this conclusion to some extent. Two methods of modifying the expansion gun to secure noise reduction are described.

AG58/13 Noise Reduction Schemes in Transverse Modulation Tubes. T.WESSEL-BERG, K.BLÖTEKJAER.
AGARDograph 58, 142-168, 6 refs., 1962.
The paper is concerned with a general analysis of noise in d.c. pumped amplifiers based on transverse waves. It is shown that any amplifier involving either the cyclotron waves or the synchronous waves has the same minimum noise temperature determined by the physical conditions at the cathode. The minimum noise temperature can be realized by inserting a suitable noise transformer between the cathode and the amplifier. Some specific examples of noise transformers are discussed. Discussion.

AG58/14 Noise Limits of a Maser System. C.R.DITCHFIELD.
AGARDograph 58, 171-188, 5 refs., 1962.
The noise of stimulated emission to provide microwave amplification results in the amplifier itself being limited solely by noise due to spontaneous emission from the upper energy state. An extension of present techniques will ensure that this emission corresponds to an effective input noise temperature many times below the ambient temperature of the maser. Stimulated emission is now being employed in the optical region and the techniques will extend to the infra-red. A comparison is made between the sensitivity of such an amplifier and a quantum-mechanical counter.

AG58/15 Research on Ruby and Ammonia Maser Amplifiers. F.W GUNDLACH.
AGARDograph 58, 189-199, 1962.
Theoretical considerations on an r.f.-equivalent circuit for a reflection type cavity maser are given by which stability, gain and bandwidth may be calculated. Constructional details of an ammonia-beam-maser and of a four-level push-pull ruby-maser and some experimental results are given. Discussion.

AG58/16 Effect of Hyperfrequency Circuits on the Performance of a Cavity Coupled Maser. (In French.) G.BROUSSAUD, L.MALNAR.
AGARDograph 58, 200-224, 1962.
The performance analysis of a cavity-coupled maser amplifier is treated initially by consideration of the propagation of waves of the form $\exp(-ikz + \alpha kz)$. The complete calculation is carried out for one, two and three symmetrical synchronous or series cavities. In each case the problem is examined from the aspects of stability, pass-band, and equivalent temperature of entry. Some examples are given for the case of rubies used in the X-band.

AG58/17 Travelling Wave Masers. J.C.WALLING.
AGARDograph 58, 225-235, 11 refs., 1962.
The background theory of the TWM is outlined, and the design, construction and performance of an S-band TWM using ruby as the active material are described. The importance of cross relaxation processes in maser operation is pointed out. Applications of the TWM in the fields of communications, radio astronomy and radar are discussed. Discussion.

AG58/18 Solid State Laser and Iraser Studies. T.H.MAIMAN.
AGARDograph 58, 236-249, 10 refs., 1962.
The pumping power requirements for three-level and four-level solid state laser and iraser systems are presented. The pertinent material parameters and properties of exciting lamps are discussed. The discussion is illustrated by calculating the relevant quantities applicable to ruby.

AG58/19 **Report from a Symposium on the Application of Low Noise Receivers to Radar and Allied Equipment.** J.W.MEYER.
AGARDograph 58, 253-265, 11 refs., 1962.
The Symposium held at Lincoln Laboratory on 24-28 October, 1960, was sponsored jointly by Canada, U.K. and U.S.A. Divided into four sections, the programme included: The Noise Environment, Noise Temperature, Noise Figure, Definitions and Measurements, Low-Noise Receiver Components, Systems Problems, Solutions and Experience. The Proceedings were published in three volumes, one classified, and the other two unclassified. It is on the unclassified portion of the Proceedings that this report is based. Discussion.

AG58/20 **Parametric Amplifiers for Radio Astronomy.** J.T. De JAGER.
AGARDograph 58, 266-270, 7 refs., 1962.
A description is given of a two-stage parametric amplifier system to be used for 21 cm hydrogen line measurements. The system consists of an up-converter from 1400 Mc/s to 2400 Mc/s, followed by a fixed-tuned regenerative amplifier at 2400 Mc/s. A frequency switching technique is used in the up-converter to provide the necessary overall stability. The calculated and measured noise temperatures for the regenerative amplifier with several varactors of different types are given. It is shown how this amplifier can be used for continuum measurements.

AG58/21 **Tests on Reception of a Troposcatter Signal with the Aid of a Parametric Device.**
P.E.GUDMANDSEN, N.H.KNUDTZON.
AGARDograph 58, 271-283, 1 ref., 1962.
In March 1960, trials were carried out with parametric up-converters operating at 875 Mc/s on a troposcatter system in Norway. The results of noise-quieting tests and telegraph error counts show that a reduction in noise of about 7 dB could be obtained with well-engineered systems. For operational reasons parametric amplifiers are preferred to parametric up-converters. Discussion.

AG58/22 **A High-Stability L-Band Travelling-Wave Tube Receiver for use in Radio Astronomy.**
H.G.MÜLLER.
AGARDograph 58, 284-295, 3 refs., 1962.
The development of a broadband travelling-wave tube receiver is described. A Dicke-system employing a travelling-wave tube switch was chosen to give maximum stability. A noise figure below 5 down to 2.95 in connection with a system stability of better than 1 in 10^4 appears sufficient for cosmic noise work in the L-band, but interference from a number of powerful radar transmitters makes broadband measurements impossible at present.

AG58/23 **A Maser System for Radar Astronomy.** W.H.HIGA.
AGARDograph 58, 296-304, 3 refs., 1962.
A ruby maser of simple design is described, and the problems associated with the operation of such a maser on an antenna are discussed. The dewar system was unique in that it was demountable. The duty time of one filling of cryogenic liquids was in excess of 24 hr; it is expected that the maser will operate continuously for 12 weeks. In order to achieve a good noise figure, the maser was followed by a parametric amplifier. Discussion.

AG58/24 **A Study of the Sources of Noise in Centimeter Wave Antennas.** D.C.HOGG.
AGARDograph 58, 307-318, 10 refs., 1962.
Deals with a theoretical and experimental investigation of antenna noise which at present limits the sensitivity of centimetre wave receivers. Of importance are the inherent characteristics of the receiving antenna, primarily its radiation pattern and resistive losses. Since paraboloids are the most commonly used microwave antennae, some of their undesirable noise characteristics are evaluated and measurements of these are discussed. Absorption by the oxygen and water vapour in the earth's atmosphere is one of the important sources of noise; its dependence on frequency and meteorological conditions is described in detail. Results of sky noise measurements at centimetre wavelengths using a receiver comprised of a horn-reflector type antenna and a travelling wave maser having a total effective noise temperature of about 20°K are discussed. Special attention is given to the thermal noise produced by rain and clouds since this gives rise to a varying noise level which must be taken into account in the design of a reliable radar or space communication system.

AG58/25 **The Capabilities of Cassegrain Microwave Optics Systems for Low Noise Antennas.** P.FOLDES.
AGARDograph 58, 319-356, 26 refs., 1962.
The maximum available range of a space-to-ground communication system is analyzed from the standpoint of the receiving ground antenna. The range, or signal-to-noise ratio of such a system is influenced by the aperture efficiency and noise temperature of the antenna. The aperture efficiency can be increased and the noise temperature decreased if the feed pattern $f(\psi)$ is unity up to the aperture angle of the paraboloid and is zero beyond this angle. The ideal feed pattern can be approximated by a Cassegrain type primary reflector if the aperture size of the secondary reflector is large. Theoretical and experimental results are provided to determine the optimum dimensions of such an antenna. Discussion.

AG59
AD-430-318
N64-15426

The Effect of Disturbances of Solar Origin on Communications. G.J.GASSMANN (Editor).
AGARDograph 59, 349 pp., 1963.
Presents a report of the sixth annual meeting of the Ionospheric Committee of the AGARD Avionics Panel, held in Naples, Italy, in May, 1961, on this subject. Abstracts of the individual papers presented are given in the succeeding items.

AG59/1

Sudden Ionospheric Disturbances. Effects Experienced and Probable Causes. (In French.) P.HALLEY.
AGARDograph 59, 1-20, 11 refs., 1963.
In this detailed consideration of the origin and effects of SIDs (Sudden Ionospheric Disturbances) the following subjects are treated: geophysical phenomena, solar chromospheric eruptions, geophysical theories of the ionization phenomena, identification of eruptions which cause SIDs, abnormal eruptions.

AG59/2

The Occurrence of Polar Cap Absorption. D.K.BAILEY, J.M.HARRINGTON.
AGARDograph 59, 21-24, 4 refs., 1963.
Preliminary statistics of the occurrence of PCA events from 1952 to 1960 are presented based on the field strength recordings of ionospheric forward scatter links. A total of 21 PCAs of medium and larger intensity have been discovered. The correlation of the size of PCAs to the intensity of cosmic ray bursts as observed simultaneously on ground is poor. Discussion.

AG59/3

Influence of Solar Particle Radiations on Arctic HF Propagation. L.OWREN.
AGARDograph 59, 25-36, 13 refs., 1963.
The response of transarctic and transauroral h.f. circuits to solar particle impacts is discussed. The experimental results are based on continuous 12 and 18 Mc/s pulse transmissions from College, Alaska, over a 5200 km arctic path to Kiruna, Sweden, over a 5300 km auroral zone path to Boston, Massachusetts, and over a 3500 km subauroral path to Stanford, California, together with measurements of ionospheric absorption from a chain of riometers. It was found, inter alia, that the 18 Mc/s transarctic circuit was very sensitive to the magnetic and auroral activity but not to the polar cap absorption. This behaviour together with best signal reception during the winter months suggests 18 Mc/s transarctic propagation by lateral deviation in the auroral zone. Discussion.

AG59/4

Ionospheric Polar Blackouts and Radio Communication Disturbances. T.OBAYASHI.
AGARDograph 59, 37-45, 19 refs., 1963.
It is generally believed that hf radio communication disturbances have two principal origins, depression of critical frequency of the F2-layer associated with geomagnetic disturbances, and increase of absorption in the lower ionosphere due to enhanced X-ray radiation or the precipitation of energetic particles from outer space. In the polar region radiowaves suffer very intense absorption occasionally and they are then known as 'polar blackouts'. It is found that the polar blackout has two different origins; one produced by low energy solar cosmic rays ejected from an intense solar flare and the other produced by auroral particles. The former is called the polar cap blackout, the latter occurs mainly along the auroral zone. Some morphological studies of these polar blackouts are reviewed and general characteristics of the world-wide development of disturbances are discussed in connection with radio communication problems. Discussion.

AG59/5

Thule to College 12 Mc Propagation during the April and May 1960 Intense Polar Cap Absorption Events. R.D.EGAN.
AGARDograph 59, 47-58, 4 refs., 1963.
During a seven-month period, continuous signal-strength measurements of pulse signals from Thule, Greenland, were made at College, Alaska. A number of significant polar cap absorption events (type III) were recorded during April and May 1960, on riometer equipment operated by the Geophysical Institute of the University of Alaska. The significance of the results obtained is discussed. Discussion.

AG59/6

A Note on HF Communications during Polar Radio Blackouts. K.FOLKESTAD, B.LANDMARK.
AGARDograph 59, 59-64, 1963.
Some preliminary results are presented from a study of hf transpolar propagation conditions. Transmissions from College, Alaska on 12 and 18 Mc/s, received at Kjeller have been analyzed. Selection has been based on results from riometer observations. The possibility of reducing the importance of the polar disturbances by means of relaying technique is also discussed. This analysis is based on results from riometer observations.

AG59/7

The Influence of Polar Blackouts on VLF Circuits. B.LANDMARK.
AGARDograph 59, 65-77, 1 refs, 1963.
Results from a study of the behaviour of long distance vlf circuits during polar radio blackout conditions, as compared with quiet conditions, are presented. There are two major types of polar

radio blackouts. The most common (auroral) type is closely related to magnetic disturbances, and occurs most often near the zones of maximum auroral activity. The results indicate that these disturbances have no great effect on the vlf circuits. The other type of polar blackouts (polar cap type events or proton events) is not closely related to magnetic activity, and occurs over most of the polar cap simultaneously. During this type of event a significant reduction of the strength of the vlf signals has been observed. Discussion.

AG59/8 **The Influence of Solar Disturbances on Very Low Frequency Radio Wave Propagation over a Long High-Latitude Path.** A.EGELAND, B.HULTQVIST, J.ORTNER.
AGARDograph 59, 79-100, 38 refs., 1963.
The effects of solar and terrestrial disturbances on the propagation conditions on 16 kc/s radio waves between Rugby, England (lat. 52.2 deg.N) and Kiruna, Sweden (lat. 67.8 deg.N), a distance of about 2100 km are examined, and the principal findings of the investigation are presented. Discussion.

AG59/9 **Influence of Solar Flares on Transarctic HF Propagation.** J.ORTNER.
AGARDograph 59, 101-107, 9 refs., 1963.
From the observed effects of solar flares on the transpolar hf transmissions between College, Alaska, and Kiruna, Sweden, the following conclusions have been reached: (i) SIDs have only been observed in summer accompanying importance 3 and 3+ solar flares; (ii) flares emitting solar protons with relativistic velocities were followed by absorption starting a few hours after the flares and lasting for several days; (iii) the correlation of absorption with geomagnetic activity as observed for Kiruna seems to be fairly good for the 18 Mc/s receptions.

AG59/10 **Comparison of Solar Flare Effects in the D and E Region of the Ionosphere.** K.LIBL.
AGARDograph 59, 109-118, 11 refs., 1963.
The different enhancement of ionization in the ionospheric D- and E-region is due to different kinds of solar radiation. An attempt is presented to find a one-dimensional parameter: $\delta''f_0E_{max}$ indicative of the energy distribution on the solar spectrum which is rather independent of strength and daytime of the event. With the help of the new technique of continuously recorded ionospheric parameters and of an automatic warning system nearly every ionospheric event can be detected and misinterpretations can be avoided. Only very narrow solar latitude spheres are responsible for the ionospheric effectiveness of flares.

AG59/11 **A Study of F2 Layer Effects as Observed with a Doppler Technique.** K.DAVIES, J.M.WATTS, D.H.ZACHARISEN.
AGARDograph 59, 119-133, 7 refs., 1963.
Changes in the height and shape of the ionosphere produce variations in the frequency, at a receiver, of waves emitted from a stable sender. WWV-10, WWV-15, WWV-20 and WWVH-10 have been recorded, at Boulder, on slow-moving magnetic tape. By rapid playback the Doppler frequency is converted into an audio frequency and the spectrum analyzed by conventional techniques. Records obtained by this technique are presented to illustrate the phenomena observed during magnetically quiet and disturbed periods. Experimental effects associated with solar flares and magnetic sudden commencements are presented. The frequency dependence of the frequency variations is shown to give information concerning the height location of the associated ionospheric effects. Discussion.

AG59/12 **Study of the Effect of Type IV Solar Eruptions on Ionospheric Absorption.** (In French.) D.LEPECHINSKY, C.DAVOUST.
AGARDograph 59, 135-142, 2 refs., 1963.
The effects of solar chromospheric flares on region D of the ionosphere, where certain types of flares produce a sudden increase of ionization and of radio waves absorption (SIDs) were examined. In particular, the following were investigated: (i) the type of solar flares; (ii) the effect on absorption of the intensity and of the duration of the solar noise burst; (iii) the effect of the distance from the subsolar point on the magnitude of the absorption. The investigation covers the period from April, 1957 to December, 1959.

AG59/13 **Backscatter Sounding during Ionospheric Storms.** I.RANZI, P.DOMINICI.
AGARDograph 59, 143-154, 6 refs., 1963.
The results of ionospheric backscatter soundings carried out at Torrechiaruccia, Rome, during severe ionospheric storms from August 1957 to February 1961, are discussed. The advantages of the backscatter soundings for studying the morphology of an ionospheric storm over a large area are demonstrated. The observed displacement of the perturbed zone may be explained as the result of the superposition of the D_{st} and S_D storm components.

AG59/14 **The Influence of Sudden Ionospheric Disturbances on Backscatter Sounding.** R.D.EGAN, A.M.PETERSON.
AGARDograph 59, 155-165, 4 refs., 1963.
Analysis of the IGY three-frequency backscatter records during sudden ionospheric disturbances (SID) has revealed some interesting and unexpected behaviour which is discussed. Long-distance high-frequency propagation-circuit data and riometer records for the same events are compared with the backscatter observations. Discussion.

AG59/15 **Effects of Magnetic Disturbance as Noted on Oblique-Incidence Ionograms.** V.AGY, K.DAVIES.
AGARDograph 59, 167-176, 6 refs., 1963.
Over the period 1951-1958 the sweep-frequency pulse technique was used to study high frequency radio propagation over two east-west paths – Washington-St.Louis (1150 km) and Washington-Boulder (2370 km). Some ionograms observed during magnetic disturbances are presented and compared with the quiet ionograms. The behaviour of the maximum observed frequency and the minimum observed frequency is also discussed. Discussion.

AG59/16 **Solar Effects on Radio Wave Propagation.** M.BOSSOLASCO, A.ELENA.
AGARDograph 59, 177-183, 3 refs., 1963.
Some results regarding the reception of WWV signals (on 15 Mc/s) at Genoa are presented. They demonstrate that the daily variation of the intensity of the signals is well controlled and represented by the MUF (4000)F2. For the first four months of 1961 at night-time the correlation coefficient between the WWV-intensity and the MUF was found to be 0.87.

AG59/17 **Solar-Induced Effects on VHF Ionospheric Propagation at Low Magnetic Latitudes.** W.F.BAIN.
AGARDograph 59, 185-192, 2 refs., 1963.
Signal-intensity behaviour on the Pacific scatter circuits was briefly examined during periods of both moderate and severe ionospheric storminess and during relatively small magnetic fluctuations such as a magnetic bay. Although hf circuits either failed or experienced substantial degradation during severe ionospheric disturbances, the vhf turbulent-scatter mode was virtually unaffected. The significance of the results obtained is discussed.

AG59/18 **On the Influence of Disturbances of Solar Origin on Oblique-Incidence Pulse Transmission.** W.DIEMINGER, H.G.MÖLLER, G.ROSE.
AGARDograph 59, 193-206, 7 refs., 1963.
During the IGY multi-frequency pulse transmissions and simultaneous backscatter observations were carried out over two paths, from Lindau, Germany, 2000 km to Finland and from Lindau 8000 km to south-west Africa. For a variety of examples the effects of solar flares, simultaneous and delayed, are described and interpreted. Discussion.

AG59/19 **The Problem of Arctic Communications Following Solar Disturbances.** S.C.CORONITI, G.E.HILL, R.PENNDORF.
AGARDograph 59, 207-227, 2 refs., 1963.
Analysis of polar ionosonde data for five solar-induced storms shows that the assumption that all links of a polar communication network are affected simultaneously by intense magnetic storms is erroneous. It was found that by use of a frequency and link switching technique (FLS) communication to the middle latitudes and within the polar area was theoretically possible even during an intense polar cap 'blackout'. The FLS technique is discussed from an operational point of view, and results from field experiments are examined.

AG59/20 **Relation of Solar Active Regions at Central Meridian Passage to Ionospheric Disturbance.** C.S.WARWICK, J.V.LINCOLN.
AGARDograph 59, 229-233, 3 refs., 1963.
Describes some of the differences in solar-terrestrial relationships during years of high solar activity and during years of low solar activity. Clear relations between individual solar events and geomagnetic disturbance are found at times of high activity, whereas only relatively weak relationships are present at times of low activity. In the low activity years 27 day recurrence patterns are established. Radio propagation effects accompanying geomagnetic disturbances at the different times of the cycle are briefly discussed.

AG59/21 **On the 27 Days Recurrence Tendency of Radio Propagation Disturbances in the Period of High Solar Activity.** A.OCHS, B.BECKMANN.
AGARDograph 59, 235-244, 3 refs., 1963.
A report is given of some statistical investigations dealing with the radio propagation quality figures determined for the North Atlantic path by the Fernmeldetechnisches Zentralamt (FTZ) and the Central Radio Propagation Laboratory (CRPL). The quality figures of the FTZ show the recurrence tendency, even present in the period of high solar activity, much clearer than those of the CRPL. A description of the method used by the FTZ for evaluating the quality figures is given in an appendix.

AG59/22 **Classification of Ionospheric Storm Types (and Type-Dependence on Solar-Geomagnetic Phenomena).** R.J.CORMIER.
AGARDograph 59, 245-259, 6 refs., 1963.
Deals with ionospheric storm types, their classification and possible prediction of phases through the use of solar and geomagnetic data. The storm types fall into two categories; a major category consisting of two types, A and C, and a minor category consisting of three types, A-1, B and D. The storm types were placed into major and minor categories because it is believed that the minor category storms are subtypes of the major category storms.

AG59/23 **A Year's Study of the Index of Ionospheric Storminess.** H.S.MARSH, R.J.CORMIER, R.A.SWIRBALUS, W.H.CAMERON, R.S.MURPHY.
AGARDograph 59, 261-286, 14 refs., 1963.
Covers an intensive study of seasonal and diurnal variations in the Index of Ionospheric Storminess previously reported and attendant anomalies, with emphasis on the effects of magnetic variations, and on the so-called 'Concord Anomalies'.

AG59/24 **Radio Propagation Quality in the North Atlantic Area 1953-1960.** M.E.NASON.
AGARDograph 59, 287-291, 1963.
A study was made of hf radio propagation disturbances, to determine the frequency of occurrence and the duration of disturbances on a monthly, seasonal and yearly basis. The 6 hr radio quality figures calculated for the North Atlantic path (e.g. New York to London) by the National Bureau of Standards' North Atlantic Radio Warning Service for the years 1953 through 1960 were used exclusively in this work. The more severe disturbances were treated separately. Graphs are presented for both types of disturbances which show the percentage of disturbed hours by months, seasons and years. Discussion.

AG59/25 **Circuit Reliability, Frequency Utilization, and Forecasting in the High Frequency Communication Band.** J.H.NELSON.
AGARDograph 59, 293-301, 1963.
Deals with high frequency propagation giving particular emphasis on circuit reliability, seasonal characteristics, frequency utilization, short range and long range forecasting of signal qualities and frequency requirements. Particular attention is given to circuits operating between New York and the Central European area. Circuits working New York-Tangier and New York-Buenos Aires are also treated. The long range forecasting of recent (1960) magnetic storms associated with solar flares is treated with an explanation of the technique used for such a manner of forecasting. Discussion.

AG59/26 **On the Effect of Solar Disturbances on the Low-Radio-Frequency Ionospheric Reflection Process.** J.R.JOHLER, J.D.HARPER, Jr.
AGARDograph 59, 303-334, 23 refs., 1963.
A flexible theoretical model plasma which can be deformed to fit almost any measured electron-ion altitude profiles is employed together with available geophysical data on the ionosphere to evaluate reflections and transmissions during quiescent and disturbed propagation conditions. The reflection and transmissions in the ionosphere are determined rigorously with the aid of the classical magneto-ionic theory. The complex indices of refraction of the medium are deduced, and a coupling in the plasma between ordinary and extraordinary upgoing and downgoing modes of propagation is investigated. The corresponding reflection and transmission coefficients are then calculated, and certain phenomena which can be expected as a result of the action of a solar disturbance on the reflection process are predicted. A particular disturbance was investigated to illustrate the application of the technique.

AG59/27 **Observations During the Eclipse in February 1961.** L. de SOCIO (Editor).
AGARDograph 59. Suppl., 53 pp., 1964.
The papers presented at the Sixth AGARD Ionospheric Research Committee Meeting on 'The Effect of Disturbances of Solar Origin on Communications' (May, 1961) were concerned with the first results obtained during the total eclipse of the sun in 1961. Individual papers are listed in the following items.

AG59/28 **Results of the Ionospheric Observations made in Rome during the Solar Eclipse of 15 February, 1961.** A.BOLLE, F.COCCIA, C.A.TIBERIO.
AGARDograph 59, Suppl., 1-7, 1964.
Some results of the ionospheric observations at the observatory 'S.Alessio' during the solar eclipse of 15 February 1961 are given, in order to evaluate the greater surface of the ionizing sun with respect to the optical sun.

AG59/29 **Eclipse Effects on Ionospheric Propagation.** M.BOSSOLASCO, A.ELENA.
AGARDograph 59, Suppl., 9-15, 1964.
Two examples of polarization effects on lightning waves recorded at Genoa are first described; by this effect the maxima azimuthal deviation of the recorded radio waves was nearly 20 degrees. During the 1961 eclipse the intensity of lightning waves recorded has shown a sharp increase. The low intensity level occurring during the eclipse for the WWV signals (15 Mc/s), also recorded at Genoa, is described and explained.

AG59/30 **First Results Obtained During the Solar Eclipse of 15 February 1961 on Cosmic Noise Absorption.** N.CARRARA, P.F.CHECCACCI, M.T. de GIORGIO.
AGARDograph 59, Suppl., 17-26, 1964.
The equipment set up in Florence for measuring the ionospheric absorption of cosmic radio noise is described. The apparatus was used for observing the absorption variations during this total eclipse. The results handled to date, are described.

AG59/31 **Photographs Taken at High Altitudes from Balloons during the Total Solar Eclipse, 15 February 1961.** R.CIALDEA, M.CIMINO, G.FEA.
AGARDograph 59, Suppl., 27-33, 1964.
Some notes are given on the technical aspects and the results of solar observations from balloons.

AG59/32 **The Organisation of the Rome Astronomical Observatory for the Observation of the Total Eclipse of the Sun on 15 February 1961. Preliminary General Results of the Observations.** M.CIMINO, G.CAPRIOLI, R.FLAMINI.
AGARDograph 59, Suppl., 35-44, 1964.

AG59/33 **Geomagnetic Observations during the Solar Eclipse of 15 February 1961.** G.SIMEON, A.SPOSITO, A.RUSSO.
AGARDograph 59, Suppl., 45-52, 1964.
The results of geomagnetic observations carried out by two standard portable variographs in the path of totality are referred to. The small variation of the geomagnetic field during the eclipse fits well the ionospheric soundings, S_q values and the simplified Chapman's theory.

AG60 **Man and Radar Displays.** C.H.BAKER.
AD-295-403 AGARDograph 60, 192 pp., 371 refs., 1962.
N63-12685 Introduction; radar scope brightness; pip decay time and the visibility threshold; visibility as a function of pip dimensions; ambient illumination; some visual and perceptual factors; searching for pips; visual estimation of range and bearing; aids to accuracy in reporting range and bearing; plotting and transmission of radar display data; the operator as a monitor.

AG61 **Visual Problems in Aviation Medicine.** A.MERCIER (Editor).
AD-290-065 AGARDograph 61, 118 pp., 1962.
N62-17142 Contains papers presented at the latest meetings of the Vision Committee of the AGARD Aero Space Medical Panel. Abstracts of the individual papers are given in the succeeding items.

AG61/1 **Vision in Aviation Today.** (In French.) A.MERCIER.
AGARDograph 61, 1-16, 55 refs., 1962.
Modern flying conditions may bring about marked visual effects. Electronic devices will be called upon to supply deficiencies of some physiological functions. Pilots' psycho-physiological balance should be subjected to check-ups at regular intervals. Other aspects dealt with are space myopia, eye protection against dazzle, the supply of oxygen, oculo-motor equilibrium and stereoscopic vision, and night and twilight vision control and training.

AG61/2 **Limitation of Ocular Motility and Pupillary Dilatation in Humans during Positive Acceleration.** E.L.BECKMAN, J.D.DUANE, K.R.COBURN.
AGARDograph 61, 17-25, 20 refs., 1962.
Discusses methods of testing subjects in a human centrifuge. Fifty subjects, male and female, ranging from eighteen to fifty-five years, participated in 350 centrifuge runs. The magnitude of acceleration required to produce limitation of ocular motility (LOMA) varied with individual subjects from 3.5 to 7.0 g. A mechanism for LOM/ is postulated.

AG61/3 **The Acceptance of Contact Lenses in Military Personnel.** C.McCULLOCH.
AGARDograph 61, 26-33, 4 refs., 1962.
Twenty-two subjects, supplied with contact lenses, allowed certain conclusions to be drawn after eighteen months. Continuous and efficient use of the lenses is only possible if a fitter is immediately available. The danger of bubbles under the lenses at high altitude is significant. The reasons subjects give for not wearing the lenses are varied and often remarkable.

AG61/4 **Protective Glasses Against Atomic Flash.** J.F.CULVER, A.V.ADLER.
AGARDograph 61, 34-38, 8 refs., 1962.
This is a brief article concerned mainly with the problem of 'flashblindness'. Types of goggles considered are the electro-magnetic type, those using electro-optic and magnetic-optic phenomena, and those using filters of photo-reactive materials. The latter is thought to be the most intriguing.

AG61/5 **Visual Problems of High Altitude Flight.** J.L.CURTIS.
AGARDograph 61, 39-44, 4 refs., 1962.
Visual problems do exist in high altitude flight. Those which are physical or physiological must probably be accepted. However, better cockpit instrumentation and lighting plus better helmets and sighting devices merit investigation.

AG61/6 **Blinking, a Possible Cause of Aircraft Accidents.** (In French.) E.EVRARD.
AGARDograph 61, 45-53, 9 refs., 1962.
Involuntary blinking produces a blind period the average duration of which has been estimated to be 0.55 sec. Inasmuch as at a speed of 300 km per hour 43 m are covered during these 0.55 sec, it has been supposed that, during the approach time, blinking would be a cause of accidents.

AG61/7 **Instrument Dials, Instrument Arrangement and Cockpit Design.** W.F.GRETHER.
AGARDograph 61, 54-70, 16 refs., 1962.
Research data and design applications are discussed which illustrate a variety of instrument and cockpit design problems, under the following topics: visibility of instrument markings, selection of instrument type according to method of use, control-instrument movement relationship, design and arrangement of engine and flight instruments, cockpit controls (design, location, actuation, standardization), and warning lights.

AG61/8 **The Origin of Black-Out.** P.HOWARD.
AGARDograph 61, 71-77, 2 refs., 1962.
Findings in the Farnborough centrifuge showed that black-out is not such a clearly-defined state as it is often thought to be, and they also suggested a method of investigating the physiological basis of the loss of vision. This paper presents the results of a number of approaches to the problem of the origin and site of black-out.

AG61/9 **Visual Problems in Flight at Low Altitude.** (In French.) A.MERCIER, G.PERDRIEL.
AGARDograph 61, 78-83, 1962.
High speeds and low altitude make detection of ground targets more difficult because visual acuity depends upon sensory-psycho-motor chronology. Meteorological and terrain conditions can also affect target detection. Training can improve flying under these conditions. Other causes of visual disturbances are variations in lighting inside and outside of the cockpit, heat, vibrations, twilight, and night flying.

AG61/10 **Training for Night Vision.** (In French.) A.MERCIER, G.PERDRIEL.
AGARDograph 61, 84-88, 1962.
Studies on the value of the morphoscopic night vision, that is to say, perception of shapes under reduced illumination is thought to be the best method of testing the value of an aviator's night vision. Simulation of conditions of night flight by a modified form of the Rose and Flack device has constituted a valuable training method which has improved the morphoscopic threshold by 18% after eight training sessions.

AG61/11 **Ophthalmic Problems Posed by the Use of Helicopters and VTOL Aircraft.** (In French.)
A.MERCIER, G.PERDRIEL.
AGARDograph 61, 89-94, 1962.
The exacting conditions required by helicopter pilots call for correction of refractive defects, mainly myopia and myoptic astigmatism. Other problems include the stroboscopic effect of the rotor blades, atmospheric turbulence at low altitude, hovering flights at high altitude, evaluation of distance, dust during take-off and landing, and the speed at which objects seem to pass by.

AG61/12 **Visual Standards in the Selection of Flying Personnel.** T.J.G.PRICE.
AGARDograph 61, 95-105, 7 refs., 1962.
Standards for aircrew members, proposed by the vision committee of the AGARD Medical Panel are outlined. These differ for different tasks. Strict accuracy in examining and maintenance of standards, both on entering flying training and continuation of the career, is called for.

AG61/13 **Eye Protection in Aviation.** N.C.TURNOUR, C.McCULLOCH.
AGARDograph 61, 106-117, 1 ref., 1962.
After a discussion of optical and physical problems of goggles and visors, the results of a trial in the use of corneal contact lenses is given. Twenty-two personnel from the R.C.A.F. were selected for the trial resulting in certain conclusions to be reached as to the advantages and disadvantages of these lenses.

AG61/14 **Problems of Empty Visual Fields.** T.C.D.WHITESIDE.
AGARDograph 61, 118-120, 1962.
In an empty visual field there is no visible detail, although luminance may not be uniform. This is recognised as a physical environment frequently encountered in flight today. A brief review is given of the physiological and psychological problems associated with it.

AG62 AD-815-345 N65-32475 **Advances in Materials Research in the NATO Nations.** H.BROOKS, N.H.MASON, N.E.PROMISEL, G.H.COOPER (Editors).
AGARDograph 62, 549 pp., 1963.
The proceedings of a NATO Symposium organized by the Structures and Materials Panel of AGARD which contains papers on fundamental research, the rôle of basic research in development, and materials research in six of the NATO countries. Abstracts of the papers are contained in the following items.

AG62/1 **Fundamental Research: Introduction.** H.BROOKS.
AGARDograph 62, 3-6, 1963.
Briefly explains the papers in this basic research section which dealt with the structure and morphology of crystals, the mechanical properties of solids, and topics related to the electrical and magnetic properties of solids.

AG62/2 **Perspectives in Materials Research.** F.SEITZ.
AGARDograph 62, 7-12, 1963.
Attempts to show how the science of atomic physics, as it has developed over the past 30 years, has gradually interpenetrated the technology of materials and changed it from an empirically-based art to an applied science.

AG62/3 **The Occurrence of Ferro-, Ferri-, and Antiferromagnetism in Connection with Crystal Structure.** E.W.GORTER.
AGARDograph 62, 13-14, 1963.
An account of the crystal chemistry of magnetic compounds, a subject which is said to have become of great technological importance.

AG62/4 **Structure and Characteristics of High Polymers in Solution.** (In French.) C.SADRON.
AGARDograph 62, 15-34, 1963.
Briefly reviews problems concerning the structure and statistics of configurations of a linear chain. The principal methods of determining the molecular weight and morphological molecular parameters in a monodisperse solution of a high polymer substance are summarized. The effect of polydispersity is also considered.

AG62/5 **Structures of Organic Solids and New Organic Polymers.** R.HOSEMANN.
AGARDograph 62, 35-53, 47 refs., 1963.
X-ray diffraction gives much new and direct information of high polymers structure. Heavy atom technique helps to analyze the atomic arrangement in crystalline proteins. Theory of paracrystals opens up the structural analysis of synthetic and natural fibres. Stretching experiments combined with small angle scattering of polyethylene show that fibres are a new type of solids with new and unusual properties.

AG62/6 **Thermodynamics and Kinetics of Phase Changes in Solids.** D.TURNBULL.
AGARDograph 62, 55-64, 40 refs., 1963.
Briefly summarizes the state-of-the-art and includes statements of recent developments. The major part of the paper is devoted to the kinetics of phase changes. The problems which appear to be most outstanding are those which deal with the nature of solid-solid interfaces and the rôle of crystal imperfections in nucleation and in some growth processes.

AG62/7 **Status of the Theory of Diffusion in Solids.** D.LAZARUS.
AGARDograph 62, 65-76, 37 refs., 1963.
Surveys the current status of the field of diffusion, noting a number of specific areas in which further experimental and theoretical studies may prove of particular value. New experimental techniques which have been developed for basic studies should be applied to such materials as refractory metals and alloys, intermetallic compounds, oxides, and spinels.

AG62/8 **Structural Study of the Precipitation and the Faults caused by Irradiation.** (In French.) A.GUINIER.
AGARDograph 62, 77-95, 41 refs., 1963.
Gives a discussion on pre-precipitation phenomena in solids, and reviews work that has been done, especially by the author and his colleagues, to study the structural defects produced in crystals by high energy radiations.

AG62/9 **Surface Properties.** R.GOMER.
AGARDograph 62, 97-102, 1963.
Reveals the tremendous unexplored area of the surface properties of solids, and suggests the potential of new experimental techniques for exploring this area.

AG62/10 **Current Status of Dislocation Theory.** A.SEEGER.
AGARDograph 62, 103-116, 33 refs., 1963.
Concerns one aspect of the dislocation theory, i.e. the theoretical study of the properties and the behaviour of dislocation in crystals (e.g. energies and stress fields, interactions between dislocations and point effects, etc.).

AG62/11 **The Direct Observation of Dislocations.** S.AMELINCKX.
AGARDograph 62, 117-169, 89 refs., 1963.
Reviews a number of methods for the direct study of dislocations which have been developed in recent years. They are classified as bulk, surface and thin film methods and their specific fields of application are outlined with respect to their advantages and limitations.

AG62/12 **Flow and Fracture.** D.McLEAN.
AGARDograph 62, 171-192, 60 refs., 1963.
This review attempts, in the first place, to locate the boundaries of present knowledge in the two fields of flow and fracture with particular reference to metals.

AG62/13 **On the Macroscopic Theory of Inelastic Stress-Strain-Time-Temperature Behaviour.** D.C.DRUCKER.
AGARDograph 62, 193-221, 64 refs., 1963.
Attempts to delineate the scope and objectives of the macroscopic theory, and to present a partial view of the present state of the subject. Attention is paid to the broad concepts underlying stress-strain relations and to fatigue and brittle fracture. A brief discussion is included of irreversible thermodynamics and the difficulties in extending it for use in the macroscopic theory.

AG62/14 **Rheology of Polymers and the Plastic Materials.** (In French.) B.PERSOZ.
AGARDograph 62, 223-246, 17 refs., 1963.
The macroscopic viewpoint is presented here, the main theme being the somewhat esoteric mechanical properties of organic materials especially polymers.

AG62/15 **Experiments on Energy Bands in Solids.** B.LAX.
AGARDograph 62, 247-279, 112 refs., 1963.
Deals with the experimental foundations of energy band theory, and explains several new experimental techniques which have come into use during recent years to study the details of energy bands in both metals and semi-conductors.

AG62/16 **Superconductivity.** J.BARDEEN.
AGARDograph 62, 281-291, 18 refs., 1963.
An outline of the physical basis for the microscopic theory and a comparison of theory and experiment for several phenomena. Outstanding difficulties and trends of future research are also discussed.

AG62/17 **Electrical Conductivity.** R.G.CHAMBERS.
AGARDograph 62, 293-302, 58 refs., 1963.
The information needed to calculate the transport properties is summarized, and two recent and very different calculations on the alkalis are discussed and compared. Results obtained by the usual Boltzmann equation methods have recently been re-investigated and generally confirmed by the more rigorous density-matrix techniques.

AG62/18 **Electrical and Thermal Conductivity of Metals and Insulators.** H.BROSS.
AGARDograph 62, 303-322, 40 refs., 1963.
Reports work on the theory of electronic transport phenomena. The theory of thermal conductivity by lattice waves (phonons) is dealt with in detail. A method for calculating quantitatively the change of thermal resistance due to scattering of phonons by lattice defects is developed.

AG62/19 **Semiconductors.** (In French.) P.AIGRAIN.
AGARDograph 62, 323-328, 1963.
Provides a simple and unified review of this specific subject. The author shows clearly how the ideas of band theory and of the nature of chemical bond have opened the field for the discovery of new types of semiconductors.

AG62/20 **Current State of Knowledge Concerning Ferromagnetism and Antiferromagnetism.** (In French.) L.NÉEL.
AGARDograph 62, 329-341, 1963.
Among the topics which receive brief attention in this survey article are the following: rôle of temperature in ferromagnetism, low temperature effects, antiferromagnetism, ferrimagnetism, negative interactions, the local molecular field, transition temperature in antiferromagnetics, the first theory of ferrimagnetism, magnetic orientation, directional phenomena, the rôle of paired atoms, oriented materials, inclined antiferromagnetism, triangular structures, spiral structures.

AG62/21 **The Rôle of Basic Research in Development: Introduction.** N.E.PROMISEL.
AGARDograph 62, 345-347, 1963.
Outlines, briefly, the contents of this section and points out how the papers emphasize the importance of intimate liaison between basic science and applied development.

AG62/22 **Interdependence between Fundamental and Applied Research.** (In French.) M.FRÉJACQUES.
AGARDograph 62, 349-360, 1963.
Gives a definition of fundamental research and shows, with some examples, its very close alliance with industrial research and the numerous advantages it offers to the industrial research worker.

AG62/23 **The Conversion of Chemical Energy into Electrical Energy.** A.J.STAVERMAN.
AGARDograph 62, 361-367, 5 refs., 1963.
Deals with the interplay between basic and applied research, fundamentals of energy conversion, low and high temperature cells, and work conducted at T.N.O., Delft, on this subject.

AG62/24 **Mechanical Properties of Composite Materials.** N.F.ASTBURY.
AGARDograph 62, 369-390, 13 refs., 1963.
Examines the implications of the description brittle mainly in the assessment of ceramics in thermal shock, impact, and in the absorption of elastic energy. Data on a wide range of ceramic materials are discussed. Some observations are included on the fatigue of ceramics, and their behaviour in creep and rocket firing tests are recorded.

AG62/25 **Fundamental Research and Manufacture of Alloys.** (In French.) L.HABRAKEN
AGARDograph 62, 391-406, 43 refs., 1963.
Deals with the improvement of mechanical resistance of alloys at elevated temperatures and the use of the order-disorder phenomenon to increase this resistance.

AG62/26 **The Contribution of Basic Research to the Development of Wrought Nickel-Base Creep-Resisting Alloys.** L.B.PFEIL.
AGARDograph 62, 407-423, 40 refs., 1963.
A summary is given of the knowledge that led to the selection of 80/20 nickel-chromium alloys as the basis for initial development, over the period 1939-45, of improved creep-resisting alloys.

AG62/27 **Refractory Materials Development and its Dependence on Basic Research.** N.E.PROMISEL.
AGARDograph 62, 425-450, 21 refs., 1963.
Deals with the topic of materials for extremely high temperatures, with the objective of highlighting engineering problems encountered in this field. The sections include raw materials, consolidation processes for producing ingots or compacts, primary fabrication, alloy development, flow and fracture, oxidation and protection and some miscellaneous items.

AG62/28 **Organization of Materials Research: Introduction.** N.H.MASON.
AGARDograph 62, 453-455, 1963.
The object of this session was to learn how materials research was arranged, supported, and administered in the NATO nations. This introductory talk summarizes papers received from Canada, France, Netherlands, Norway, U.K., and the U.S.A.

AG62/29 **Organisation of Materials Research in Canada.** H.V.KINSEY.
AGARDograph 62, 457-461, 1963.
A brief paper discussing Canadian organizations and their interrelationships in a superficial manner. A chart gives a general picture commencing with the Government of Canada through the service, civil and research departments to the industry.

AG62/30 **Organization and Co-Ordination of Materials Research in France.** (In French.) C.CRUSSARD.
AGARDograph 62, 463-472, 1963.
The aim of the present note is to draw a catalogue of the French laboratories working on materials research, depending on their more-or-less fundamental or applied character, and on the organizations on which they depend. A detailed list of the laboratories, with some indication on their main activities, is given in the paper.

AG62/31 **Materials Research in the Netherlands.** H.F.J.FREUTEL.
AGARDograph 62, 473-482, 1963.
Surveys the most important organized institutes sponsored by the government to carry out research and development, giving approximate budgets. Two appendices give information on the Netherlands Organisation for Pure Scientific Research (Z.W.O.), the Foundation for Fundamental Research on Matter (F.O.M.), and the Central Organisation for Applied Scientific Research (T.N.O.).

AG62/32 **Materials Research Organization in Norway.** H.KJØLLESDAL.
AGARDograph 62, 483-486, 1963.
Norway has provided research institutes and universities with new buildings and fairly well equipped laboratories. Some details of research expenditure, the organization of scientific and industrial research, and of the Royal Norwegian Council for Scientific and Industrial Research, are outlined.

AG62/33 **The Organization of Materials Research in Great Britain.** N.P.ALLEN.
AGARDograph 62, 487-499, 1963.
In addition to outlining the parts played by the several organizations and institutions on materials research together with overall costs, a useful table is given which shows the research associations and the materials and subjects they deal with.

AG62/34 **Organization of Materials Research in the United States.** W.J.HARRIS, Jr.
AGARDograph 62, 501-511, 1963.
Gives a general discussion of the support of materials research and development in the U.S.A., the administration of programmes, the rôle of committees in organization, and some general problems which would affect NATO.

AG63 **Radio Navigation Systems for Aviation and Maritime Use: A Comparative Study.** W.BAUSS (Editor).
AD-426-749 AGARDograph 63, 206 pp., 1963.
N64-13150 This volume presents a study of an examination and comparison of present long and medium-range navigation systems, applying uniform rules of evaluation. It analyzes the extent to which the systems are suitable for common use by civil aviation and merchant marine. Abstracts of the papers included are given in the succeeding items.

AG63/1 **Introduction.** H.C.FREIESLEBEN.
AGARDograph 63, 1-15, 13 refs., 1963.
Contents: navigation and location; radio navigation systems which have been examined; basis of comparison of the systems; viewpoints for comparative consideration in shipping and aviation; the accuracy of a system; concluding remarks; supplementary remarks.

AG63/2 **Radio Direction-Finding on Board Aircraft and Ships.** W.T.RUNGE.
AGARDograph 63, 19-27, 13 refs., 1963.
Radio direction finding as used in this paper is defined specifically as 'determining the bearing of radio transmitting stations by means of an airborne or shipborne radio direction finder'. The system is described briefly, together with the general methods of use, types of equipment and accuracy to be expected.

AG63/3 **Consol and Consolan.** E.KRAMAR.
AGARDograph 63, 29-39, 23 refs., 1963.
CONSOL is the international designation of the German radio navigation system 'Sonne' which was developed from the 'Elektra' beacon. CONSOLAN is a slightly modified version having only two antennae instead of three aerials in a straight line. They are suitable for long range navigation. The principle of the system and accuracy is included in the description.

AG63/4 **Navaglobe.** T. von HAUTEVILLE.
AGARDograph 63, 41, 1963.
A very short description of this long-range rotating radio beacon which operates in the 100 kc/s frequency band and which was developed in the U.S.A. Indications are given where a technical description may be seen of 'Navarho' which is essentially similar to the original 'Navaglobe'.

AG63/5 **VOR-System: The Very High Frequency Omni-Directional Range System.** K.BÄRNER.
AGARDograph 63, 43-57, 27 refs., 1963.
In order to overcome interferences by static and night effect, v.h.f. omni-directional range VOR was developed in the U.S.A., and is still operating on the same principle, although a variety of constructions are in use. The principles, accuracy, expenditure and types of equipment are discussed.

AG63/6 TACAN: Tactical Air Navigation. T. von HAUTEVILLE.
AGARDograph 63, 59-70, 8 refs., 1963.
This is a 1000 Mc/s Rho-Theta system for short range navigation developed in the U.S.A. since 1950. Further developments include its application to instrument landing and as a data link which allows simultaneously and without mutual interference on the same r.f. channel, the transmission of bearing and distance information together with communication air-to-ground and ground-to-air. Principles, errors and equipment are outlined.

AG63/7 VORTAC and VOR/DMET. K.BÄRNER.
AGARDograph 63, 71, 3 refs., 1963.
The VORTAC radio navigation system is a combination of the VOR system operating in the v.h.f. band and TACAN system operating in the u.h f. band. VOR and DMET (distance measuring equipment TACAN) is intended for use in civil aviation only. The paper very briefly outlines their use.

AG63/8 Navarho. T. von HAUTEVILLE.
AGARDograph 63, 73-80, 6 refs., 1963.
This is a long-range Rho-Theta navigation aid operating in the 100 Kc/s band. It has full compatibility with short range systems and has the ability to display bearing and distance information directly to the pilot. Test results show that the system does not yet meet the accuracy required by ICAO. The system is described together with equipment needed and expenditure.

AG63/9 Decca. H.LUEG.
AGARDograph 63, 81-101, 16 refs., 1963.
Describes the system and equipment for ground stations, ships and aircraft. The Decca system is based on the principle of phase comparison. Thus the ground transmitters can be operated without modulation. Frequency-groups of Decca-chains in operation to December, 1960 are tabulated.

AG63/10 DECTRA: Decca Tracking and Ranging. H.LUEG.
AGARDograph 63, 103-112, 4 refs., 1963.
This system has been evolved from the Decca system. It is a hyperbolic long-range radio navigation aid for continuous position-fixing between two base lines which may be disposed at 3000 to 4000 km apart. In addition to aircraft navigation, its application to shipping was being tested at the time of writing this report.

AG63/11 Standard-LORAN: Long Range Navigation. E.KRAMAR.
AGARDograph 63, 113-118, 11 refs., 1963.
Loran is a system based upon an American proposal in 1940. It depends on the measurement of the time difference between pulses which are radiated synchronously by a pair of transmitters located at a distance of several hundred kilometres. Description and brief details of equipment are given.

AG63/12 LORAN-C. E.KRAMAR.
AGARDograph 63, 119-126, 9 refs., 1963.
The Loran-C uses the same principles as Standard-Loran (see previous abstract) but uses the low frequency range of 100 kc/s. The coverage of the Loran-C chain is outlined, together with system description, equipment, and the other relevant details.

AG63/13 The Radio Mesh System (Radio-Mailles). H.SCHUCHMANN.
AGARDograph 63, 127-138, 14 refs., 1963.
This system is a French development carried out by an American company. It is a hyperbolic navigation system in which a low frequency modulation of the transmitters is used for the creation of hyperbola systems. It is suitable for air and marine navigation and is being tested in the Paris area.

AG63/14 DELRAC (Decca Long Range Area Coverage) and Omega. H.LUEG.
AGARDograph 63, 139-145, 3 refs., 1963.
Both systems are hyperbolic radio navigation equipments operating in the 10-14 kc/s band, and are designed to give world-wide coverage. Phase comparison of c.w. signals from two stations enables the determination of a line of position. Cost of the equipment is included in this description.

AG63/15 Navarho-H. T. von HAUTEVILLE.
AGARDograph 63, 147-148, 3 refs., 1963.
This is a proposal by ICAO. A 30-station Navarho network would be needed for world-wide coverage. By measuring the bearing to one station and the difference between the distances of two stations, the position fix is determined by the intersection of a radial and a hyperbolic line of position. To-date nothing is known concerning its state of development.

AG63/16 **Navarho-HH.** T. von HAUTEVILLE.
AGARDograph 63, 149-150, 3 refs., 1963.
This version replaces the radial line of position, used in Navarho-H, by a second hyperbolic line of position and to get a fix from two similar lines of position. Navarho-HH requires three ground stations with stable phase relation and which can be received simultaneously to provide a fix. The description is very brief.

AG63/17 **Navarho-RHO.** T. von HAUTEVILLE.
AGARDograph 63, 151, 3 refs., 1963.
Position is determined by two distance measurements thereby giving greater accuracy than a system depending on a bearing measurement. Very brief details are given here of the system, accuracy, operational considerations, and equipment.

AG63/18 **Accuracy and Range of Radio Navigational Systems.** G.ULBRICHT, K.BÄRNER, W.FEYER, H.C.FREIESLEBEN, R.KÜMMICH, H.LUEG.
AGARDograph 6. 153-179, 1963.
Contents: definition of the term 'positional accuracy'; the standard deviation and the root mean square error; the radio error; conclusions; tables and diagrams of the radial error of radiolocation systems.

AG63/19 **Introduction to the Tables.** T. von HAUTEVILLE.
AGARDograph 63, 181-190, 1963.
The tables contain (i) general physical and technical data relating to various radio navigation systems; (ii) considerations on the navigational use including operation of the equipment; and (iii) data on the expenditure involved. The tables thus allow a comparison and facilitate the evaluation of the various characteristics of the different systems.

AG64 **A Review of Measurements on AGARD Calibration Models.** R.HILLS (Editor).
AD-296-753 AGARDograph 64, 245 pp., 1961.
N63-13508 Six papers are presented giving analyses of measurements made in various wind tunnels on AGARD calibration Models A, B, C, D and E. The results show a considerable scatter, particularly at transonic speeds on Models B and C. Abstracts of the individual papers are given in the following items.

AG64/1 **Tests on AGARD Model A.** R.HILLS.
AGARDograph 64, 1-34, 27 refs., 1961.
An analysis was made of wind tunnel, flight and range measurements on a slender body of revolution. The tests covered a range of Re from 1×10^6 to 140×10^6 and Mach 0.85 to 6.9. With transition fixed near the nose of the body, the measurements of drag in the various facilities show reasonable agreement but, with a smooth model there are wide variations due to differing transition positions.

AG64/2 **A Review of Measurements on AGARD Calibration Model B in the Transonic Speed Range.** H.VALK, J.H. van der ZWAAN.
AGARDograph 64, 35-94, 15 refs., 1961.
Contains a survey and a comparison of the results from tests with AGARD Calibration Model B at Mach 0.7 to 1.3. The available data include tests in different wind tunnels, at different Re and blockage percentages for models with and without fixed transition. The results from different sources show many discrepancies. A first effort is made to establish reference curves, to facilitate further comparison.

AG64/3 **A Review of Measurements on AGARD Calibration Model B in the Mach Number Range from 1.4 to 8.** J.P.HARTZUIKER.
AGARDograph 64, 95-136, 33 refs., 1961.
Contains a survey and a comparison of the results from tests with AGARD Calibration Model B at Mach 1.4 to 8. The data include tests from various wind tunnels and in free flight, for a range of Re between 10^6 and 98×10^6. Models with and without fixed transition of the boundary layer are considered. Good agreement between the various measurements of the lift, the pitching moment and the neutral point location is found. With respect to drag many differences exist, some of which can be explained.

AG64/4 **A Review of Measurements on AGARD Calibration Model C in the Transonic Speed Range.** H.VALK.
AGARDograph 64, 137-211, 14 refs., 1961.
Contains a survey and a comparison of the results from tests with AGARD Calibration Model C at Mach 0.7 to 1.3. The available data include tests in different wind tunnels, at different Re and blockage percentages, on models with and without fixed transition of the boundary layer. The correspondence between the results of the various tests is not very satisfactory. There are many differences and the pitching moment, especially, shows large discrepancies in value and in trend.

AG64/5 **Tests on AGARD Model D.** R.HILLS.
AGARDograph 64, 214-227, 5 refs., 1961.
Measurements of damping derivatives made in four different low speed tunnels on an unswept tapered wing are compared. All the tunnels used a forced oscillation technique, but had different methods of taking the measurements. The results show reasonable agreement, though there is a considerable scatter in any one set of measurements.

AG64/6 **Tests on AGARD Model E.** R.HILLS.
AGARDograph 64, 229-245, 18 refs., 1961.
Tests on hemispheres in various hypersonic facilities are summarized. Pressure distribution and heat transfer measurements are in reasonable agreement over the forebody though there are some discrepancies in results over the afterbody. A few measurements of shock wave detachment distance are also compared with theoretical curves.

AG65 **Structural Aspects of Acoustic Loads.** B.L.CLARKSON.
AD-294-146 AGARDograph 65, 115 pp., 91 refs., 1960.
N63-80506 Experimental and theoretical work is reviewed. The sound pressure levels in the near field of jets and rockets have been investigated for a range of operating conditions. Work on boundary layer fluctuations has established the skin r.m.s. pressure levels up to transonic speed, but further investigations are in progress to establish these values for supersonic speeds. Finally, studies are reported which involve the response to random pressure fluctuations and it is concluded that more experimental work is needed before the various theories can be put to practical use.

AG66 **Requirements for an Axial Fatigue Machine Capable of Fast Cyclic Heating and Loading.**
AD-407-088 H.P. van LEEUWEN, M.C.MUCUOĞLU.
N63-17668 AGARDograph 66, 101 pp., 59 refs., 1961.
Types of axial fatigue machines were studied with regard to the drive system, load capacity, frequency and accuracy. Additional studies concerned fast heating and cooling methods and their compatibility with the machines. Suggestions are made for modifications of existing equipment. Additional problems, such as extension measurement and temperature measurement, are briefly discussed.

AG67 **Ground Effect Machines.** T.D.EARL.
AD-406-351 AGARDograph 67, 150 pp., 128 refs., 1962.
N63-16456 A study of the problems and controlling parameters in the application of annular jet and other techniques to aircraft and to the design of ground and water-borne craft.

AG68 **The High Temperature Aspects of Hypersonic Flow.** W.C.NELSON (Editor).
AD-853-931 AGARDograph 68, 786 pp., 1964.
N64-26126 This contains the Proceedings of the AGARD-NATO Specialists' Meeting sponsored by the Fluid Dynamics Panel of AGARD and held in Belgium, April, 1962. The papers include articles on future problems, inviscid flows, experimental techniques, chemical kinetics and radiation, radiation and wakes and heat transfer and viscous flows. A discussion is appended on high temperature hypersonic facilities. Individual abstracts of the papers are given in the succeeding items.

AG68/1 **Hypersonic Aerodynamic Problems of the Future.** H.J.ALLEN.
AGARDograph 68, 1-41, 40 refs., 1964.
Discusses the subsatellite-speed vehicle problems of the past, the near-Earth space vehicle problems of the present, and the deep space vehicle problems of the future. Included are heating problems, determination of retrorocket braking, gas radiation effects on flow, and analyses of meteor tracking data which demonstrate the usefulness of the tracking camera for yielding information on aerodynamic heating. Discussion.

AG68/2 **Unsteady Shock Propagation in a Relaxing Gas.** D.A.SPENCE.
AGARDograph 68, 43-47, 1 ref., 1964.
A study is made of the motion of the shock wave produced when a piston is impulsively set in motion with constant velocity into a diatomic gas at rest, conditions being such that behind the shock there is a zone of vibrational or dissociational relaxation. Distributions of pressure and velocity between the piston and the shock are found. Some applications to other shock motions are considered. Discussion.

AG68/3 **The Effect of Vibrational Relaxation on Hypersonic Nozzle Flows.** J.L.STOLLERY, J.E.SMITH, C.PARK.
AGARDograph 68, 49-66, 21 refs., 1964.
Part 1 reproduces an earlier note in which a simple method is given of estimating the distribution of vibrational temperature along a hypersonic nozzle. In Part 2 more exact solutions of the non-equilibrium nozzle flow of a vibrating gas are given. The solutions were obtained on a Ferranti 'Mercury' computer. Discussion.

AG68/4 **Electron-Ion Recombination in Argon Flowing through a Supersonic Nozzle.** K.N.C.BRAY.
AGARDograph 68, 67-87, 21 refs., 1964.
A mechanism is postulated for the recombination of electrons and ions in a high temperature argon plasma. This, together with the quasi-one-dimensional flow equations, is used to study the flow of ionized argon through a supersonic wind tunnel nozzle. The results of numerical computations are presented. Discussion.

AG68/5 **Characteristic Calculation of Non-Equilibrium Flows.** R.SEDNEY, J.C.SOUTH, N.GERBER.
AGARDograph 68, 89-104, 18 refs., 1964.
Discusses the numerical method of characteristics, and develops a successful technique which is of second order accuracy. The choice of dependent variables was important to the success of computation. The results of computing flows over wedges are given. Discussion.

AG68/6 **A Similitude for Non-Equilibrium Phenomena in Hypersonic Flight.** W.E.GIBSON, P.V.MARRONE.
AGARDograph 63, 105-131, 24 refs., 1964.
Presents a general discussion of binary scaling; analyzes binary scaling for normal shocks; treats the case of blunt body flows, the accuracy of the basic Newtonian theory, and Newtonian solutions for non-equilibrium flows; determines the range of validity of binary scaling for non-equilibrium airflows. The concluding remarks point out the implications for flight testing. Discussion.

AG68/7 **Theoretical Studies of Inviscid Hypersonic Flows with Chemical Reactions.** R.VAGLIO-LAURIN.
AGARDograph 68, 133-148, 5 refs., 1964.
Continuum flows about blunt-nosed slender bodies representative of missiles and satellites are considered with emphasis on observables. Solutions applicable near the nose and very far downstream are presented and evaluated by comparison with a large number of results obtained by 'numerical experiments'. Effects of chemical reactions on fluidmechanical aspects of the problem, in particular on similitude, are discussed.

AG68/8 **Hypersonic Flow Field Calculations: Three-Dimensional and Real Gas Flows.** C.MORETTI, R.W.BYRNE.
AGARDograph 68, 149-162, 26 refs., 1964.
Describes numerical methods used to provide the hypersonic vehicle designer with information about the local environments surrounding these vehicles. First, the methods used at the General Applied Science Laboratories for the calculation of hypersonic flow fields about axisymmetric bodies at zero angle of attack are briefly discussed. Secondly, details are given of the method used to calculate three-dimensional flow fields.

AG68/9 **Recent Investigations of the Aerodynamic Characteristics of General and Specific Lifting and Non-Lifting Configurations at Mach 24 in Helium, Including Air-Helium Simulation Studies.** A.HENDERSON, Jr.
AGARDograph 68, 163-190, 27 refs., 1964.
Presents hypersonic data obtained in helium at Langley Research Center and includes information on (i) induced pressures on cylindrical rods behind various noses, (ii) variation of the longitudinal aerodynamic characteristics of a series of low fineness ratio bodies with systematic changes in geometry, and (iii) an experimental air-helium simulation investigation on a variety of general and specific configurations. Discussion.

AG68,10 **On Two New Methods for the Solution of Non-Equilibrium Flows.** L.G.NAPOLITANO.
AGARDograph 68, 191-216, 15 refs., 1964.
Presents two approximate methods, the first being developed with reference to linear flow and the second with reference to one dimensional flow. The first is based on a suitable power series solution in terms of a parameter which is a measure of the difference between the equilibrium and frozen Mach numbers of the free streams. The second method is based on a construction of uniform approximations of systems of ordinary differential equations with a small parameter in the higher derivatives.

AG68/11 **Shock Tunnel Studies of High-Enthalpy Ionized Airflows.** A.Q.ESCHENROEDER, J.W.DAIBER, T.C.GOLIAN, A.HERTZBERG.
AGARDograph 68, 217-254, 48 refs., 1964.
Recent developments in shock tunnel techniques have permitted experimentation in hypersonic airflows having very high enthalpies. In the present paper, the Cornell Aeronautical Laboratory 6 ft shock tunnel is described, the effects of non-equilibrium flow in such a device are assessed, and high-enthalpy experiments involving nozzle flow ionization are examined. Discussion.

AG68/12 **Temperature Measurements in a Hypersonic Shock Tunnel.** K.C.LAPWORTH.
AGARDograph 68, 255-269, 9 refs., 1964.
Temperatures in the region just before the reflecting end of a reflected-shock hypersonic tunnel have been measured by the method of sodium-line reversal. It is found that steady temperatures are achieved at below-tailoring conditions. Temperature measurements give a good indication of the actual duration of high temperature in the shock-heated gas. In many cases the duration of high temperature turns out to be much less than previously estimated. Discussion.

AG68/13 **A Mass Flow Probe for use in Short Duration Hypersonic Flows.** R.J.STALKER.
AGARDograph 68, 271-280, 1 ref., 1964.
A probe is described which measures mass flow per unit area in a hypersonic shock tunnel and therefore, in combination with the pitot pressure provides a measurement of local velocity and density. Gas is entrained from a stream tube of known cross-sectional area, cooled to ambient temperature by passage through a bed of small glass spheres, and ejected through a choked orifice of known size. A measurement of pressure ahead of the orifice is then used to deduce the mass flow without reference to the high temperature properties of the gas. Characteristics of the probe and experimental results are discussed. Discussion.

AG68/14 **Optical Measurement of High Temperatures.** (In French.) L.NADAUD, M.GICQUEL.
AGARDograph 68, 281-297, 16 refs., 1964.
The O.N.E.R.A. method for measuring flame temperatures below 3,000 deg.K, based on the reversal of the spectral beam and comparison with a standard light source, is described. The use of a light standard at 5,000 deg.K enables the range of application of this method to be extended to about 10,000 deg.K. The response time of this method is of the order of 10^{-5} sec. Discussion.

AG68/15 **An Experimental Method for Measuring the Flow Properties of Air under Equilibrium and Non-Equilibrium Flow Conditions.** O.L.ANDERSON.
AGARDograph 68, 299-313, 8 refs., 1964.
This is a spectroscopic method suitable for use in shock tubes which has been developed to measure the temperature and mole concentration of oxygen in air between 300 and 3,000 deg.K. Temperature and density measurements were made to evaluate the accuracy of the equipment using shock-heated oxygen-argon mixtures, and also air. Discussion.

AG68/16 **Improvement of a Short Duration Arc Wind Tunnel by the Development of a Rotating Arc in the High Pressure Chamber.** (In French.) M.DELATTRE.
AGARDograph 68, 315-322, 1964.
O.N.E.R.A. have constructed an arc wind tunnel designated ARC 1 in which the conditions generated are obtained by the dissipation of energy of 1 megajoule in the interior of the arc chamber. However, this apparatus was subject to various inconveniences in use due to the variations in mean value of the arc voltage; these disadvantages were circumvented by the use of a rotating arc. Experimentation with the rotating arc apparatus is described. Discussion.

AG68/17 **Status of Development of Hotshot Tunnels at the AEDC.** J.LUKASIEWICZ, R.JACKSON, J.D.WHITFIELD.
AGARDograph 68, 323-356, 15 refs., 1964.
Present status of the AEDC-VKF hotshot tunnels, resulting from development during the last two years, is reported. Development of arc chambers and instrumentation is described. It is shown that good quality force and pressure measurements are made at test section velocities of about 10,000 ft/sec. Correlation of heat transfer rate and velocity measurements shows that heat transfer rates can be measured to within ±20 per cent. Limitations of hotshot operation at high enthalpies, due to material problems and excessive heat losses, are discussed. Discussion.

AG68/18 **Problems of Interpreting the Results of Measurements in Arc Wind Tunnels.** (In French.) J.P.CHEVALLIER, F.BOUNIOL.
AGARDograph 68, 357-370, 8 refs., 1964.
O.N.E.R.A. built in 1959 a short-duration hypersonic tunnel (ARC 1) in which an electric arc supplied the operating conditions required for the flow. The following problems that arose in the use of this installation are examined: determination of the operating conditions; determination of reference conditions by means of corrective factors, the calculation of the nozzles; the process of terminating the flow; errors arising in the determination of reference values. Discussion.

AG68/19 **High Velocity Guns for Free-Flight Ranges.** A.C.CHARTERS, J.S.CURTIS.
AGARDograph 68, 371-404, 12 refs., 1964.
Discusses a recent development – the accelerated-reservoir light-gas gun (AR-LG). This gun has fired a saboted glass sphere at a velocity of 26,800 ft per sec, and a solid plastic cylinder at a velocity of 32,800 ft per sec. A description of the physics range at DRL General Motors Corporation is also included. Discussion.

AG68/20 **Plasma Studies in Hypersonic Ranges.** M.LETARTE, M.GRAVEL, L.E.MOIR.
AGARDograph 68, 405-417, 17 refs., 1964.
Two different approaches for the study of the plasma in high temperature flow surrounding a hypersonic projectile in flight are (i) on-board telemetry, and (ii) microwave diagnostic techniques external to the model. The paper describes the equipment involved and up-to-date results. The latter are also compared with theoretical predictions. Discussion.

AG68/21 **Langmuir Probe and Velocity Measurements in the ARDE Plasma Jet.** W.A.CLAYDEN.
AGARDograph 68, 419-446, 13 refs., 1964.
The velocity has been obtained from the measurements of the potential produced by a magnetic field normal to the direction of flow of ionized gases and a typical velocity is 10^5 cm/sec. The effects of the degree of ionization, shape of probes and the eddy currents on the velocity measurements are discussed. A simple theory is given for the interpretation of results from a Langmuir probe operating in a hypersonic plasma flow when the mean free path of the neutral particles is larger and the Debye length smaller than a typical probe dimension; typical measurements give an electron density of 10^{13} electron/cm^3 and a temperature of 2,000 deg.K.

AG68/22 **On Chemical Effects and Radiation in Hypersonic Aerodynamics.** P.H.ROSE, J.D.TEARE.
AGARDograph 68, 447-470, 37 refs., 1964.
This paper represents a review of the state of knowledge, with special emphasis on the work in progress at the Avco-Everett Research Laboratory, of the radiative characteristics of non-equilibrium flows and strong normal shocks. This problem couples our knowledge of chemical kinetics, radiation physics and the dynamics of hypersonic flows. Consequently, a short review of chemical kinetics and radiative properties of air is also made. Discussion.

AG68/23 **A Measurement of the Recombination Rate of Oxygen.** J.WILSON.
AGARDograph 68, 471-483, 13 refs., 1964.
The recombination rate has been measured in a low expansion ratio shock tube which is described. Shock waves between M = 7.5 and 9.5 in argon and oxygen are used. The temperature drop across the expansion is about 700 deg.K. Measurement of the degree of dissociation downstream of the expansion leads to the recombination rate. The means of measurement is by absorption of ultraviolet light. The rate constants for recombination are compared with those obtained by reflecting the known dissociation-rate constants through the equilibrium constant.

AG68/24 **The Problem of Ionizational Relaxation for Moderately Strong Shocks in Monatomic Gases.** D.G.H.FROOD.
AGARDograph 68, 485-500, 10 refs., 1964.
It is pointed out that in addition to phenomena already described, the mechanism of initial ionization may be due to the few, free electrons which always exist inherently to some degree in the undisturbed region ahead of the shock, and which, after crossing the shock front, become capable of initiating the ionizing process. The possibility of this ionization mechanism occurring is examined in detail. Discussion.

AG68/25 **Methods and Results of the Study of Hot Hypersonic Flows by Means Exterior to the Flow.** (In French.) A.AURIOL.
AGARDograph 68, 501-517, 17 refs., 1964.
Introduction: visualization methods; results from visualization methods; light-emission by a projectile and its wake; methods of study using centimetre and millimetre waves; conclusion. Discussion.

AG68/26 **Experimental Measurement of Shock Detachment Distance on Spheres Fired in Air at Hypervelocities.** R.K.LOBB.
AGARDograph 68, 519-527, 6 refs., 1964.
Presents results from some recent measurements of shock detachment. These tests yield accurate information about the thermodynamic state variables of high temperature air in equilibrium as well as a check on available calculated data. Moreover if the density is low, then the shock detachment distance becomes a measure of lag in the exchange between the energy of translational motion and the internal modes and chemical reactions. Discussion.

AG68/27 **Fundamental Equations of Radiation Gas Dynamics.** R.GOULARD.
AGARDograph 68, 529-554, 4 refs., 1964.
Radiation energy transfer is introduced as an average representation of electromagnetic transport processes. Fundamental properties are defined and an analogy drawn with molecular properties. The interaction parameters with homogeneous matter and with interfaces are discussed. Radiation terms are then introduced into the conservation laws and into several classical relations of fluid dynamics. Discussion.

AG68/28 **Radiation Measurements from the Plasma Sheath Surrounding Hypersonic Projectiles.** A.LEMAY.
AGARDograph 68, 555-567, 3 refs., 1964.
The measurements fall into three broad categories corresponding to three main types of experiment performed: (i) those of total intensity of radiation from the stagnation region within given spectral bandwidths, obtained using photodetectors; (ii) those of spectral distribution of intensities for the integrated radiation from the plasma as a whole, obtained using conventional spectrographs; (iii) those of spatial distribution of intensities within a given spectral bandwidth obtained using an image converter camera. The results are of particular interest in the study of relaxation and ablation phenomena and yield some preliminary information on wake structure. Discussion.

AG68/29 **Measurements of Radiation from the Flow Fields of Bodies Flying at Speeds up to 13.4 Kilometers per Second.** T.N.CANNING, W.A.PAGE.
AGARDograph 68, 569-582, 12 refs., 1964.
The integrated effects of radiation sources are deduced from photometric measurements of the radiation from shock layers of small bodies fired from light gas guns. Tests were performed over widely varying density. The measurements of radiation for wavelengths greater than about 0.5μ disclose important radiation from the hot model surface and ablated material from plastic models. Ablation of the model surface appears to control the amount of radiation emitted from the wake to an even greater extent. Discussion.

AG68/30 **Hypersonic Heat Transfer in the Air Laminar Boundary Layer.** J.A.FAY.
AGARDograph 68, 583-605, 38 refs., 1964.
A review is given of the methods and data used in computing the transport properties in a laminar boundary layer in air on a vehicle moving at velocities as great as 50,000 ft/sec. Particular attention is given to the problem of determining the transport properties of partially ionized air. Comparisons are made of the transport properties which have been estimated by various authors as well as the heat transfer determined from the solution of the laminar boundary layer equations for stagnation point flow. The latter are compared with some experimental measurements. Discussion.

AG68/31 **Radiative Heating of Vehicles Entering the Earth's Atmosphere.** B.H.WICK.
AGARDograph 68, 607-627, 21 refs., 1964.
Considers the problem of calculating the equilibrium radiative heating of vehicles entering the Earth's atmosphere at up to twice satellite velocity with particular attention to manned vehicles returning from the Moon or Mars. Numerical results are given for evaluating stagnation point heat flux and heat flux distributions from spherical segment noses for wide ranges of velocity and altitude. Included are calculated values of stagnation point radiative heat flux and total heat for manned Lunar and Mars vehicles. Discussion.

AG68/32 **Hypersonic Ablation.** L.STEG, H.LEW.
AGARDograph 68, 629-680, 53 refs., 1964.
Types of material are considered which are useful for the survival of re-entry conditions. They include quartz, Teflon, reinforced phenolic resin, and graphite. Their behaviour is studied from an experimental and theoretical point of view. Discussion.

AG68/33 **The Effect of Catalytic Surfaces on Stagnation Point Heat Transfer in Partially Dissociated Flows.** J.R.BUSING.
AGARDograph 68, 681-691, 9 refs., 1964.
Experimental results are presented, which show that the heat transfer rate to a silicon monoxide coated surface is less than that to a platinum surface when the flow outside the boundary layer is partially dissociated. The recombination coefficient for the platinum surface used in these tests lies between 6×10^{-4} and 6×10^{-3}. The flow in the stagnation region was not in equilibrium and was only half dissociated. Suggestions are made for the construction of a probe to measure atom concentrations and relaxation times in short duration flows. Discussion.

AG68/34 **Development of the Boundary Layer in a Hypersonic Nozzle.** (In French.) R.MICHEL.
AGARDograph 68, 693-716, 4 refs., 1964.
Presents a summary of work carried out to establish the basis of an approximate method of calculation for predicting the development of the boundary layer on the walls of nozzles for the case of high-enthalpy hypersonic flows. The method is a prolongation and extension of that in O.N.E.R.A. Publ.102. Discussion.

AG68/35 **Leading Edge Bluntness and Slip Flow Effects in High Temperature Hypervelocity Flow over a Flat Plate.** H.T.NAGAMATSU, J.A.WEIL, R.E SHEER, Jr.
AGARDograph 68, 717-742, 43 refs., 1964.
The flow phenomena over a plate with leading edge thickness of 0.035 in at rarefied hypersonic flow conditions were investigated by taking schlieren photographs and measuring local heat transfer rates. Flow Mach numbers were 7.8 to 25.4 with reflected equilibrium stagnation temperatures of approximately 2600 and 7000 deg.R. The experimental heat transfer measurements were correlated with theory, which was based upon the assumption of no slip at the surface. Discussion.

AG68/36 **An Assessment of Our Present Status and Future Requirements for High Temperature Hypersonic Facilities.**
AGARDograph 68, 743-778, 1964.
The moderator of this discussion was R.N.Cox of the R.A.R.D.E. Questions considered were (i) What conditions must we simulate and to what extent is partial simulation possible? (ii) What existing facilities can simulate conditions of interest to real gas studies? (iii) What are the limitations on existing facilities? (iv) To what accuracy must quantities be measured? Are flow quantities known to that accuracy on, say, a typical wind tunnel nozzle? (v) Are the right facilities being developed for the future?

AG69
AD-440-312 **A Correlation Study of Methods of Matrix Structural Analysis.** R.D.GALLAGHER, I.RATTINGER, J.S.ARCHER.
AGARDograph 69, 113 pp., 35 refs., 1964.
The results of a review of airframe matrix structural analysis are presented. Concepts of the force and displacement approaches are described and areas of agreement between published methods are indicated. Techniques for determining the force displacement properties of discrete elements employed in the analytical idealizations of structures are reviewed, and their use and limitations illustrated. Extensive analyses of multiweb low AR wings are described and the results obtained presented. A detailed discussion of future research topics in matrix structural and aeroelastic analysis is included.

AG70
AD-438-017
N64-19716 **Flow Visualization in Wind Tunnels using Indicators.** R.L.MALTBY.
AGARDograph 70, 179 pp., 1962.
Various flow visualization techniques in current use in British wind tunnel practice which are not dealt with fully elsewhere are described. Emphasis is on those techniques that have been developed during recent years – particularly those devised for the understanding of separated flows. These include two of the most valuable methods for investigating three-dimensional flow (the vapour screen and surface oil flow techniques). Other techniques described include those for locating boundary-layer transition, and smoke techniques for use in low-speed wind tunnels. An extensive bibliography is included. Abstracts of the individual papers are given in the succeeding items.

AG70/1 **The Surface Oil Flow Technique: The Motion of a Thin Oil Sheet under the Boundary Layer on a Body.** L.C.SQUIRE.
AGARDograph 70, 7-28, 8 refs., 1962.
The main parameter in this problem is the ratio of the viscosity of the fluid in the boundary layer to the viscosity of the oil. The solutions obtained are valid for all values of this ratio likely to be found in practice. Numerical results have been produced for infinite wings with velocity distributions outside the boundary layer of the form $U = ax$ or $B = B_0 - B_1x$. The parameters have been related to typical pressure distributions and are calculated in an appendix. A second appendix presents a discussion of the extension of the results to compressible and turbulent layers.

AG70/2 **The Surface Oil Flow Technique for use in Low Speed Wind Tunnels.** R.L.MALTBY, R.F.A.KEATING.
AGARDograph 70, 29-38, 6 refs., 1962.
Composition of the paints (general principles, the oil medium, additives, pigments, application of paints, recipes); photographic recording; interpretation of oil flow patterns.

AG70/3 **The Surface Oil Flow Technique for use in High Speed Wind Tunnels.** A.STANBROOK.
AGARDograph 70, 39-74, 8 refs., 1962.
Aspects discussed include: experimental study of the development of the pattern (effect of pigment concentration, oleic acid additive, thickness of the oil sheet); comparison of the various forms of the technique (general comments, correlation of running times); multiple patterns during a single run; concluding remarks – recommended mixture. An appendix gives characteristics of the various oils in use.

AG70/4 **Techniques for Locating Boundary Layer Transition**
AGARDograph 70, 75-81, 5 refs., 1962.
The 'china clay' and 'liquid film' methods for locating the position of boundary layer transition in low speed studies, are briefly described. The use of sublimation methods in high speed wind tunnels is then noted.

AG70/5 **Smoke Techniques for use in Low Speed Wind Tunnels.** R.L.MALTBY, R.F.A.KEATING.
AGARDograph 70, 87-109, 10 refs., 1962.
Brief descriptions are given of the following techniques: oil smoke, α-bromonaphthalene mist ($C_{10}H_7Br$), titanium tetrachloride ($TiCl_4$), water vapour, soap bubbles, vaporized resin smoke, smoke from cellulose materials, smoke visualization of vortex-type edge separations (smoke tube method, the 'smoke screen' technique).

AG70/6 **Development of the Vapour Screen Method of Flow Visualization in a 3 Ft x 3 Ft Supersonic Tunnel.** I.McGREGOR.
AGARDograph 70, 115-164, 21 refs., 1962.
Describes an experimental investigation carried out at R.A.E., Bedford, to examine the suitability of the method for providing information concerning the structure of separated flow areas near wind tunnel models. The investigation included the development of a technique which provided an improved resolution of detail over a range of Mach numbers.

AG71 **Light and Heat Sensing.** H.J.MERRILL (Editor).
AD-430-339 AGARDograph 71, 457 pp., 1963.
N64-15452 Contains material presented at the Sixth AGARD Avionics Panel Meeting, July, 1962; the material relates to the properties of sensors used in the visual and infrared spectrum, atmospheric effects, imagery effects, lasers, fibre optics, and sensor systems. Abstracts of the individual papers are given in the following items.

AG71/1 **Information Capacity of Sensors of Heat and Light.** R.C.JONES.
AGARDograph 71, 3-12, 11 refs., 1963.
This paper is a summary of the numerical results of four papers that have appeared in the Journal of the Optical Society of America. The only theoretical aspect considered is the information capacity of a beam of light.

AG71/2 **Recent Advances in Infrared Detectors.** V.ROBERTS.
AGARDograph 71, 13-24, 27 refs., 1963.
This paper briefly reviews the present state of the art on thermal and photo-detectors, and treats in more detail the development at the Royal Radar Establishment of InSb photo-conductive detectors for both the near and far infrared. As a result of these developments it is now possible to make fast sensitive photo-detectors for all infrared wavelengths from the visible limit to overlap the microwave region at a few millimetres. Progress is reported on a new scheme for a tunable infrared detector based on cyclotron absorption by free carriers in semiconductors.

AG71/3 **Limits of Imaging at Low Brightness.** H.G. de WINTER.
AGARDograph 71, 25-29, 4 refs., 1963.
As is now generally recognized the photon noise may become noticeable at very low brightness levels. With sensitive receivers this noise will be the ultimate limit for the resolution. Apart from this, receivers such as image intensifier systems show a transfer of contrast, which diminishes for smaller object sizes. The limit of perceptibility of objects at low brightness levels is determined from the transfer characteristics of the system.

AG71/4 **Ultraviolet Imaging from Satellites.** E.C.HUTTER.
AGARDograph 71, 31-42, 8 refs., 1963.
Requirements of astronomers for satellite observations of sun and stars in the far ultraviolet region have led to studies of imaging in this region by television techniques. Two representative specific systems have been studied and are described. One, for stellar observation, is designed to possess a high sensitivity in the region of the Lyman Alpha line of 1216Å. The other system is designed for solar observation in the region of 10-800Å. Theoretical calculations on the performance of these overall systems and results of experimental work on critical camera tube elements are described.

AG71/5 **Comparative Advantage of Infrared and Hertzian Radiometers.** (In French.) G.BROUSSAUD, B.RICHARD.
AGARDograph 71, 43-73, 1963.
Without discounting the military significance of radar systems, it is pointed out that they have the disadvantages of being easily located, and requiring high energy levels. The advantages of the recently developed radiometric methods (i.e. those utilizing thermal radiation) are indicated.

AG71/6 **Dust Concentrations in the Upper Atmosphere.** (In French.) F.ROSSLER.
AGARDograph 71, 77-85, 8 refs., 1963.
Measurements of the variation of diffused light in the atmosphere as a function of altitude, were made in the spring of 1961 using the 'Veronique' sounding rocket. These measurements have been used to determine the concentration of dust particles in the upper atmosphere. Discussion.

AG71/7 **Atmospheric Aerosol Particle Size Distributions and their Influence on the Light Scattering Properties of the Atmosphere.** R.W FENN.
AGARDograph 71, 87-88, 2 refs. '53.
The light scattering properties of single natural aerosol particles are analyzed. Based on the scattering theory by Mie, the extinction coefficients and scattering functions for spherical particles with refractive index 1.55 and size parameter values $\alpha = 2\pi r/\lambda$ between 0.1 and 15 have been computed. The influence of various power series aerosol size distributions and particle size ranges on the complex scattering function is discussed. Based on these analyses the optical properties of the atmosphere are investigated by measurements of the aerosol particle concentrations and size distributions and by measurements of the sky brightness. Discussion.

AG71/8 **The Use of Stars in Estimating the Attenuation of Light in the Atmosphere.** A.N.MOSSES.
AGARDograph 71, 89-99, 2 refs., 1963.
Existing instruments are not effective in measuring the loss of light over long paths. The method of using stars was developed to estimate attenuation during night photographic trials. When first (or last) seen rising above (or falling towards) the horizon, a star has a residual brightness, and measurement of its angle of elevation at appearance (or disappearance) enables the light loss to be related to the length of the light path in the atmosphere. If it is assumed that most of the attenuation occurs below the height of the light source, the attenuation of the light passing at any known angle can be estimated. Discussion.

AG71/9 **Evaluation of the Image Intensifier.** H.J.DIRKSEN, J. van SCHIE.
AGARDograph 71, 103-114, 4 refs., 1963.
A general method is introduced to describe what is just visible with the naked eye, and with the eye assisted by different night vision equipment. Especially it is indicated what can be seen with image intensifiers with objectives of different sizes and one or more stages. Finally the diameter of the objective of an image intensifier with which 'everything' can be seen at a given brightness level is calculated.

AG71/10 **Air-to-Ground Applications of the Visual Detection Lobe Theory.** E.HEAP.
AGARDograph 71, 115-136, 1963.
Considers air-to-ground applications of the theoretical equations for visual detection lobes, which depend upon the observed contrast of an object and its area. Taking into account the meteorological range, atmospheric attenuation and the sky-to-ground brightness ratio, curves are produced which show the sectional area on the ground within which detection is possible. Optimum heights and look angles are determined such that the ground area is maximized for a given maximum slant range to the ground. Details of many varied detection lobes are also tabulated.

AG71/11 **Elimination of the Screen from Images as a Procedure for Obtaining Optimum Information.** (In French.) J.SURGET, C.VÉRET.
AGARDograph 71, 137-149, 2 refs., 1963.
Describes the principle and operation of a method of eliminating the screen pattern (détramage) from an image by optical filtration of the spatial frequency. The method has application to the improvement of photographic prints, the suppression of lines on television images, and to the clarification of schlieren pictures taken through the perforated walls of wind tunnels.

AG71/12 **The Study of Time and Space Variable Surface Temperatures of Self-Luminous Bodies and Other Brightness Parameters by Colour Densitometry.** I.OVERINGTON.
AGARDograph 71, 151-181, 6 refs., 1963.
Certain surface temperature measurements met within hypersonic flow investigations where high rates of change of temperature with time and space are coupled with ablation problems make conventional temperature measurement techniques unsatisfactory. A system of photographic densitometry making use of the stability and predictability of modern colour film together with a novel sampling camera has therefore been developed. This system is easy to handle, can accept brightness levels of over 10^6 : 1 at one setting and can sample temperatures of up to 300 points at rates from 4 to 25 samples per deg. Absolute accuracies of better than 10 deg.C at 1500 deg.C are claimed with known emissivity whilst relative temperatures may be measured to better than 3.5 deg.C at 1500 deg.C.

AG71/13 **Lasers and Semiconductors.** (In French.) M.G.A.BERNARD, G.DURAFFOURG.
AGARDograph 71, 185-191, 8 refs., 1963.
Considers theoretically the conditions necessary for obtaining stimulated emission in semiconductors, and the sufficient condition for obtaining oscillation.

AG71/14 **Characteristics of a Gaseous Optical Maser.** A.JAVAN.
AGARDograph 71, 193-197, 8 refs., 1963.
This report concerns the basic operation and frequency characteristics of gaseous optical masers. The presently operating He-Ne maser is particularly emphasized. The use of this device as a standard of length and some of its spectroscopic applications are discussed. Brief discussion.

AG71/15 **Continuously Pumped Solid State Optical Masers.** W.S.BOYLE, D.F.NELSON.
AGARDograph 71, 199-206, 8 refs., 1963.
Two specific devices, the chromium-doped aluminium oxide (ruby) and neodymium-doped calcium tungstate solid state masers are examined. A comparison is drawn between two different pumping geometries, and the importance of the spectroscopic properties of maser crystals in determining the pumping requirements is illustrated.

AG71/16 **Methods of Modulating Infrared Radiation.** T.S.MOSS.
AGARDograph 71, 207-220, 15 refs., 1963.
Various methods of modulating infrared radiation are discussed, with emphasis on systems that can operate at very high frequencies, the aim being to modulate up to about 10^{10} c/s. Three classes of effect are considered (based on three types of limiting time constant): effects limited by carrier lifetimes in semiconductors, solid state devices limited by scattering times, and pure field effects. Discussion.

AG71/17 **Lasers for Communications and Optical Ranging.** G.F.SMITH.
AGARDograph 71, 221-234, 18 refs., 1963.
Introduction; modulation techniques (regeneration modulation, hair trigger modulation); optical receivers; optical communications, optical ranging, conclusions. Discussion.

AG71/18 **Radio and Optical Space Communications.** P.POTTER, R.STEVENS, V.WELLS.
AGARDograph 71, 235-262, 30 refs., 1963.
The theory and state-of-the-art of laser sources is reviewed, with the possible application of these devices to space communications and long-range radar (or lidar). Sample optical and radio-frequency systems are analyzed in detail. Practical system and component problems which arise in optical communication and lidar systems are discussed.

AG71/19 **Fiber Optics – Principles, Properties and Design Considerations.** W.P.SIEGMUND.
AGARDograph 71, 265-296, 12 refs., 1963.
The basic principles of fiber optics are reviewed and the properties of a variety of fiber optics materials are described. Important design considerations are discussed with respect to the application of these materials to various optical problems. To illustrate these design considerations a number of specific optical problems and their possible solution by means of fiber optics are described. Discussion.

AG71/20 **Fiber Optics and its use in Electro-Optical Devices.** L.J.KROLAK.
AGARDograph 71, 297-310, 1963.
The advantages of fiber optics configurations optical systems are described briefly. Four of the devices to which fiber optics have been applied are discussed in some detail (an airborne camera utilizing a fiberscope and a special vidicon picture tube with a fiber optics faceplate; a unique type of high-speed printer; a high-resolution television reconnaissance system; an improved analogue-to-digital converter).

AG71/21 **Optical Systems using Fiber Optics.** D.F.CAPELLARO.
AGARDograph 71, 311-324, 4 refs., 1963.
Through a new technique recently evolved, it has become possible to view and image opaque objects through fibers alone. The design of such systems and their performances are discussed. Several specific systems as well as different configurations using fiber optics for viewing opaque objects are described, both as examples of optimized design, and in order to demonstrate the principle application of fiber optics.

AG71/22 **Use of Optical Trihedra for Determining the Position of a Moving Object in Space.** (In French.) R.MOREAU.
AGARDograph 71, 327-336, 1963.
The properties of optical trihedra are first summarized. Preliminary experimental investigations into the use of systems employing optical trihedra for missile tracking are reported, and possible extensions of this technique for space applications are indicated.

AG71/23 **Detection of Satellites and Space Probes by Means of Ultraviolet, Visible and Infrared Radiations.** K.N.SATYENDRA.
AGARDograph 71, 337-370, 13 refs., 1963.
Develops criteria for detection and discrimination of a solar illuminated target space vehicle against a celestial background, consisting mostly of stars. At the surface of the Earth, the short wavelength limit of observations of electromagnetic radiations from space is about 2850Å. All shorter wavelengths are absorbed by atmospheric gases, oxygen, ozone and nitrogen. The detection problem is then discussed from the following viewpoints: signal attenuation if the observer is on the ground; eclipsing of the space vehicle by the Earth; target signal variation due to phase angle for diffuse reflection; size, shape and reflecting properties of target vehicle and its distance from observer. Typical detection ranges are calculated. The techniques for calculating the orbits of target space vehicles by such optical observations are also presented.

AG71/24 **An Optical Static-Split Receiver for Moon-Trackers in Satellites and Sounding Rockets.** P.IRVIN.
AGARDograph 71, 371-394, 1963.
Describes a study of certain aspects of an optical static-split receiver suitable for use as the input element of a moon-tracking servomechanism. Discusses the misalignment characteristics to be expected when photo-diodes are used in conjunction with a diffusing type of image-splitting block having a circular central mask, or when solar cells are placed in the image plane of a telescope in such a way as to split the Moon's image. Considers the effects upon the output of the receiver of changes in the detector geometry theoretically, and presents the results of experiments.

AG71/25 **The Application of Optical Sensors for Lunar and Planetary Space Vehicles.** J.R.SCULL.
AGARDograph 71, 395-410, 11 refs., 1963.
Some examples of optical sensors used for lunar and planetary missions are presented. The results of trade-off studies on sensitivity, accuracy, and field of view are discussed. The ground testing and simulation techniques which are unique for interplanetary optical sensors are described. Flight test results from the Ranger spacecraft are reported.

AG71/26 **Infrared Horizon Scanning for Attitude Control.** J.T. La Van.
AGARDograph 71, 411-435, 18 refs., 1963.
The system described is a scheme to detect the infrared interface between a planet and its surrounding space. It consists of an optical arrangement which focuses the radiated power from the planet into an infrared sensitive detector. The optics will be mounted on a moving assembly which scans 360 degrees/cycle at x cycles. The sensitive element in the detector is a material which is a conductor of electrical current. When the temperature of this material is changed by radiation, its resistance varies proportionally with the temperature; hence, a potential is generated which is a function of the received radiation.

AG71/27 **Detector of High Sensitivity of Extensive Range in the Infrared Spectrum.** (In French.)
H.J.L. Le BOITEUX.
AGARDograph 71, 437-450, 8 refs., 1963.
An accurate method of determining the static and dynamic characteristics of infrared detectors has been developed by O.N.E.R.A., and is described. An account is also given of a new detector, and its associated circuits, which has also been developed.

AG72 **Matrix Methods of Structural Analysis.** B.M.FRAEIJS de VEUBEKE.
AD-438-230 AGARDograph 72, 343 pp., 1964.
N64 20938 Five papers presented to the Structures and Materials Panel are reproduced; they report progress and the current state-of-the-art in the application of matrix algebra and computer language to the structural analysis of complicated structures. Abstracts of the individual papers are given in the succeeding items.

AG72/1 **Matrix Methods of Structural Analysis: A Précis of Recent Developments.** J.H.ARGYRIS, S.KELSEY, H.KAMEL.
AGARDograph 72, 1-164, 16 refs, 1964.
Summarizes some of the progress achieved in developing the first matrix theory of structures, to be given in dual form both with forces and displacements as unknowns. The range of subject matter is indicated by the separate headings used, as follows: matrix force method; displacement method; matrix force method in non-linear problems; matrix displacement method in non-linear problems. Appendices treat the following: the stiffness of triangular elements; stiffness matrix for an arbitrary but plane quadrilateral panel; stiffness matrix of spar elements; stiffness matrix of a parallelogram element; the buckling and large displacement theory of elastic systems

AG72/2 **Upper and Lower Bounds in Matrix Structural Analysis.** B.M.FRAEIJS de VEUBEKE.
AGARDograph 72, 165-201, 8 refs., 1964.
Dual treatment of the triangular panel; the stiffness method of resolution. the quadrilateral panel sub-divided by diagonals; the force method of resolution; principles for the determination of upper and lower bounds to influence coefficients; examples and numerical results.

AG72/3 **Further Development and Applications of the Stiffness Method.** M.J.TURNER, H.C.MARTIN, R.C.WEIKEL.
AGARDograph 72, 203-266, 13 refs., 1964.
The paper is divided into four parts as follows: (i) Introduction containing general information associated with computer programming of the method; (ii) Stress calculations; (iii) Thermoelastic analysis and elastic stability; (iv) Applications to complex structures.

AG72/4 **Some Problems in the Discrete Element Representation of Aircraft Structures.** I.C.TAIG, R.I.KERR.
AGARDograph 72, 267-315, 12 refs., 1964.
Reviews a number of problems encountered when idealizing complex aircraft structures into discrete elements for the purpose of matrix stress analysis. Problems arising in the analysis of wing-type structures by the matrix displacement method are first considered. A number of general topics are also covered. A different set of problems which have been encountered in analyzing fuselage structures by the matrix force method are then examined.

AG72/5 **Digital Analysis of Non-Linear Structures by the Force Method.** P.H.DENKE.
AGARDograph 72, 317-342, 14 refs., 1964.
Current linear and non-linear problems in the field of digital structural analysis are considered, and the extension of the Douglas Force Method to provide solutions to the non-linear problems is presented. The idealization of structures utilizing rectangular and non-rectangular gridworks is discussed. Basic equations for the geometric deflection problem are derived and some applications presented. The small deflection stability problem is considered and the solution to a problem involving the buckling of a stiffened plate is presented. A method of solution to the structural plasticity problem, based on the Prandtl-Reuss plasticity equations, is described. The creep problem is briefly considered, and some results relative to the calculations of natural modes and frequencies for low-aspect-ratio wings are presented.

AG73
AD-421-428
N63-23200 **Anthropometric Survey of Turkey, Greece and Italy.** H.T.E.HERTZBERG (Editor).
AGARDograph 73, 302 pp., 1963.
Presents tabulated data of 150 body dimensions taken on 3356 military personnel: 915 Turks, 1084 Greeks, and 1357 Italians. Details of the measurement procedures and a summary of the statistical procedures used are included. Information is also given on somatypes, skinfold thickness and other measures permitting assessment of body composition.

AG73/1 **Introduction (to Anthropometric Survey of Turkey, Greece and Italy).** H.T.E.HERTZBERG.
AGARDograph 73, 1-5, 9 refs., 1963.
This introduction to the survey first describes its purpose and organization; the composition of the personnel samples are then considered (pilots, flying cadets, Air Force ground staff, Army and Navy personnel were included in each country); finally the practical applications of the data are discussed.

AG73/2 **Equipment and Procedures.** H.T.E.HERTZBERG.
AGARDograph 73, 7-22. 7 refs., 1963.
The tools used are first described; as well as conventional instruments, these included some unconventional ones specially designed for this survey. The overall statistical design of the survey and the method of recording the data are then briefly referred to. The use of the 'landmarks' which were drawn on the subjects is also discussed, as is the variability of these subjects.

AG73/3 **Statistical Procedures.** E.CHURCHILL.
AGARDograph 73, 23-34, 5 refs., 1963.
This review of the statistical procedures used for interpreting the survey data covers the following topics: averages; measures of variability; measures of 'position' or 'order'; the standard errors, computational procedures.

AG73/4 **A Preliminary Somatype Description of Turkish, Greek and Italian Military Personnel.** C.W.DUPERTIUS.
AGARDograph 73, 35-60, 5 refs., 1963.
In order to make an appraisal of the physical types and to obtain some ideas of the frequency distribution of body builds among the subjects studied in each country, somatype photographs were taken of every individual who was measured. The somatype pictures and their subsequent analysis were made according to the method devised by Sheldon. The photographic equipment and the posing of the subjects is described, and the somatype groupings obtained are discussed.

AG73/5 **Skinfold Thickness Measurements.** R.M.WHITE.
AGARDograph 73, 61-65, 6 refs., 1963.
Skinfold thickness measurements were made at four sites on the body· the sites are described, as is the method of making the measurement. The calculation of the amount of fat in the body from measurements is explained and the significance of the results obtained is discussed.

AG73/6 **Utility of NATO Anthropometric Survey Data.** A.DAMON
AGARDograph 73, 67-84, 110 refs., 1963.
A brief historical account of civilian and military anthropometric surveys is first given. The use of anthropometric survey data in the following subjects is then discussed: human engineering, biological anthropology, and medicine.

AG73/7 **The Sample.** E.CHURCHILL.
AGARDograph 73, 87-274, 1963.
The basic statistical summaries of the data gathered are first presented; a visual index illustrating the sites of the dimensions measured is then gi.en; finally the data obtained are tabulated.

AG74 **Propagation of Radio Waves at Frequencies below 300 Kc/s.** W.T.BLACKBAND (Editor).
AD-439-450 AGARDograph 74, 478 pp., 1964.
N64-19676 The proceedin,, of the Seventh Annual Symposium of the Ionospheric Research Committee of the AGARD Avionics Panel are presented. The symposium produced a valuable exchange of ideas having important applications to the design of long-range navigational aids for aircraft. Abstracts of the individual papers are given in the succeeding items.

AG74/1 **Present Knowledge of the Lowest Ionosphere.** J.S.BELROSE.
AGARDograph 74, 3-23, 44 refs., 1964.
An attempt is made to summarize the current state of knowledge of the D-region. Although an attempt is made to include all pertinent recent data, the conclusions reached, as well as much of the data presented, are based on a recent review and studies. Discussion.

AG74/2 **Electron Density Profiles in the Quiet D-Region Derived from Observations of Cross Modulation.** R.L.BARRINGTON, E.V.THRANE.
AGARDograph 74, 25-33, 9 refs., 1964.
Observations of pulsed cross-modulation were made during quiet days in the spring, summer and fall of 1960. A brief description of the experimental method is given. It was possible from these observations to establish a definite diurnal variation in electron densities between 60 and 80 km for quiet spring days. A small seasonal variation in the observations is interpreted tentatively as a seasonal change in the electron density profiles. The deduced diurnal variation is discussed in the light of theoretical predictions which assume that cosmic rays and solar Lyman-α radiation account for the normal ionization in this region. Discussion.

AG74/3 **On Some New Properties of the Lower Ionosphere.** M.CUTOLO.
AGARDograph 74, 35-42, 8 refs., 1964.
Deals with the main non-linear effects discovered in the ionosphere (Luxembourg-Gargov effect, self modulation, gyrointeraction, etc.). Due to the remarkable non-linearity of the lower part of the ionosphere, it is thought that the plasma may behave as a 'detector' separating the low frequency from the carrier of a modulated wave. This paper refers to the experiments carried out between 1953 and 1962 which confirm that a detection effect does occur.

AG74/4 **Analysis of Cross-Modulation by V.A.Bailey's Equation.** A.POZZI.
AGARDograph 74, 43-48, 4 refs., 1964.
Deals with a method of evaluating the electronic collision frequency in the ionosphere. V.A.Bailey's equation is solved and the accuracy of the proposed solution is checked by comparison with an exact one. It is then shown how these results can be applied to study the ionospheric properties by utilizing Cutolo's experiments.

AG74/5 **Irregularities of the D-Layer and their Effect on the Waveform of Atmospherics.** (In French.)
J.DELLOUE, M.GARNIER.
AGARDograph 74, 51-80, 1964.
Observation of the waveforms of atmospherics with two loops spaced a very small fraction of a wavelength apart very often shows differences in induced signals which cannot be attributed to the equipment. The main characteristic of the phenomenon is its variability in form and time. The nature of these irregularities is described. These phenomena are attributed to D-layer irregularities producing focusing effects and interference patterns on the ground. Brief discussion.

AG74/6 **The Nature and Scale Size of Irregularities in the D-Region of the Ionosphere as Observed on a Near Vertical Incidence V.L.F. Sounder.** M.R.PAULSON, E.E.GOSSARD, W.F.MOLER.
AGARDograph 74, 61-72, 6 refs., 1964.
A v.l.f. ionospheric sounding system has been designed, built and operated by the U.S. Navy Electronics Laboratory for the purpose of examining the structure and propagation characteristics of the D-region. The system is described. Spaced receiver measurements were made at 10, 13, 17 and 23 Kc/s. Spectra of phase and amplitude fluctuations and the cross correlograms between phase and amplitude are presented. The profiles of electron density and collision frequency which give the best agreement between the theoretical and experimental results are discussed. Discussion.

AG74/7 **An Interpretation of LOFTI-I: V.L.F. Observations.** L.H.RORDEN, R.L.SMITH, R.A.HELLIWELL.
AGARDograph 74, 75-81, 5 refs., 1964.
During February and March of 1961, the Naval Research Laboratory LOFTI-I satellite received very low frequency signals transmitted into the ionosphere from U.S. Navy stations NBA in the Canal Zone and NPG in Jim Creek, Washington. The signals were sometimes observed to have been delayed by as much as 600 milliseconds. It was possible to deduce the thickness (scale height) of the ionosphere above the height of maximum electron density. The values correspond roughly to those previously found from rocket measurements. In general, the whistler mode signals observed in LOFTI-I show no evidence of having been trapped in columns of enhanced ionization. The difference between these whistler mode signals and those observed on the ground may be explained by noting that whistler energy not trapped in columns of enhanced ionization is not observed on the ground, presumably as a result of total internal reflection at the lower boundary of the ionosphere.

AG74/8 **Studies of the Echo Polarization from High Gradient Profiles.** A.J.FERRARO, C.P.TOU.
AGARDograph 74, 83-99, 14 refs., 1964.
In a previous report, the phenomenon of interference fringes on swept low-frequency polarization records has been interpreted by Brunnschweiler as formed from two overlapping echoes. On further examination, this has been found to be inadequate to explain the phenomenon. Here the interference fringes are interpreted as formed from the waves of two different modes reflected by a high gradient sporadic layer in the E-region. This interpretation has shown satisfactory agreement with the experimental data.

AG74/9 **On the Propagation of Long Wavelength Terrestrial Radio Waves -- Two Theoretical Techniques.** J.R.JOHLER, L.A.BERRY.
AGARDograph 74, 101-129, 20 refs., 1964.
The rigorous theory of long wavelength terrestrial radio propagation has recently been analyzed by Johler and Berry by means of the direct summation of the classical series of zonal harmonics. An alternative method is proposed in this paper which makes use of the well-known Watson transformation directly. A comparison of the two procedures apparently provides a useful checking technique. The the latter method are, of course, exactly equivalent to the former by the theory of func , out a drastically different computation technique is introduced by the Watson transformation Discussion.

AG74/10 **Oblique Incidence Pulse Measurements at 100 Kc/s.** R.H.DOHERTY.
AGARDograph 74, 133-148, 13 refs., 1964.
Fast rising pulses propagated over long ranges have provided a means for separating the ground-wave and various order sky-wave time modes at 100 Kc/s. Amplitude and phase measurements of the once-reflected sky wave show that besides the normal phase variations other phenomena occur. The observed phenomena are described and interpreted as further evidence of the existence of a low altitude low electron density region in the ionosphere. The results are shown to be consistent, at least qualitatively, with the propagation theory for the lower ionosphere derived by Johler et al. Discussion.

AG74/11 **The Oblique Reflection of CW Low-Frequency Radio Waves from the Ionosphere.** J.S.BELROSE.
AGARDograph 74, 149-165, 6 refs., 1964.
Propagation factors peculiar to the l.f. and v.l.f. band have resulted in their continued use over the years. An account is given of some measurements made on waves of low and very low frequency reflected from the ionosphere at oblique incidence (specifically the amplitude and phase variations of waves propagated over distances up to 2500 km over middle to high latitude paths). Both normal and abnormal propagation phenomena (such as SID's, PCD's, ionospheric storms, and nocturnal anomalies) are summarized. Discussion.

AG74/12 **The Statistical Frequency Spectrum of Atmospherics.** H.VOLLAND.
AGARDOgraph 74, 169-173, 1964.
In the Heinrich-Hertz-Institut, Berlin-Charlottenburg, an equipment has been developed for simultaneous counting of atmospherics at eleven different frequencies between 5 and 50 Kc/s. The receiver measures the vertical component of the electric field strength of the atmospherics. The receiver is briefly described, and methods of evaluating the results are presented. Discussion.

AG74/13 **Band Emissions at Gyro Frequencies of Ionospheric Ions and Hiss Frequencies.** G.GUSTAFSSON, A.EGELAND, W.BARRON, J.AARONS.
AGARDograph 74, 175-189, 9 refs., 1964.
The background noise level in the frequency range 10-10,000 c/s was monitored at Kiruna and Sagamore Hill. Three emission bands were found centred at 33, 750 and 2,500 c/s. The 33 c/s and 750 c/s bands were found to be dependent on the latitude but not the 2,500 c/s band. Different properties of the 750 c/s emission are discussed. An analysis of the diurnal variation of the background noise level is made for several frequency bands. Discussion.

AG74/14 **Characteristics of Very Low Frequency Atmospheric Noise in the Arctic.** A.L.WHITSON.
AGARDograph 74, 191-208, 1 ref., 1964.
A three-station arctic monitoring net to record spheric activity throughout the Northern Hemisphere has accumulated many data. Some of these data have been analyzed to define arctic atmospheric noise conditions. The amplitude distributions of spherics received at Fairbanks, Thule, and St. Johns from September 1958 through March 1959 have been determined. Atmospheric noise amplitude data indicate that atmospheric noise level as a function of frequency is dependent upon the latitude of the receiving station. Discussion.

AG74/15 **Continuous Records of Radio Noise in the V.L.F. Band and their Attachment to Sources.** (In French.) G.MATTERN.
AGARDograph 74, 209-215, 1964.
Several results of observations of radio noise in the v.l.f. region over a period of five years are given. It is possible to distinguish three sources of noise: (i) parasites; (ii) whistlers: (iii) extraterrestrial phenomena.

AG74/16 **Diurnal Changes in the Time of Propagation of V.L.F. Waves over Single Mode Paths.** W.T.BLACKBAND.
AGARDograph 74, 219-229, 10 refs., 1964.
Introduction; the diurnal change in transmission time; variation of $\Delta t/D$ with frequency; single mode propagation on short paths; the effect of transmission direction; a comparison of land and sea paths; variation of $\Delta t/D$ with geographical latitude. Discussion.

AG74/17 **The Statistical Prediction of Diurnal Phase Changes.** D.E.HAMPTON, A.S.HILL.
AGARDograph 74, 231-237, 1 ref., 1964.
The elementary physical model used envisages that the height of the ozone and the effective reflecting height of the ionosphere are the variable parameters, and a family of curves based on these is considered. By statistical methods, that curve which is the best fit to the experimental data is then determined. The choice of parameters and the closeness of the fit is discussed.

AG74/18 **The Mode Theory of V.L.F. Radio Propagation for a Spherical Earth and a Concentric Anisotropic Ionosphere.** J.R.WAIT.
AGARDograph 74, 239-256, 17 refs., 1964.
The problem is idealized to the extent that, at the boundaries of this spherical waveguide, the tangential field components are related in a prescribed way. On this basis a solution is sought for the total field produced by a vertical electric dipole. Explicit results are obtained under the assumption of azimuthal symmetry. By applying the Watson transformation, a representation in terms of guided waves is obtained.

AG74/19 **Phase Variations in V.L.F. Propagation.** C.J.CHILTON, D.D.CROMBIE, A.G.JEAN.
AGARDograph 74, 257-290, 63 refs., 1964.
The purpose of this paper is to review the experimental work describing variations in phase of v.l.f. signals received after ionospheric reflections at small and large distances. At all distances, regular systematic variations in phase occur, when the path changes from day to night, which are closely related to solar illumination. This diurnal change in phase can be interpreted as a variation in the effective height of reflection of the ionosphere. The diurnal changes can be interpreted in terms of waveguide mode theory. Discussion.

AG74/20 **Propagation of V.L.F. Radio Waves in the Ionosphere.** D.W.SWIFT.
AGARDograph 74, 291-319, 6 refs., 1964.
Equations describing the propagation of radio waves in a horizontally stratified anisotropic ionosphere were developed by considering the limiting case of a large number of infinitesimally thin slabs of constant electron density and collision frequency. The quasi-longitudinal approximation was used. The propagation equations appeared as four coupled first-order linear differential equations, coupled by gradients in electron density and collision frequency.

AG74/21 **Phase Anomalies Observed in Very Low Frequency Propagation during Nuclear Test of July 9, 1962.** R.H.WOODWARD, G.J.GASSMANN.
AGARDograph 74, 321-333, 15 refs., 1964.
Highly stabilized routine phase recordings of the v.l.f. stations NPM, NPG, NBA and GBR were taken near Boston, Mass., U.S.A The regular diurnal phase variations show a predictable pattern. The nuclear detonation of July 9, 1962, of the megaton range several hundred kilometres above Johnston Island caused phase anomalies commencing within a few minutes. The phase anomalies are thought to be caused by electrons dumped from the man-made radiation belt. Duration and magnitude of the effects are determined by geometry and by the nature of the two electron sources, the neutron decay, and the radioactive debris cloud. Discussion.

AG74/22 **Recent V.L.F. Work at the U.S. Army Electronics Research and Development Laboratory.** F.H.REDER, G.M.R.WINKLER.
AGARDograph 74, 335-338, 7 refs., 1964.
Since 1959, v.l.f. and l.f. propagation studies and long-distance clock synchronization experiments have been conducted at USAERDL. Atomic Cs beam frequency standards, type NC 1001, have been used for driving transmitters and clocks, and for providing local references for v.l.f. and l.f. receivers. This summary of results was presented at the 7th Ionospheric Research Committee Meeting outside the scheduled programme, for the benefit of European participants who do not have ready access to some U.S. publications. Discussion.

AG74/23 **Effect of the Distribution of Current in a Lightning Discharge on Electromagnetic Radiation at a Great Distance.** (In French.) J.PAPET-LEPINE.
AGARDograph 74, 341-350, 9 refs., 1964.
An attempt is made to predict the influence of the non-uniform current distribution on the magnetic field at great distance (but less than 1000 km). It is shown, in particular, that the influence on the spectrum of the field is such that it is not solely a function of the derivative of the current but is the sum of three spectra, produced respectively by the three terms describing the non-uniform distribution. The coefficients of these terms depend on the local characteristics of the discharge.

AG74/24 **Extremely Low Frequency Magnetic Waves in an Inhomogeneous Hydromagnetic Medium.** W.C.HOFFMAN.
AGARDograph 74, 351-360, 10 refs., 1964.
An apparently new type of extremely low frequency (e.l.f.) wave motion of the magnetic field in an inhomogeneous hydromagnetic medium flowing about a conducting magnetized sphere is shown to exist under certain conditions upon the flow velocity, the conductivity, and their respective divergence and gradient. Satellite magnetometer data and the characteristics of geomagnetic micropulsations are discussed in relation to this theoretical model.

AG74/25 **The Influence of the Ionosphere on the Polarization of V.L.F. and E.L.F. Radio Waves.** F.W.CHAPMAN. D.G.C.JONES.
AGARDograph 74, 361-369, 8 refs., 1964.
Measurements of the polarization of atmospheric waveforms have been made in the frequency range 500 c/s to 12 Kc/s, for propagation distances between 300 and 3000 km. Using these results, the variation of polarization with distance and direction of propagation was investigated. The theoretical problem of the propagation of radio waves in the earth-ionosphere waveguide was also examined with special reference to the calculation of theoretical values of polarization, and the relevant equations were solved using a high speed digital computer. The theoretical and experimental results were compared for both v.l.f. and e.l.f.

AG74/26 **Magnetic Records between 0.2-30 c/s.** R.GENDRIN, R.STEFANT.
AGARDograph 74, 371-400 52 refs., 1964.
A magnetometer, designed to record and analyze the geomagnetic field fluctuations in the frequency range 0.2-30 c/s, has been in almost continuous operation for ten months, partly in France, and partly in Norway. With the help of this equipment the two types of phenomenon which occur in this frequency range (Earth-ionosphere cavity resonances between 5 and 30 c/s, and discrete oscillations between 5 and 30 c/s) were studied.

AG74/27 **Thunderstorm Excitation of the Earth-Ionosphere Cavity.** M.BALSER, C.A.WAGNER.
AGARDograph 74, 403-411, 7 refs., 1964.
Early results of a programme to study the spectrum of e.l.f. radio noise in the band 5-30 c/s were obtained by simulated filtering on a digital computer. This processing revealed the peaks in the spectrum resulting from the responses of the first five resonant modes of the Earth-ionosphere cavity. The measured diurnal power variations were found to correspond with mean worldwide thunderstorm activity. Recently, this information has been used to build analogue equipment to examine selected portions of the spectrum at greater length. Power variations of individual modes can now be displayed continuously.

AG74/28 **Earth-Ionosphere Cavity Resonances and Effective Ionospheric Parameters.** F.W.CHAPMAN, D.L.JONES.
AGARDograph 74, 413-420, 12 refs., 1964.
The Cavity Resonator region of the electromagnetic noise spectrum has been observed since June 1961 by means of an integtating spectrometer which sweeps the frequency range 4-40 c/s in a period of one hour. The results obtained are discussed. Calculations show that the lower D-region of the ionosphere is effective in electromagnetic wave propagation at cavity mode frequencies.

AG74/29 **The Natural E.L.F. Electromagnetic Noise in the Band 2-40 c/s; Apparatus and some Preliminary Results.** M.J.RYCROFT, T.W.WORMELL.
AGARDograph 74, 421-434, 25 refs., 1964.
A programme of observations on radio noise in the frequency range from 2 to 40 c/s is discussed. The experimental arrangements are considered in detail, particular attention being paid to the devices for rejecting the unwanted man-made disturbances which are prominent at an ordinary site. Preliminary results are presented, including power spectral densities of sample records.

AG74/30 **Some Recent Magnetic Field Measurements in the Earth-Ionosphere Resonance Region.** C.POLK.
AGARDograph 74, 435-456, 21 refs., 1964.
Amplitude vs time records of 2-min. duration of north-south and east-west magnetic field variations in the 5-20 c/s frequency range, and 24-hr records of 7.5-10 c/s magnetic fields which were obtained over a period of several months are analyzed. Discussion.

AG74/31 **Notes on Sets of Conjugate Pairs.** N.C.GERSON.
AGARDograph 74, 457-463, 11 refs., 1964.
For a given v.l.f. signal, it seems possible to define at least two sets of conjugate pairs which together define four natural foci on Earth. This paper attempts to deduce some aspects relative to propagation of radio waves between the four natural foci. Radio frequencies involved are such that the wavelength $\lambda \ll Z$, where Z = altitude of the ionic layer assumed concentric to a spherical Earth.

AG74/32 **Concluding Remarks.** W.DIEMINGER, E.VASSY.
AGARDograph 74, 465-468, 1964.
W.Dieminger's general remarks at the end of this symposium are reproduced in English. E.Vassy summarizes the progress accomplished in French.

AG75 **Non-Steady Flame Propagation.** G.H.MARKSTEIN (Editor).
AD-442-504 AGARDograph 75, 328 pp., 1964.
N64-26003 This work was prepared with the object of collecting in one volume material on non-steady flame propagation that had hitherto been accessible only through widely scattered original publications or had remained unpublished. The interaction between flames and flow fields is stressed. Abstracts of the individual papers are given in the following items.

AG75/1 **Introduction.** G.H.MARKSTEIN.
AGARDograph 75, 1-3, 11 refs., 1964.
Non-steady flame propagation as a study presents the complex problem of combining the non-linearity of fluid dynamics with that of chemical kinetics. By using linearized perturbation treatments it is possible to suppress the essentially non-linear character of the flame phenomena artificially. Current analyses, with few exceptions, use this approach and the results are compared with experimental observations. Material on this subject, which is widely scattered in the literature, is brought together in this AGARDograph.

AG75/2 **Theory of Flame Propagation.** G.H.MARKSTEIN.
AGARDograph 75, 5-14, 40 refs., 1964.
Theoretical treatments of the propagation of a flame front through a combustible gas mixture that assume a simple geometry such as plane, spherical or cylindrical symmetry are discussed. Other approaches are mentioned. The general flame equations can be solved by suitable approximations including source and sink methods and by the use of electrical and electro-thermal analogues.

Alternatively the fluid dynamics treatment can be separated from that of the flame zone by regarding the flame front as a surface of discontinuity.

AG75/3 **Perturbation Analysis of Stability and Response of Plane Flame Fronts.** G.H.MARKSTEIN.
AGARDograph 75, 15-74, 34 refs., 1964.
Equations expressing the kinematic conditions and the conservation of mass and momentum in a burning gas flow are applied to the distortions of a flame front regarded as small perturbations of a non-dimensional steady state. Models are introduced to relate the local and instantaneous value of the burning velocity to the shape of the flame front and the nature of the flow field in the immediate vicinity of the flame front. An extension of the treatment of steady, finite-amplitude cellular flames to higher-order approximations is given.

AG75/4 **Experimental Studies of Flame-Front Instability.** G.H.MARKSTEIN.
AGARDograph 75, 75-105, 43 refs., 1964.
Experimental results are given of spontaneous instability and instability produced by artifically disturbed burner flames. A method of radiation measurement is described which would seem to offer an opportunity of obtaining simultaneously a record of the instantaneous burning rate. Brief reference is made to instability due to shock wave/flame front interaction. Streak camera records, stroboscopic photographs, spark schlieren photographs and high speed shadowgraph motion picture figures are used to illustrate this chapter.

AG75/5 **Flame Propagation in Tubes and in Closed Vessels.** H.GUENOCHE.
AGARDograph 75, 107-181, 110 refs., 1964.
Propagation is examined in tubes under the following conditions: tubes closed at both ends; closed at the ignition end and open at the other; open at the ignition end and closed at the other; and open at both ends. The work relating to tubes and spherical vessels is essentially descriptive. Results demonstrating the effect of obstructing a certain region of the flame propagation are given; these have been used to study the influence of turbulence on flame propagation, to study flame acceleration, or to increase combustion instability.

AG75/6 **General Considerations of Autonomous Combustion Oscillations.** A.A.PUTNAM.
AGARDograph 75, 183-198, 55 refs., 1964.
The various oscillations observed in combustors are grouped in three categories: system instability; acoustic instability; and transition instability. These categories are discussed and the possible sources of driving energy for the oscillations indicated. Consideration is then given to the various approaches that have been used in treating the problem of combustion oscillations. Rayleigh's criterion of driving oscillations by a periodic release of heat in a gaseous medium is presented.

AG75/7 **Experimental and Theoretical Studies of Combustion Oscillations.** A.A.PUTNAM.
AGARDograph 75, 199-290, 88 refs., 1964.
The results of a number of studies of organ-pipe oscillations and transverse oscillations in combustion systems, as reported by various investigators, are discussed. The various published results are classified into these two main groups (organ-pipe and transverse oscillations) and then each group is subdivided according to the basic arrangement of the components of the combustion unit.

AG75/8 **Practical Considerations of Combustion Oscillations.** A.A.PUTNAM.
AGARDograph 75, 291-314, 36 refs., 1964.
Experimental studies of suppression methods are considered, and then, taking the view that oscillations can be useful, various possible applications of autonomous combustion oscillations are outlined.

AG75/9 **Conclusion.** G.H.MARKSTEIN.
AGARDograph 75, 315-317, 6 refs., 1964.
Summarizes the more important conclusions to be drawn from the contributions to this AGARDograph. The analysis of flame-front stability in steady flow is in satisfactory qualitative agreement with experimental results but a quantitative comparison is not yet possible. Similarly in flame propagation studies, a quantitative understanding of the experimental results is almost completely lacking. A considerable degree of understanding of combustion oscillations has been attained but almost exclusively at the level of linearized analysis. The possibilities of applying pulsating combustion have not been fully exploited.

AG76
AD-438-018
N64-19780 **Free and Semi-Free Model Flight-Testing Techniques used in Low-Speed Studies of Dynamic Stability and Control.** J.P.CAMPBELL.
AGARDograph 76, 52 pp., 47 refs., 1963.
The various free and semi-free model flight-testing techniques used in low-speed studies of aircraft dynamic stability and control are summarized and discussed. The most appropriate uses for these flying-model techniques and the relative merits of the various techniques for particular applications are indicated.

AG77 **Micropower Electronics** E.KEONJIAN (Editor).
AD-442-944 AGARDograph 77, 220 pp., 1964.
The lectures which form the substance of this volume were presented during June of 1963 in the following NATO countries, at their request: France, Germany, Italy, and the United Kingdom, before audiences totalling some nine hundred scientists and engineers. The lectures were on the following subjects: relations between minimum required power density and frequency response for present circuits; metal-oxide-semiconductor field-effect devices for micro-power logic circuitry; micropower microelectronic subsystems. a microminiature digital integrator using microcircuits; the multiple emitter transistor in low power logic circuits; designing minimum power digital circuits for Mariner II and other spacecraft; static and dynamic performance of micropower transistor linear amplifiers. Abstracts of the individual contributions are given in the succeeding items.

AG77/1 **Relations between Minimum Required Power Density and Frequency Response for Present and Future Semiconductor Triode Amplifiers.** J.L.MOLL.
AGARDograph 77, 3-17, 4 refs., 1964.
It is shown that at low power densities the major limit on speed of response and frequency is emitter charging time for amplifiers that inject carriers as in the case of the bipolar transistor, space-charge limited triode, etc. The limit on the field effect transistor is the gate charging time. The proper design of emitter for the bipolar amplifier (electrons and holes, or hot electrons and cold electrons) or the proper design for the gate of the field effect transistor results in essentially the same limit on required power density. The switching time in each case is determined by the time to charge a capacitor with a given current.

AG77/2 **Physical Realization of Digital Logic Circuits.** A.W.LO.
AGARDograph 77, 19-39, 1964.
A unified concept of the requirements pertinent to the physical realization of 'elementary digital networks' is given to provide a common basis for evaluating the merits and limitations of the large variety of presently available and prospective digital devices and circuit techniques proposed for the implementation of practical low-power digital systems. The basic requirements of elementary digital networks are discussed under quantization, fan-in and fan-out, directivity and isolation, and implementation of logical functions. Brief accounts are given of four- three- and two-terminal switching elements. The requirements of micropower digital logic circuits are illustrated by reference to a direct-coupled transistor logic circuit.

AG77/3 **Metal-Oxide-Semiconductor Field-Effect Devices for Micropower Logic Circuitry.** G.E.MOORE, C.T.SAH, F.M.WANLASS.
AGARDograph 77, 41-55, 8 refs., 1964.
Very low standby power circuitry is achievable with high switching speed and with large allowable circuit margins by using novel semi-conductor devices. A description of complementary polarity metal-oxide-semi-conductor field-effect triodes and their characteristics is given. The basic circuit configuration is examined and extensions to other configurations are included. The technology is not adequately developed to make devices of both polarities in the same piece of silicon such as is required for the complementary circuitry.

AG77/4 **Micropower Microelectronic Subsystems.** W.W.GAERTNER, M.SCHULLER, C.HEIZMAN, C.LEVY.
AGARDograph 77, 57-84, 12 refs., 1964.
Describes the microelectronic concept which has evolved at CBS Laboratories during the past three years and the performance achieved in micropower subsystems which have been built as a realization of this concept. CBS Laboratories originated the concept of 'minimum power microelectronics' which requires that each electronic function be performed at the minimum supply power level possible. Fabrication techniques for micropower microelectronic function blocks are described. As examples a microwatt NOR gate and a microwatt amplifier stage are described. The 'micropower microelectronics' concept is expected to have a significant impact on space, military and medical electronics.

AG77/5 **A Microminiature Digital Integrator using Micropower Circuits.** A.T.WATTS.
AGARDograph 77, 85-103, 5 refs., 1964.
A Digital Integrator is described which is constructed entirely of thin-film microcircuits by Mullard Ltd. The system consists of three identical Integrator channels together with a control unit to provide the necessary timing waveforms. Three basic circuits are required, a NAND or NOR gate, a bistable circuit with pulse-steering facilities for use in shift-registers and counters, and a driver circuit for multi-stage shift registers. Construction of the Integrator is described.

AG77/6 **The Multiple-Emitter Transistor in Low Power Logic Circuits.** B.A.BOULTER.
AGARDograph 77, 105-120, 7 refs., 1964.
A multiple emitter transistor is used in the circuits described to provide the input functions required in a logical gate. Directly coupled to a saturating common emitter transistor, the multiple emitter transistor minimizes the leakage current effects in that transistor, enabling operation at lower current levels. The load presented to the output by similar circuits is such that no large standing collector current is required.

AG77/7 **Designing Minimum Power Digital Circuits for Mariner II and other Spacecraft.** R.C.BARON.
AGARDograph 77, 121-151, 15 refs., 1964.
Discusses some of the special factors encountered in the design of digital systems for the space environment. The circuitry used in the Scientific Data Conditioning System on board the Mariner II spacecraft is described to illustrate one approach to the design of low power, high reliability equipment. Some conclusions are drawn to indicate possible trends in the design of spacecraft data handling equipment, and the potential role of microelectronics in this area.

AG77/8 **Static and Dynamic Performance of Micropower Transistor Linear Amplifiers.** J.D.MEINDL, R.A.GILSON, O.PITZALIS, W.KISS.
AGARDograph 77, 153-197, 9 refs., 1964.
The first section describes the salient characteristics of micropower transistors for the common emitter mode, including the static base and collector characteristics and the small signal fourpole parameters and equivalent circuit. The second section describes an optimum design theory for linear broadband micropower amplifiers. The third section describes the overall performance of broadband micropower amplifiers, including their effective large signal mode of operation, frequency response, temperature behaviour and the influence of key design parameters on amplifier performance.

AG77/9 **Panel Discussion (on Micropower Electronics).**
AGARDograph 77, 199-212, 1964.
Presents a condensed version of the discussion at which the panel (comprising R.C.Baron, B.A.Boulter, W.W.Gaertner, A.W.Lo, J.D.Meindl, J.L.Moll, G.E.Moore, and A.T.Watts) answered questions relating to micropower electronics from the audience; E.Keonjian acted as moderator.

AG78 **Arctic Communications.** B.LANDMARK (Editor).
AD-450-991 AGARDograph 78, 297 pp., 1964.
N65-10592 This AGARDograph comprises the Proceedings of the Eighth Meeting of the AGARD Ionospheric Research Committee held in Athens in July, 1963. The papers are presented under two main headings: Physical properties of the arctic ionosphere and Arctic h.f. communication. Abstracts of the individual papers are given in the succeeding items.

AG78/1 **Some Experimental Studies of the Arctic D-Region.** O.HOLT, B.LANDMARK.
AGARDograph 78, 3-25, 28 refs., 1964.
High latitude absorption phenomena may be divided into three types: (i) auroral absorption, (ii) polar cap absorption and (iii) sudden commencement absorption. Experimental studies of these phenomena are reviewed, including their morphology, duration, structure and relation to other geophysical phenomena, as well as direct measurements of D-region electron densities during the absorption periods.

AG78/2 **Conjugate Point Observations at a Variety of High Geomagnetic Latitudes.** H.J.A.CHIVERS.
AGARDograph 78, 27-38, 4 refs., 1964.
Summarizes the current status of some studies of the ionospheric absorption of cosmic noise observed at conjugate points; these studies include: Quebec City/Eights Coast of Antarctica programme 1961-62; Longyearbyen/Mirnyy programme 1961; the current study by C.R.P.I. and the Canadian Government of absorption at three pairs of conjugate points.

AG78/3 **On the Strong Ionospheric Absorption at Kerguelen studied by means of the f_{min} Characteristic of the Ionosphere Probe.** (In French.) G.BOECKEL, P.HALLEY.
AGARDograph 78, 39-45, 3 refs., 1964.
The ionospheric station at Kerguelen, on the border of the auroral zone, 57 deg.S geomagnetic latitude, has made possible absorption observations at such latitudes. The f_m characteristic in the iongrammes is an objective parameter although it does not give a quantitative measure of the absorption. The frequency of occurrence of observed values of the parameter (E, 3Mhz, B) makes possible qualitative studies of the absorption and its variations.

AG78/4 **Ionospheric Ionization Produced by Solar Flares as Measured by Continuous Recordings of f_{min}. Comparison between Pulse and Multifrequency Riometer Techniques.** M.ANASTASSIADES, D.ILIAS, P.GIOULEAS.
AGARDograph 78, 47-52, 8 refs., 1964.
Discusses ionospheric absorption produced by solar flares as observed by continuous recordings of f_{min}. The results are compared with those of riometer studies; particular attention is given to the possibilities offered by multifrequency riometer observations.

AG78/5 **Diurnal Variation of Type III Absorption at the Dumont D'Urville Station.** (In French). A.LEBEAU.
AGARDograph 78, 53-62, 8 refs., 1964.
Presents a study based on the parameter f_{min} from ionospheric soundings at the station Dumont d'Urville (70°5'S, 230°9'E). The diurnal and seasonal variations of the absorption are studied.

AG78/6 **Summary of Discussion (of Papers on Physical Properties of the Arctic Ionosphere).**
AGARDograph 78, 63, 1964.
In this very brief summary, the points raised relate mainly to the paper by H.J.A.Chivers on conjugate point observations. Commandant Halley, in reference to the paper by O.Holt and B.Landmark, asked how far to the south the absorption region shifted during high magnetic activity. Dr Landmark replied that the maximum absorption occured somewhere between Trondheim and Mosjøen.

AG78/7 **Military Communications in the Canadian Arctic.** G.J.BURY.
AGARDograph 78, 67-71, 1964.
Describes the experiences of the military in the establishment and operation of communication facilities in the Canadian arctic. After discussing the logistics problems short descriptions are given of the following facilities that have been provided: h.f. circuits, l.f. circuits and scatter circuits.

AG78/8 **Communications Propagation Trials During the British North Greenland Expedition October 1952 to July 1954.** D.G.COOPER, A.K.REDHOUSE.
AGARDograph 78, 73-81, 1964.
Summarizes an analysis of observational data recorded during the above expedition. Several stations mainly in the U.K., transmitting on low, medium and high frequencies were monitored for signal strength, readability and interference, using the SINPO code, at two sites. The assessment of such data is necessarily qualitative.

AG78/9 **Polar Communications.** N.C.GERSON.
AGARDograph 78, 83-96, 5 refs., 1964.
The particular problem considered is communication from one polar cap region to the other. Present studies indicate that h.f. radio wave propagation is possible. Over a typical arctic-antarctic circuit the operating frequency could be constant throughout the day. On some occasions m.u.f.'s for a pole-to-pole circuit exceeded those for an equator-to-pole circuit. Results from limited tests implied that h.f. interpolar propagation may be exploited for communications by allowing a middle latitude station to contact one polar region which may then contact the opposite polar site.

AG78/10 **Reception of Mid-Latitude Transmissions in Northern Canada.** J.R.HERMAN, R.B.PENNDORF.
AGARDograph 78, 97-119, 9 refs., 1964.
Transmissions of WWV on six frequencies between 2.5 and 25 Mc/s were aurally monitored hourly at four Canadian stations in subauroral, auroral and polar-cap regions. WWVH transmissions on 5, 10 and 15 Mc/s from Maui, Hawaii, were similarly monitored. The results of analysis of the quiet-day data for WWV and WWVH and of analysis of reception during a period of ionospheric disturbance are presented and discussed.

AG78/11 **Note on Backscatter in the Auroral Zone.** (In French.) P.HALLEY, N.FAURÉ.
AGARDograph 78, 121-126, 1964.
A discussion of the significance of the field-strength recordings made at Paris-Saclay between October, 1960 and February, 1961 of the back scatter from the transmissions from London to Reykjavik on a frequency of about 32.8 Mc/s.

AG78/12 **Radio Noise Problems in Arctic Regions.** J.R.HERMAN.
AGARDograph 78, 127-146, 15 refs., 1964.
The three main types of radio noise that should be considered when establishing noise levels for communication or in experiments utilizing radio techniques in Arctic regions are discussed; these are atmospheric noise, man-made noise, and precipitation static.

AG78/13 **Polar Radio Noise.** N.C.GERSON.
AGARDograph 78, 147-149, 1 ref., 1964.
Brief comments, relating to polar radio noise, are made on the following topics: man-made noise levels, precipitation static, l.f. seasonal noise variation, terrestrial origins of radio noise, noise-latitude dependence.

AG78/14 **Summary of Discussion (on Arctic h.f. Communications).**
AGARDograph 78, 151-153, 2 refs., 1964.
Brief comments by Halley on the paper by Cooper and Redhouse, and by Williams on man-made noise levels in ships and the general variability of noise from one site to another are followed by more detailed comments by Gerson on the paper by Bury, in which he discusses the basic question of the optimum design of radio circuits in the arctic.

AG78/15 **H.F. Propagation in the Arctic.** G.W.JULL.
AGARDograph 78, 157-176, 11 refs., 1964.
The results of several studies of oblique incidence frequency sounding and 30 Mc/s riometer absorption are examined with the object of using this information to increase the reliability of h.f. communications on auroral zone circuits. Studies were carried out during low and high intensity polar-cap absorption events and moderate and severe geomagnetic storms, to determine the effect of these disturbances on h.f. transmissions on a number of auroral zone point-to-point circuits and on a circuit from a ground station to an aircraft flying into and through the auroral zone.

AG78/16 **Backscatter Observations at Lindau-Harz with Variable Frequency Directed to the Auroral Zone.** H.G.MÖLLER.
AGARDograph 78, 177-188, 1964.
Variable frequency backscatter experiments were carried out by the Max Planck Institut with the object of observing from one point the variation of the ionosphere reflection conditions with time and distance. The apparent path of these backscatter traces shows a typical frequency dependence.

AG78/17 **Field Strength Measurements over a 2000 Km Subauroral Path (Sodankylä-Lindau) Compared with the Absorption Observed at the Terminals.** G.ROSE.
AGARDograph 78, 189-203, 7 refs., 1964.
Field strength measurements were carried out over the subauroral Sodankylä-Lindau path and at the same time along two other lines Norddeich-Lindau (300 Km) and Kemi-Sodankylä (200 Km). With the aid of oblique ionograms obtained from the Sodankylä-Lindau line and the vertical ionograms of Sodankylä, Uppsala and Lindau the field strength recordings of undisturbed winter days have been interpreted in terms of ionospheric D-region absorption. Anomalous winter absorption occurs over all three lines.

AG78/18 **Observations of Phase-Instabilities on a V.L.F. Transmission Fath Passing through the Auroral Zone.** P.T.W.BAKER.
AGARDograph 78, 207-215, 2 refs., 1964.
Describes briefly a programme of observations of the phase stability of v.l.f. radio signals over a long propagation-path passing through the auroral zone, and gives examples of some of the ways their behaviour differs from the regular diurnal variations normally expected over a non-auroral path. The observations were made by the Admiralty Surface Weapons Establishment, Portsdown, England.

AG78/19 **The Phase Stability of V.L.F. Signals on Polar Paths.** D.E.HAMPTON, A.S.HILL.
AGARDograph 78, 217-232, 2 refs., 1964.
Measurements of the phase and field strength of the signal received from v.l.f. transmitters located in U.K. and U.S.A. were made at various places throughout the world. The resulting data were analyzed with the object of distinguishing between normal and abnormal propagation phenomena. The notable fact that emerged was that there is a remarkable day to day stability exhibited by both the phase and amplitude of the received signals.

AG78/20 **Seasonal Changes in the Diurnal Variation of the Phase of V.L.F. Waves Traversing Arctic Regions.** (In French.) B.DECAUX, A.GABRY.
AGARDograph 78, 233-235, 1964.
The Departement Frequences du C.N.E.T. has been recording on a permanent basis for several years the phase of the following v.l.f. transmissions: GBR, NAA, NBA, NPG/NLK, NPM, NSS. The paths for NPM and NPG/NLK cross the arctic region, and this note discusses the seasonal variations of the phases for these circuits.

AG78/21 **Very Low Frequency Radio Wave Propagation at High Latitudes.** A.EGELAND, W.RIEDLER.
AGARDograph 78, 237-252, 14 refs., 1964.
Continuous field strength measurements of the 16 Kc/s transmissions from Rugby, England have been made at Kiruna Geophysical Observatory since September 1958. The observational data presented in this paper have been studied with respect to the normal diurnal, seasonal and yearly variation of the received field strength. The observed day-night variation of the 16 Kc/s signal strength is discussed in relation to the variation of apparent reflection heights.

AG78/22 **V.H.F.-Bistatic-Aurora Communications as a Function of Geomagnetic Activity and Magnetic Latitude.** G.LANG-HESSE.
AGARDograph 78, 253-262, 17 refs., 1964.
Observations of v.h.f.-bistatic-aurora-backscatter communications on 145 Mc/s within Middle Europe and from Middle Europe to Great Britain and Scandinavia covering the period 1957 to early 1963 are analyzed with respect to the probability of occurrence of these phenomena as a function of the magnetic dip angle and the degree of geomagnetic activity. An interpretation is given of the results obtained.

AG78/23 **Observations Made by the Ionospheric Institute of Athens During the Series of Nuclear Weapon Tests at Novaja Zemlya Between 10 September and 4 November 1964.** M.ANASTASSIADES, D.ILIAS, G.MORAITIS, P.GIOULEAS.
AGARDograph 78, 265-279, 10 refs., 1964.
A report of seismological, geomagnetic, meteorological (microbarograph), ionospheric and radioactive fallout observations made during the nuclear explosions cited in the title.

AG78/24 **Observation of Ionospheric Disturbances Caused by Nuclear Explosions.** (In French.) P.HALLEY, F.BIRAUD, A.M.BOURDILA.
AGARDograph 78, 281-292, 7 refs., 1964.
A summary of the results obtained by studying the ionograms recorded at the Paris-Saclay, Dakar-Camberene, Tahiti-Taravao stations following the explosions of 23rd and 31st October, 1961 at Nova Zembla.

AG78/25 **Concluding Remarks.** (In French.) E.VASSY.
AGARDograph 78, 293-294, 1964.
In his brief closing address, Mr Vassy thanked the various people concerned with the organization of this meeting and expressed his satisfaction with the very full treatment the subject of arctic communications had received both from a practical and scientific standpoint.

AG79 **Jet Simulation in Ground Test Facilities.** M.PINDZOLA.
AD-440-903 AGARDograph 78, 56 pp., 69 refs., 1963.
N64-22224 Summarizes techniques which are used to obtain the jet-on characteristics of an axisymmetric, underexpanded jet, a jet exhausting into a medium at rest and into a moving stream. Some of the scaling laws of particular concern to the subject are presented. Methods of jet simulation using ground test facilities and typical test results using these facilities are presented, and the more important results are discussed.

AG80 **Development of a Simple Runway Waviness Measuring System.** F.J.PLANTEMA, J.BUHRMAN.
AD-440-750 AGARDograph 80, 39 pp., 12 refs., 1963.
N64-23375 A discussion is given of the shortcomings of existing systems and methods for measuring the range of wavelengths from 4 feet to 200 feet. An optical system developed by the NLR which avoids these shortcomings is described. It is concluded that the NLR-system shows favourable characteristics as a rapid and simple measuring system. A few current and possible future extensions of the work are dealt with briefly.

AG81 **Combustion and Propulsion: Sixth AGARD Colloquium: Energy Sources and Energy Conversion.**
AD-665-915 H.M.DeGROFF, R.F.HOGLUND, J.FABRI, T.F.NAGEY, M.E.RUMBAUGH, Jr (Editors).
N68-17793 AGARDograph 81, 926 pp., 1967.
This Colloquium was sponsored by the Combustion and Propulsion Panel of AGARD. Here 37 papers are presented under the headings: dynamic energy conversion; direct energy conversion – thermal sources; direct energy conversion -- chemical sources; direct energy conversion – radiant sources. Abstracts of the individual papers are given in the succeeding items.

AG81/1 **Nuclear Energy Source Limitations for Dynamic Energy Conversion Systems.** F.K.PITTMAN, J.D.LAFLEUR, Jr.
AGARDograph 81, 5-23, 12 refs., 1967.
The limitations which the nuclear energy source imposes on the dynamic power system fall into two categories: (i) the reactor fuel temperature; (ii) shielding, to protect spacecraft components and to prevent injury to crews. These limitations, and the associated development problems are examined. Discussion.

AG81/2 **Solar Collection Limitations for Dynamic Converters.** G.L.SCHRENK.
AGARDograph 81, 25-46, 21 refs., 1967.
A mathematical model for analysis of actual solar collectors has been developed. It allows one to calculate the energy flux on any arbitrarily shaped focal surface from any arbitrarily shaped collector surface without making numerical approximations. Typical results are presented to show the effects of surface and orientation errors. This model has been used to investigate the interface

between the collector and the heat receiver (the cavity opening). Detailed analytical work has been performed on cylindrical heat receivers coupled with typical collectors. Discussion.

AG81/3 **Radiator Design Limitations for Dynamic Conversion.** A.KOESTEL, C.M.SMITH.
AGARDograph 81, 49-109, 43 refs., 1967.
Reviews the technology for design of radiators associated with dynamic converters in which the working fluid is condensed directly in the tubes of the radiator. General design procedure and its optimization are discussed. Various constraints are integrated through use of information flow charts indicating the sequence of computations. The appropriate equations and their source are noted. A method for estimating the optimum condensing temperature is explained and developed. The application of Lagrangian multipliers in the optimization of design is discussed. Single-phase boundary layer stability techniques are applied to two-phase flow mechanics for predicting the transmission of flow regimes. Experimental data which correlate wetting and nonwetting characteristics in the forced convection condensation of mercury are presented.

AG81/4 **Heat Transfer Limitations for Dynamic Converters.** A.P.FRAAS.
AGARDograph 81, 111-134, 7 refs., 1967.
Heat transfer considerations are major limiting factors in the design, development, and operation of dynamic conversion systems for space power plants. The nature of these limitations varies with the component. For example, in the heat source, whether nuclear or solar, thermal conduction affects the thermal stresses, thermal distortion, and local hot spots. These factors are likely to limit the practicable power density in the heat source to a lower value than might be permitted by the obvious problem of heat transfer from the heated solid surface to the fluid cooling it. The latter is likely not to be a difficult problem except for local hot spots caused by poor flow distribution, etc. Other heat transfer limitations include problems in the boilers and condensers for Rankine cycle systems, and heat conduction, emission, and reflection in the radiator. Some typical examples of these problems that are particularly likely to be determining factors in the design of turbine-generators space power plants are presented. Discussion.

AG81/5 **Prospects for Thermal Energy Storage.** M.ALTMAN.
AGARDograph 81, 135-149, 25 refs., 1967.
The problem of developing a method of storing thermal energy by using the heat of fusion of suitable compounds is treated. Incentives for the development of this type of energy storage, the problem of synthesising suitable materials, and the problem of obtaining the needed heat transfer properties are discussed. The main conclusions are: a good case can be made for space power systems utilizing thermal energy storage; a great deal of work remains to be done on the determination of phase diagrams of promising eutectic mixtures and on the experimental and theoretical determination of heat transfer properties; a carefully planned systematic approach is needed to obtain the information necessary for systems comparisons. Discussion.

AG81/6 **Thermodynamics of the Two-Phase Cycle for Space Applications.** (In French.) J.PLOTKOWIAK.
AGARDograph 81, 153-179, 3 refs., 1967.
Study of the possible use of the Rankine cycle in gas-turbines for space applications; Definition of the lower power limit which would still provide good performance; Research on working fluids suitable for these engines; Analysis of losses and effect of irreversible processes within the various components of the power plant on the system efficiency; Technological limitations, and possible development of a low-power turbocompressor unit using the Rankine cycle. Discussion.

AG81/7 **Thermodynamics of the Brayton Cycle for Space Applications.** (In French.) P.BARTHELEMY, C.CHAUVINEAU, G.DJEULOT.
AGARDograph 81, 181-205, 7 refs., 1967.
The following topics are treated: the Brayton cycle; qualitative thermodynamics of the Brayton cycle; the working fluid; the recuperation process, effect of the particle concentration on the principle parameters of the conversion system.

AG81/8 **Thermodynamics of Piston Engines for Space Applications.** (In French.) M.VERNET-LOZET.
AGARDograph 81, 207-221, 7 refs., 1967.
Review of the Stirling cycle characteristics and possible use of alternative engines for power supply on space vehicles. Comparison of the performances of various types of engines. Studies of the specific mass of a power plant using a solar collector as power source. Research on radiator temperature minimizing this specific mass.

AG81/9 **Working Gas Selection for the Closed Brayton Cycle.** J.L.MASON.
AGARDograph 81, 223-252, 5 refs., 1967.
The properties of the cycle working gas influence the design of all major components except the alternator. Gas selection indices are developed here for a representative Brayton cycle turbo-component, the compressor, and a representative heat transfer component, the recuperator.

Especially at low power levels, these selection indices indicate substantial advantages associated with use of helium-xenon gas mixtures. Such binary inert-gas working fluids provide outstandingly low Prandtl numbers along with variable molecular weights to meet turbomachinery design requirements at various power levels.

AG81/10 **Nuclear Source Limitations for Direct Conversion Devices.** R.W.BUSSARD.
AGARDograph 81, 257-277, 12 refs., 1967.
Includes: survey of energy conversion systems (systems using conversion external to the source systems using direct conversion in the source); survey of nuclear source limits (solid fission reactor fuels (3000/4000 deg.K), liquid fuels (3500/4500 deg.K), gaseous fission plasmas, fusion plasmas); potentialities and characteristics of two specific systems (advanced solid fuel fission reactors, internal direct conversion gaseous fuel fission reactors). Discussion.

AG81/11 **Limitations of Solar Collectors for Converters.** (In French.) F.TROMBE, E. Le GRIVES.
AGARDograph 81, 279-314, 22 refs., 1967.
Research on solar energy collectors and receivers for space applications. Review of various concentrator concepts and definition of receiver configurations leading to most promising performances. Analysis of main factors affecting efficiency (geometrical perfection, optical qualities, structural rigidity, response to meteorite impacts, etc.), and receiver efficiency (absorption characteristics, surface radiation etc.). Discussion.

AG81/12 **Thermodynamics of Thermionic Energy Conversion.** W.B.NOTTINGHAM.
AGARDograph 81, 317-335, 18 refs., 1967.
A review under the headings: general considerations; systems considerations; thermionic emission from tungsten in the presence of caesium, ionization and excitation properties of caesium; voltage-current curves from a research diode. Discussion.

AG81/13 **Physical Methods of Investigation Applied to Thermionic Converters.** W.KLUGE, K.BAUER, W.BLOSS.
AGARDograph 81, 337-344, 1967.
The efficiency, stability and lifetime of thermionic converters are defined primarily by the surface properties of the emitter and collector materials. New methods for surface investigations are described. Studies of emitter material properties through the measurement of work function distributions by emission microscopy, the use of measured emitter resistance along with an energy balance to give overall effective work functions, and the measurement of evaporation rates by means of a quartz oscillator microweighing apparatus are included. A method of measuring the collector work function distribution, using an image orthicon tube with the storage plate replaced by collector material, is described. Discussion.

AG81/14 **Properties of Emitters and Collectors for Thermionic Converters.** (In French.) J.E.PICQUENDAR, O.CAHEN.
AGARDograph 81, 345-355, 1967.
Research on a thermionic converter without auxiliary electrode and using electronic emission and resonance ionization. Heterogeneous metal emitters are achieved by a mixture of tungsten and barium aluminate powders pressed at the bottom of a capsule; the collector is a molybdenum cylinder and a low-pressure caesium plasma is maintained between the electrodes. Tests performed with these converters promise a high efficiency source of energy operating at low temperature. Discussion.

AG81/15 **A Process for Conversion of the Energy Released from Ionized Vapour by Fission Products.** (In French.) S.KLEIN, P.KRAUS.
AGARDograph 81, 357-374, 12 refs., 1967.
When two electrodes maintained at different temperatures are immersed in ionized vapour, a potential difference appears between them. Tests have been performed in a nuclear reactor channel where the predominating ionizing agent is constituted by the fission products released by a thin layer of uranium oxide. Experience has shown that in this conversion process the negative charge carriers are not constituted by electrons only but also by negative ions or negative droplets. Further experimentation should permit the development of these converters. Discussion.

AG81/16 **The Diagnostics of Plasmas.** J.A.THORNTON, R.C.WARDER, Jr, A.B.CAMBEL.
AGARDograph 81, 377-418, 75 refs., 1967.
In energy conversion processes, both natural and man-made plasmas may be used to advantage. However, regardless of origin, it is necessary to know the properties of plasmas before reliable energy conversion devices can be designed and constructed. It is the purpose of this paper to highlight the theoretical considerations underlying plasma diagnostic techniques used in the Northwestern University Gas Dynamics Laboratory in conjunction with a variety of plasma generation facilities. Discussion.

AG81/17 **Thermodynamics of MHD Energy Conversion.** H.M. De GROFF, R.F.HOGLUND.
AGARDograph 81, 419-475, 22 refs., 1967.
Previous theoretical and experimental work is reviewed in order to assess the accuracy to which the performance of MHD Energy Conversion devices can be predicted. It is concluded that: (i) in the case of closed-cycle generators, successful operation depends upon achievement of adequate electrical conductivity at relatively low temperatures; (ii) the most promising approach is through non-equilibrium ionization. The thermodynamic energy exchange processes which govern the extent of non-equilibrium ionization are discussed. Future prospects for development of key research areas pertinent to closed-cycle MHD power generation are described. Discussion.

AG81/18 **Non-Equilibrium Modes of MHD Converters.** I.FELLS.
AGARDograph 81, 477-500, 23 refs., 1967.
The following are treated: the non-equilibrium plasma; combustion-driven systems; closed-cycle systems; ionization using radiation and applied RF fields. Discussion.

AG81/19 **A Non-Equilibrium Electron Mode for Kilowatt Range MPD Space Power.** I.R.McNAB.
AGARDograph 81, 501-515, 26 refs., 1967.
Many techniques for producing extra-thermal ionization in magnetoplasmadynamic (MPD) generators are currently under investigation in the hope that reductions in the operating temperature of these generators will result. This is particularly important in the nuclear closed-cycle concept, which is of interest for space power systems, where the available gas temperature is limited by foreseeable nuclear reactor developments. One method of producing electron concentrations considerably greater than for thermal equilibrium is to expand rapidly the working fluid by means of a nozzle. This effect is investigated here, particular attention being paid to its influence on MPD generators in the range 10-100 kW output. Discussion.

AG81/20 **Generalized Saha Equation for Non-Equilibrium Two-Temperature Plasmas.** R.MONTI, L.G.NAPOLITANO.
AGARDograph 81, 517-537, 16 refs., 1967.
The present work is intended as a higher approximation with respect to the theory which proposes the use of the Saha equilibrium equation based on the electron temperature; in the present analysis both electron and atom temperature are taken into account for the calculation of the equilibrium electron concentration. As an application of this theory, the electrical conductivity has been calculated under a number of suitable simplifying hypotheses, as a function of the plasma pressure and temperatures. The correlation of the available experimental results appears to be improved with respect to other more simplified theories.

AG81/21 **Electro-Fluid Dynamic Energy Conversion Processes for Power Generation.** S.HASINGER, M.HAWES, M.O.LAWSON, H. Von OHAIN, F.WATTENDORF.
AGARDograph 81, 539-630, 25 refs., 1967.
The purpose of this paper is to give a general review of fundamental thermodynamic and electrical aspects of EFD conversion processes with special reference to viscous coupling phenomena, generation of ions, and charged colloids. Discussion.

AG81/22 **Thermodynamics of Thermoelectric Conversion.** V.FERRO.
AGARDograph 81, 633-649, 14 refs., 1967.
After an examination of experimental thermoelectric phenomena, their interpretation and correlation is discussed in the light of the thermodynamic theory of irreversible processes. The case is then considered of an ideal thermoelectric generator operating at optimum efficiency or at maximum electric power output.

AG81/23 **High-Temperature Thermoelectric Material Limitations.** C.M.KELLEY, G.C.SZEGO.
AGARDograph 81, 651-677, 11 refs., 1967.
A wide range of properties are considered to determine the limits set by materials properties to the application of thermoelectric energy conversion. Melting points and vapour and decomposition pressure phenomena begin to restrict the choice of materials just below 2000 deg.K and this restriction becomes continually more severe through the next 1000 deg.K. Discussion.

AG81/24 **Fuel Cell Reactant Properties.** R.G.H.WATSON.
AGARDograph 81, 681-707, 54 refs., 1967.
The fuel cell is considered as a chemical energy converter and the components which contribute to its important dimensions are discussed. The reactant properties that are useful in fuel cell system design are derived and concern the fuel, oxidant and exhaust products, and the electrodes and electrolyte. Appropriate values are tabulated and used to illustrate factors in cell design. Areas of apparent ignorance are discussed in relation to the need for further work. Discussion.

AG81/25 **Mechanism of Electrical Conductivity of Fused Salts.** F.R.DUKE.
AGARDograph 81, 709-715, 10 refs., 1967.
The lack of correspondence between viscosity and electrical conductivity, and particularly the temperature coefficients of these properties, indicates that Stokes' law does not apply to the motion of the ions in a fused salt. Experiments on transport numbers and on relative mobilities of ions in mixtures indicate that the conductivity process is poly-ordered in the moving ion; that is, the ions would appear to move in groups. One interpretation of this effect is that an ion vacancy moves, in each activation step, through several or many ionic diameters. Discussion.

AG81/26 **Electrochemical Catalysis.** J.O'M.BOCKRIS, H.WROBLOWA.
AGARDograph 81, 717-767, 102 refs., 1967.
The factors affecting the rates of chemical and electrochemical reactions are discussed. The differences between chemical and electrochemical catalysis arising from the existence of the applied field and from the presence of solvent are shown from the theoretical and experimental points of view. A review of the possible ways to enhance electrocatalysis is presented. Discussion.

AG81/27 **Kinetic Factors in Fuel Cell Systems: The Oxygen Electrode.** E.YEAGER, A.KOZAWA.
AGARDograph 81, 769-793, 19 refs., 1967.
The results of various studies of the oxygen-peroxide couple on carbon, graphite, lithiated nickel oxide, and platinum are summarized with emphasis on the dependence of the results on electrode composition, surface preparation, pH, and electrolyte composition. Some of the implications of these fundamental studies in the optimization of oxygen cathodes for aqueous fuel cells are discussed. Discussion.

AG81/28 **Thermally Regenerative Fuel Cells.** R.E.HENDERSON.
AGARDograph 81, 795-809, 19 refs., 1967.
The thermally regenerative fuel cell is discussed in terms of modes of regeneration. The thermodynamic cycle is analyzed from the standpoint of reversible thermodynamics and a limiting efficiency is thereby calculated. A practical system, namely, the K-Hg system, is discussed in light of fuel cell data and boiler separator data. Space power system weights for such a system are estimated on the basis of this data. The various components of such a system are itemized and discussed from the standpoint of anticipated future developments.

AG81/29 **Thermodynamics and Applications of Bioelectrochemical Energy Conversion Systems.**
M.G. DEL DUCA, H.M.FUSCOE.
AGARDograph 81, 811-839, Numerous refs., 1967.
Biochemical energy conversion is the process of converting chemical free energy of biologically catalyzed reactions to electrical energy. Particular attention in the past two years has been directed to applying the results of biochemical research and development to this type of energy conversion. This paper considers these applications in a state-of-the-art review and presents a synopsis of suggested applications, ranging from the use of bioelectric currents to identify toxic materials and power human implanted cardiac pacemakers, to the generation of electric power in remote areas of the world. Discussion.

AG81/30 **Quantum Efficiency of Radiant Energy Photons in Semiconductors.** G.C.JAIN.
AGARDograph 81, 843-861, 7 refs., 1967.
The efficiency of conversion of radiant energy from the sun, nuclear or fossil fuels to electrical energy depends upon the efficiency with which a radiant energy photon is capable of generating a useful charge carrier. Using Shockley-Read statistics a general expression for the quantum efficiency of a monochromatic incident radiant photon has been derived in terms of the absorption coefficient $(L_\lambda)^{-1}$ of the incident wave-length in the semi-conductor material, the minority carrier lifetime and the thickness of the exposed layer of the P-N cell. Germanium cells show a great potential for solid-state conversion of energy from radiant sources. Discussion.

AG81/31 **Photovoltaic Cells with Concentrators.** (In French.) P.LECLERC.
AGARDograph 81, 863-871, 1967.
Effect of development and operational parameters of a photo-diode on its photovoltaic efficiency. Investigation of the effect of the series resistance on generator efficiency and of possible means of improving cell performance.

AG81/32 **Realization of a Thermophotovoltaic Converter.** (In French.) A.FORTINI, P.BAUDUIN, P.SIBILLOT.
AGARDograph 81, 873-896, 14 refs., 1967.
Following a brief survey of the basic theory for the photovoltaic effect, theoretical analysis is made of the influence of geometrical and electrical parameters defining a photovoltaic cell on the conversion efficiency for the conversion of luminous energy into electrical power. Study of spectral adaptation of the cell. Theoretical predictions and experimental data are compared.

AG81/33 P-I-N Structures for Controlled Spectrum Photovoltaic Converters. D.C.WHITE. R.J.SCHWARTZ.
AGARDograph 81, 897-922, 23 refs., 1967.
The factors to be considered in the design of such systems are: (i) radiant source characteristics; (ii) spectral modification through the use of selective filters and reflectors; (iii) collection efficiency of the p-n junction; (iv) the internal dissipation of energy due to series resistance within the cell; (v) the intensity of incident radiation required for efficient operation of the photovoltaic device. Considering the above factors an edge-irradiated P-I-N structure is analyzed and marked advantages are found because of higher output voltages, reduced series resistance, and improved collection efficiencies. This type of structure also possesses potential advantages for the conversion of high energy particles to electrical energy. Discussion.

AG82 The Science and Technology of Tungsten, Tantalum, Molybdenum, Niobium and their Alloys.
AD-442-505 N.E.PROMISEL (Editor).
N64-27576 AGARDograph 82, 588 pp., 1964.
This is based on an AGARD Conference on Refractory metals held in Norway in June, 1963. Seven sections deal with an introduction to the subject, alloys and alloying behaviour, properties and engineering applications, deterioration and protection, analysis and testing, primary fabrication, and secondary fabrication. Abstracts of the individual articles are given in the subsequent items.

AG82/1 Why Refractory Metals? N.E.PROMISEL.
AGARDograph 82, 3-13, 1964.
Presents briefly the scope of the applications of these metals (propulsive systems, electric power generation for space vehicles, nuclear systems, etc.), the material requirements resulting therefrom, and reasons for concentrating on tungsten, tantalum, molybdenum and niobium, with consideration of other materials and techniques as alternatives to using refractory materials.

AG82/2 Trends and Stimulation in Solid State Science. F.SEITZ.
AGARDograph 82, 15-23, 1 ref., 1964.
Discusses briefly the following areas in solid state science: macroscopic properties, lattice properties, electronic bands, imperfections, and surface properties. The author believes that the solid state scientist is making a great contribution to technology and that his future is assured.

AG82/3 Accelerated Progress through Cooperative NATO Effort. R.SCHRADER.
AGARDograph 82, 25-26, 1964.
A very brief and general description of the contribution made by the NATO Science Committee towards progress in the materials science field, and its support given to the AGARD Structures and Materials Panel.

AG82/4 Alloys and Alloying Behaviour: Rapporteur's Interpretive Statement. W.OWEN.
AGARDograph 82, 29-30, 1964.
Experimental work on dislocation behaviour has concerned f.c.c. metals. Dislocation theories must therefore be extended and modified to include refractory metals. This is discussed together with other mechanical properties such as strain-hardening and fracture.

AG82/5 Alloys and Alloying Behaviour: Rapporteur's Interpretive Statement. A.D.McQUILLAN.
AGARDograph 82, 31-32, 1964.
Reasons are given why, in relation to refractory metals, an increased effort must be put into electronic studies, which should be concentrated in the direction of attempting to relate electron structure to elastic constants. The information gained will have use in the problem of the mechanical behaviour of alloys of refractory metals.

AG82/6 Alloys and Alloying Behaviour: Rapporteur's Interpretive Statement. R.I.JAFFEE.
AGARDograph 82, 33-50, 11 refs., 1964.
A short introduction on refractory metal alloys is followed by a discussion on their applications, types, and the usefulness of basic research. The conclusions are that practically no use has been made of heat treatment to enhance their properties. Another neglected field is powder-metallurgy of molybdenum alloys; also the welding metallurgy of refractory metals is relatively unexplored.

AG82/7 The Electronic Structure and Alloying Characteristics of the Early Transition Metals.
A.D.McQUILLAN.
AGARDograph 82, 51-61, 17 refs., 1964.
The electronic structure of early transition metals is a complex problem unlikely to yield to a completely theoretical attack. The most promising physical properties are the temperature coefficient of electronic specific heat, the magnetic susceptibility, and possibly the critical temperature for superconductivity. Results so far obtained are reviewed. An important property of the metals is the ability of certain members of the group to take into solution large quantities of non-metallic

elements. The decrease in this ability to dissolve interstitial atoms with increasing electron/atom ratio of alloys is discussed.

AG82/8 **Structural Considerations in Developing Refractory Metal Alloys.** L.L.SEIGLE.
AGARDograph 82, 63-93, 54 refs., 1964.
An attempt has been made to evaluate the effect of individual dissolved elements on the strength and hardness of Cb, Ta, Mo and W, based upon available experimental data. An important factor in the effect of solutes upon the strength of refractory metals is the possibility of interactions between the substitutional and interstitial solutes which modify the influence of these solutes on mechanical properties.

AG82/9 **The Interaction of Interstitial Solute and Substructure in Refractory Metals.** D.HULL, W.S.OWEN.
AGARDograph 82, 95-109, 59 refs., 1964.
Discusses the substructure of these metals from the point of view of recovery and crystallization and also structures developed on deformed annealed material, interstitial solutes, discontinuous yield, strain hardening, and brittle fracture.

AG82/10 **The Trend and Status of Development of Refractory Metal Alloys.** A.B.MICHAEL, W.O.GENTRY.
AGARDograph 82, 111-129, 53 refs., 1964.
Discusses molybdenum, columbium, tantalum and tungsten base alloys for elevated temperature applications, based on commercial and experimental alloys in the United States. Strength is considered from alloying and metallurgical points of view. The importance of low temperature ductility, fabricability, and weldability is discussed and future areas of investigation suggested.

AG82/11 **Summary and Conclusion (of Alloys and Alloying Behaviour).**
AGARDograph 82, 131-133, 1964.
R.Castro and I.Jenkins with the assistance of this Sessions rapporteurs highlight the main points of the papers and make suggestions for future research.

AG82/12 **Properties and Engineering Applications: Rapporteur's Interpretive Statement.** W.H.DUKES.
AGARDograph 82, 137-156, 1964.
Discusses material property data that the designer requires for the design of efficient, economical, and reliable structural and mechanical elements, particularly for airframe and propulsion systems. Also briefly mentioned are points in refractory metal development which increase strength and decrease oxidation.

AG82/13 **The Physical Properties of Refractory Metals with Reference to Other Engineering Materials.**
E.GEBHARDT, R.ROTHENBACHER.
AGARDograph 82, 157-173, 64 refs., 1964.
The properties of Nb, Ta, Mo and W are discussed in this report. The first part enumerates the physical properties of the pure metals, the second part deals with the effects of alloyings in these metals, and the third part is concerned with those changes in properties that results from reactions between metals and gases.

AG82/14 **The Effects of Trace Elements on the Mechanical Properties of Refractory Metals.**
A.J.NICOL-SMITH, L.NORTHCOTT.
AGARDograph 82, 175-190, 19 refs., 1964.
A brief assessment of the mechanical properties of refractory metals shows that fabrication with these materials is still subject to handicaps. Against this background the present state of fabrication and use of refractory metal is considered from the point of view of the way in which the properties are affected by trace elements. An assessment of present lines of attack and some suggestions for future discussion conclude the paper.

AG82/15 **Knowledge of the Thermochemistry of Refractory Metals and its Application in Prediction of Engineering Structures.** O.KUBASCHEWSKI.
AGARDograph 82, 191-204, 23 refs., 1964.
It is shown that a two-fold contribution can be made by the thermochemist. Firstly, the thermochemical properties of alloys are likely to be reflected in the mechanical properties. Secondly, when the necessary thermochemical information is available, or can be reliably estimated, the exact state of equilibrium of an alloy can be calculated.

AG82/16 **Determination and Application of Thermophysical Properties of Refractory Metals.** G.D.RIECK.
AGARDograph 82, 205-217, 104 refs., 1964.
The properties referred to in this paper are diffusion under the influence of a temperature gradient, emissivity, heat capacity, thermal conduction and liability to structural change when heated. The determination of these in W, Ta, Mo and Nb is considered.

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AG82/17 **Effects of High-Energy Rate-Forming on Properties of Refractory Metals.** C.A.VERBRAAK.
AGARDograph 82, 219-231, 14 refs., 1964.
High strain-rate and high-energy rate forming are defined and differences noted. Shock loadings, normally by explosives are used in high-energy rate forming, but this has caused unfavourable effects on the metal properties. This paper gives a short survey of the principles derived from former works on explosively-loaded single crystals of various f.c.c. and b.c.c. metals. The results of work on Mo single crystals are also discussed in more detail.

AG82/18 **Summary and Conclusion (of Properties and Engineering Applications).**
AGARDograph 82, 233-236, 1964.
H.Kjollesdal and L.Northcott with the assistance of the rapporteur report the discussion of this Sessions papers and make recommendations regarding thermochemistry, high-energy rate forming, thermophysical properties, and mechanical properties.

AG82/19 **Deterioration and Protection: Rapporteur's Interpretive Statement.** P.KOFSTAD.
AGARDograph 82, 239-249, 12 refs., 1964.
Tungsten, tantalum, molybdenum and niobium exhibit extremely high reactivity in oxidizing environments at high temperatures, and this constitutes a major problem in using these refractory metals for structures. This report deals with the more applied aspects and liquid metal-refractory metal reactions.

AG82/20 **Deteoriation and Protection: Rapporteur's Interpretive Statement.** (In French.) R.SYRE.
AGARDograph 82, 251-256, 3 refs., 1964.
Presents comments on, and a combined summary of, the papers of Distefano and Hoffman, Speiser and St.Pierre, Levinstein and Wlodek, and Czarnecki and Braun. It is suggested that in addition to the points raised by Levinstein and Wlodek on the effects of alloying and coating on the elevated temperature corrosion resistance of the refractory metals, a systematic study is required of the effect of additive elements in the base alloy on the characteristics of the coatings, on the 'coatability' and on the interactions between the coating and the substrate.

AG82/21 **Corrosion Mechanisms in Refractory Metal-Alkali Metal Systems.** J.R.DISTEFANO, E.E.HOFFMAN.
AGARDograph 82, 257-288, 102 refs., 1964.
Discusses corrosion mechanisms which have been observed in alkali metal-solid metal systems; presents a brief summary of results that have been obtained on specific refractory metal-alkali systems; suggests areas of research on the latter systems which are needed to better understand the fundamental corrosion processes.

AG82/22 **Fundamentals of Refractory Metal-Gaseous Environment Interaction.** R.SPEISER, G.R.ST.PIERRE.
AGARDograph 82, 289-330, 129 refs., 1964.
Reviews the present status of the fundamental aspects of the oxidation behaviour of Mo, W, Nb, and Ta in gaseous atmospheres such as air, O_2-N_2, CO-CO_2, and H_2-H_2O mixtures at elevated temperatures. The first part discusses the refractory metal-oxygen equilibria, while the second part reviews the kinetics of oxidation of each refractory metal.

AG82/23 **Effects of Alloying and Coating on the Elevated Temperature Corrosion Resistance of the Refractory Metals.** M.A.LEVINSTEIN, S.T.WLODEK.
AGARDograph 82, 331-356, 85 refs., 1964.
Briefly reviews the mechanics of oxidation and contamination of refractory metals in the regions above 500 to 700 deg.C. A critical approach is then considered of those concepts that have proved useful in the protection by alloying and coating molybdenum, tungsten, columbium and tantalum. Fundamental research is still required in the study of the oxidation mechanism of these metals and of the coatings, and on volatilization and diffusion.

AG82/24 **Devlopment and Evaluation of Coatings for Earth Re-entry Systems.** E.G.CZARNECKI, M.T.BRAUN.
AGARDograph 82, 357-368, 7 refs., 1964.
Discusses the development and testing of refractory metal coatings for these systems, with particular emphasis on the environment, coating applications, test facilities, test results, and recommendations for future work. The methods of application of disilicide coatings to molybdenum and columbium are compared.

AG82/25 **Summary and Conclusion (of Deterioration and Protection).**
AGARDograph 82, 369-374, 1964.
I.Jenkins and D.Tytgat with the assistance of this session's rapporteurs report a discussion of the papers and make suggestions for future research on high temperature corrosion, the development of corrosion-resistant materials and coatings, and the compatability of alkali metals and refractory metals for compact nuclear reactors.

AG82/26 **Analysis and Testing: Analytical Methods: Rapporteur's Interpretive Statement.** G.L.MILLER.
AGARDograph 82, 377-379, 1964.
Reviews the two papers presented in this section, one of which examines the physico-chemical methods of analysis, and the other which comments on results obtained by several laboratories on their analyses of samples of refractory metals.

AG82/27 **Spectrographic and Newer Methods of Impurity Analysis in Refractory Metals.** A.H.GILLIESON.
AGARDograph 82, 381-393, 69 refs., 1964.
The existing or potential methods for the determination of interstitial and substitutional impurity elements in trace amounts in the refractory metals molybdenum, niobium, tantalum, and tungsten are reviewed with particular reference to vacuum-fusion, emission spectrography, mass spectrometry, and activation analysis.

AG82/28 **The Analysis of Refractory Metals for Impurities.** R.ORSAGE.
AGARDograph 82, 395-396, 1964.
Presents methods considered most advisable for routine analysis for oxygen, hydrogen, nitrogen, carbon, and iron, excluding all methods implying exceptional techniques or apparatus.

AG82/29 **Summary and Conclusion (of Analysis and Testing: Analytical Methods).**
AGARDograph 82, 399-400, 1964.
A brief report of the discussion of this session is presented by H.A.Sloman and H.Kinsey with the assistance of the Session's rapporteur. An important point arising from the discussion was that, while physico-chemical methods of analysis offer much promise, their ultimate development is largely dependent on the application of conventional chemical techniques.

AG82/30 **Analysis and Testing: Mechanical Testing: Rapporteur's Report.** G.T.HARRIS.
AGARDograph 82, 401-404, 1964.
Discusses the problems of evaluating the mechanical properties of refractory metals which differ from those encountered with the more conventional materials. Briefly the reasons given are (i) reaction with the atmosphere, (ii) specimen heating, and temperature measurement and control, (iii) the importance of axiality of loading, and (iv) the significance of surface finish.

AG82/31 **Outline Evaluation of Fabricability of Refractory Metals.** J.T.STACY.
AGARDograph 82, 405-420, 11 refs., 1964.
A number of mechanical tests are described for sheet materials of molybdenum, niobium, tantalum, and tungsten. Test data are presented and their significance discussed in relation to forming operations.

AG82/32 **Evaluation and Test Methods for Refractory Metals.** D.COUTSOURADIS.
AGARDograph 82, 421-449, 57 refs., 1964.
A short review of experimental techniques used in refractory metal testing includes details on tensile tests, heating and temperature control, and test environment. The discussion of the various parameters has shown the influence of the procedure on the reliability of the results. The control of test variables is shown to be of particular importance. The capabilities and limitations of available equipment is noted.

AG82/33 **Summary and Conclusion (of Analysis and Testing: Mechanical Testing).**
AGARDograph 82, 451-453, 1964.
A short paper prepared by T.A.Taylor and H.Kinsey, with the assistance of this Session's rapporteur discusses test conditions of uncoated refractory alloys, mechanical testing of coated refractory metal composites, test result reporting, mechanical testing of weldments, and fabricability of refractory alloys. Recommendations are made for future work.

AG82/34 **Primary Fabrication: Rapporteur's Interpretive Statement.** W.A.BACKOFEN.
AGARDograph 82, 457-463, 1964.
A critical review is made of the four papers given in this Session. Although many different operations are considered by the authors and the discussions differ in detail, it is pointed out that the overall processing objectives remain much the same in all papers.

AG82/35 **Consolidation of Refractory Metals.** J.WONG.
AGARDograph 82, 465-476, 17 refs., 1964.
Comments are made on the seniority of powder metallurgy processing and why it no longer predominates except for pure tungsten. Also contamination control might be handled through vacuum sintering. The status of melting practices is considered on the basis of 'contaminant balance'. Electron-beam melting for the consolidation of refractory metals is said to be an important method practiced during the last decade. Several commercial practices are described from which the author generalizes on what the best practice should be.

AG82/36 **Flat Rolling of Refractory Metals.** P.S.DARBY.
AGARDograph 82, 477-484, 2 refs., 1964.
The available methods for manufacture of sheet are mentioned discussing (i) thin and wide dimensions, (ii) flat and uniform thickness, (iii) contamination-free processing, and (iv) ductility. Suggestions are made as to possible solutions of problems encountered; it is considered that these possible solutions have not received sufficient attention as yet.

AG82/37 **Primary Working of Refractory Metals.** A.S.NEMY.
AGARDograph 82, 485-502, 33 refs., 1964.
Primary working operations convert ingot and billet material into more useful mill product shapes and improvement of properties by grain refinement, strain hardening, and redistribution of micro-constituents. The paper discusses the extent of current development in this area and attempts an analysis in the problem areas which constitute a gap between current capability and future technology.

AG82/38 **Shape Forming of Refractory Metals.** M.E.CIESLICKI.
AGARDograph 82, 503-516, 8 refs., 1964.
Considers closed die forging, ring rolling, shear forming, tube extruding, shape extruding and centrifugal casting. A particular component considered from design and forming aspects is a tungsten rocket nozzle. A description of electric furnace heating, die-steel tooling, lubrication and oxidation protection is also included.

AG82/39 **Summary and Conclusion (of Primary Fabrication).**
AGARDograph 82, 517-518, 1964.
A paper prepared by W.Rostoker with the assistance of this Session's rapporteur discussed the papers presented. A number of specific points of discussion come under the term quality control. Lack of communication between laboratories and mills is shown by the differences of opinion and experience.

AG82/40 **Secondary Fabrication: Rapporteur's Interpretive Statement.** H.M.FINNISTON.
AGARDograph 82, 521-525, 1964.
Discusses the four papers presented to this Session and notes that all papers show some attempt at systemizing facts but much of the matter is descriptive with only just sufficient data to show whether a process will be workable.

AG82/41 **Machining of Refractory Metals.** F.W.BOULGER.
AGARDograph 82, 527-540, 7 refs., 1964.
Machinability ratings are given for drilling and turning these materials. Grinding ratios are also given together with the overall problems of machining and grinding. The conclusions are that the difficulties in machining will have to continue since attempts to make parts to close, much less finished, tolerances by primary processes will not succeed technically or economically.

AG82/42 **Forming of Refractory Metal Sheet.** R.A.PERKINS.
AGARDograph 82, 541-556, 9 refs., 1964.
Current status and problems of production forming of refractory metal sheets are considered. The results are reported on bending of sheet of columbium, molybdenum and tantalum alloys, and of unalloyed tungsten to form sections, flanges, contours, etc. The conclusion drawn is that major problems are those of ensuring material which is free from defects and which has inherent ductility.

AG82/43 **Joining of Refractory Metals.** A.G.METCALFE.
AGARDograph 82, 557-570, 12 refs., 1964.
Deals with the joining of these materials for aeronautical applications. Metals include tungsten, molybdenum, tantalum and niobium. The metallurgical aspects are considered as well as joints by welding, brazing, diffusion-bonding and pin-joining. The acceptance standards for joints are also discussed.

AG82/44 **Flow Turning (Shear Forming) of Refractory Metals.** B.NATTER, R.MACHENSCHALK.
AGARDograph 82, 571-580, 1964.
Flow turning is a combination of both deep drawing and spinning. Heating to temperatures of 700 to 1000 deg.C is necessary to make this method technically practicable. The technique has the advantage of applying stress locally rather than mass movement or shear of the material, and it could be very attractive with improvements in atmosphere control and under special conditions such as size and shape of the work piece.

AG82/45 Summary and Conclusions (of Secondary Fabrication).
AGARDograph 82, 581-582, 1964.
The problem of formability of refractory metals and suggestions for future work are reported in the discussion of this Session's papers by N.Grant and R.Lachemund together with the assistance of the session's rapporteur.

AG83 Manual on Aircraft Loads. J.TAYLOR.
AD-458-256 AGARDograph 83, 350 pp., 163 refs., 1965.
N65-18187 This Manual describes the loads that an aircraft encounters at speeds up to Mach 2.5 and heights up to 100,000 ft. Extensive measurements of aircraft loads have been made during the last 10 years on particular aircraft and this study co-ordinates these separate researches. Generally the data are presented in basic form, independent of the particular aircraft on which the measurements were made.

AG84/1 Arc Heaters and MHD Accelerators for Aerodynamic Purposes.
AD-452-716 AGARDograph 84, Pt.1, 514 pp., 1964.
N65-12379 This AGARDograph contains a collection of papers presented at the AGARD Specialists' Meeting on 'Arc Heaters and MHD Accelerators for Aerodynamic Purposes'. The collection of papers emphasizes aerodynamic applications of electric arc and magnetohydrodynamic methods.

AG84/1/1 Research on Linear Crossed-Field Steady-Flow D.C.Plasma Accelerators at Langley Research Center, NASA. G.P.WOOD, A.F.CARTER, A.P.SABOL, D.R.McFARLAND, W.R.WEAVER.
AGARDograph 84, Pt.1, 1-45, 9 refs., 1964.
Results obtained and research in progress with 1 cm square and small expanding accelerators is described. The solutions to problems incurred with the arc heater and seeding apparatus for a 2.5 cm square accelerator are given and operational problems due to large Hall potentials and to erosion are discussed. The 2.5 cm square accelerator works well and accelerates nitrogen from 2,000 to 6,000 metres/sec with an exit density corresponding to an altitude of 45 Km.

AG84/1/2 Application of Distributed Charge Exchange to a Crossed-Field Accelerator. J.L.WYATT, W.B.DAY.
AGARDograph 84, Pt.1, 47-68, 1 ref., 1964.
Presents an analysis of the technique of distributed charge exchange, as an alternative to elastic collisions, for exchanging momentum between a plasma and a neutral gas for the E x B accelerator. It is shown that proper adjustment of plasma density, background neutral particle density, and electric and magnetic fields can produce a continuous high velocity stream of neutral particles useful in many E x B accelerator applications.

AG84/1/3 Theory of Rarefaction Waves in a Plasma. G.W.PAXTON, R.G.FOWLER.
AGARDograph 84, Pt.1, 69-108, 26 refs., 1964.
A theory for the rarefaction process in a plasma carrying an electric current is developed for the one-dimensional case. Criteria are derived which determine the nature of the rarefaction process as a function of the electron temperature and degree of ionization in the plasma. The theory is applied to the rarefaction wave in the driver section of the electric shock tube in order to determine the velocity of the compressional shock produced in terms of the electron temperature, degree of ionization, and plasma density in the driver section.

AG84/1/4 Blast Wave and Characteristics Analysis of the Flow in an Electromagnetic Tee-Tube.
D.C.DRYBURGH.
AGARDograph 84, Pt.1, 109-161, 19 refs., 1964.
The theory of characteristics and blast wave theory were applied to assess the degree of non-uniformity in the flow experienced at a fixed position behind the decaying shock wave in an electrically driven T-tube. The results agree well, the residual descrepancies being due, in part to the deviation of the shock from an ideal blast wave, and in part to an error in the blast wave solutions. Characteristics theory, although more involved, may be applied more generally: modifications necessary to use this method with a gas in ionization equilibrium are described.

AG84/1/5 Fundamental Research on Plasmas in a Magnetohydrodynamic (MHD) Shock Tube. (In French.)
R.M.HEAD, J.VALENSI, Y.CHARVET.
AGARDograph 84, Pt.1, 163-245, 26 refs., 1964.
Experimental tests, carried out in a MHD shock tube at the Fluid Mechanics Institute of Marseille, in order to measure the light front velocity and to determine the plasma ion density, temperature and speed by means of spectrographic analysis, are described. The results obtained are presented and discussed.

AG84/1/6 **Transient Electrical Characteristics of Inductance-Drive Arc Discharges in High Density Nitrogen.** R.R.WALKER, 3rd, J.D.WHITFIELD.
AGARDograph 84, Pt.1, 247-276, 12 refs., 1964.
An analytical representation of an arc discharge is developed by accounting for experimentally observed variations of arc voltage with current. The semi-empirical theory developed may be applied to (i) scaling power supply requirements, (ii) scaling arc chamber requirements, (iii) predicting arc heating performance for different initial gas densities, electrode gaps and arc chamber geometries. Agreement between this semi-empirical theory and experiment is reasonable for arc currents of 10^4 to 5×10^5 Amp.

AG84/1/7 **A Survey and Prediction of the Performance Capability of Coaxial Arc Heaters.** G.L.CANN, R.D.BUHLER.
AGARDograph 84, Pt.1, 277-322, 29 refs., 1964.
To estimate the ultimate technical limits of arc gas heater performance the well-known approximate theories for the fully developed arc column (Parabola and Bessel models) were extended to include radiation and, for the high current regime, the self-magnetic pressure gradient. Hot gas containment limits were calculated for air, for a range of allowable wall heat loads (0.1 to 10 KW/sq.cm).

AG84/1/8 **Arc Gas Heaters – Present and Future.** J.A.BROWNINC, J.W.POOLE.
AGARDograph 84, Pt.1, 323, 352, 3 refs., 1964.
This survey considers: the history of arc heater development; modern arc heater design; possible future design improvements; hypothetical design of future high-power arc heaters.

AG84/1/9 **Summary of Some of the Arc-Heater Hypersonic Wind-Tunnel Development Effort Underway at the Langley Research Center.** W.B.BOATRIGHT, R.B.STEWART, D.I.SEBACHER, M.A.WALLIO.
AGARDograph 84, Pt.1, 353-377, 11 refs., 1964.
The results of recent research using three separate arc-heated facilities are summarized; these facilities were a Mach 12 arc-heated wind tunnel, a hypersonic arc-heated tunnel with a 4 ft diameter test section and a rotary-arc plasma accelerator.

AG84/1/10 **Irreversible Flow in Reservoir and Throat Sections of Wind Tunnels with Constricted-Arc Heaters.** J.L.POTTER, G.D.ARNEY, Jr, W.H.CARDEN, M.KINSLOW.
AGARDograph 84, Pt.1, 379-412, 12 refs., 1964.
The title subject is discussed under four main headings: flow uniformity; thermo-chemical equilibrium, heat loss, and flow steadiness. The effect of typical variations in structural design and flow properties is shown by presentation of experimental data and related theoretical analysis.

AG84/1/11 **Three-Phase A.C. Arc Heater Studies at the U.S. Naval Ordnance Laboratory.** E.M.WINKLER, R.E.LEE, R.L.HUMPHREY, L.J.MILNER.
AGARDograph 84, Pt.1, 413-449, 11 refs., 1964.
The approach to the development of this heater has been both experimental and analytical. The studies have shown that the electrical requirements for high pressure operation have led to design improvements and revealed the severity of convection and radiation losses. Conclusions reached from tests on the first heater have been utilized in designing two more heaters; preliminary data on these two new heaters are presented.

AG84/1/12 **Effect of Axial Flow on the Behavior of The Wall-Constricted Arc.** H.A.STINE, V.R.WATSON, C.E.SHEPARD.
AGARDograph 84, Pt.1, 451-485 12 refs., 1964.
An experimental and theoretical study of the interaction between an electric arc and a coaxial flow of gas was carried out in the range of size, enthalpy level, and pressure level where radiation heat loss constitutes a noticeable part of the total loss from the system. Numerical calculations were performed and compared with earlier analytical calculations and also with experimental results.

AG84/1/13 **Utilization of Electromagnetic Forces in a Coaxial Arc for High Velocity and Enthalpy Re-entry Simulation.** R.L.HARDER, G.L.CANN.
AGARDograph 84, Pt.1, 487-513, 7 refs., 1964.
The purpose of this paper is to show how Lorentz (J x B) forces affect the design and operation of axially symmetric d.c. arc heaters. Radial and axial forces are considered to demonstrate the effect they have on velocities and losses in the heater. Mathematical expressions are given for some simple cases including pressure distribution in an arc column and total momentum increment in an expanding arc. Using the analysis, an accelerator configuration and a model electromagnetic interaction with the plasma are postulated. Several accelerators have been built and tested; details are given of the operational performance attained.

AG84/2 **Arc Heaters and MHD Accelerators for Aerodynamic Purposes.**
AD-452-825 AGARDograph 84, Pt.2, 536 pp., 1964.
N65-12393 This collection of fourteen papers emphasizes aerodynamic applications of electric-arc and magnetohydrodynamic methods. Abstracts of the individual papers are given in the subsequent items.

AG84/2/1 **Radiation from an Alternating Current Nitrogen Arc.** P.W.SCHREIBER.
AGARDograph 84, Pt.2, 15-584, 8 refs., 1964.
Presents a summary of the experimental methods and the experimental results obtained from an investigation of the total radiation emitted from a vortex-stabilized arc operating in 1 atmosphere of nitrogen. The arc was operated on alternating and direct current. In addition, a simplified analytical solution of the alternating current arc is given and a comparison is made with experimental results.

AG84/2/2 **Real Gas Radiation with Self-Absorption and Space Varying Temperature.** C.H.MARSTON, T.K.PUGMIRE.
AGARDograph 84, Pt.2, 585-632, 14 refs., 1964.
Frequency dependent radiant flux density from an infinity long cylindrical arc column, including self-absorption, was calculated and summed for pressures up to 300 atm for several measured and assumed temperature profiles. Use was made of a digital computer. Measurements of total radiant flux density made at 2.0 atm are somewhat lower than the calculations. A 'quasi-optically thin' model was accurate up to about 50 atm.

AG84/2/3 **The Radiating Arc-Column.** G.L.MARLOTTE, R.L.HARDER, R.W.PRICHARD.
AGARDograph 84, Pt.2, 633-672, 11 refs., 1964.
Simple analytical expressions are derived for describing the radiation from an arc confined in a cylindrical constrictor. The radiation from such arcs in argon and nitrogen has been measured as a function of the arc current and the gas pressure in the confining cylinder. Comparison of the measurements and analysis is found to be good except for the electric field dependence upon current. Similarity parameters inferred from analysis and approximately derived from the basic equations, are applied successfully to the measurements with argon and to extensive calculations with nitrogen.

AG84/2/4 **Effects of a Radiative Heat-Sink on Arc Voltage-Current Characteristics.** W.T.LORD.
AGARDograph 84, Pt.2, 673-708, 21 refs., 1964.
A simple radiative heat-sink is introduced into a well-known theoretical arc model. The arc voltage current characteristic is expressed in a non-dimensional form which shows the importance of the effect of heat-sink. The theory is applied to (i) the wall-stabilized static arc in a cylindrical tube of finite radius, and (ii) the convection-stabilized arc held at rest (by a magnetic field) against a uniform flow of finite velocity. Numerical examples, based on published experimental results, are given.

AG84/2/5 **Analysis of Experimental Results Obtained from an Argon Arc.** (In French.) J.FABRI.
AGARDograph 84, Pt.2, 709-726, 6 refs., 1964.
Concerns the comparison of theory and experiments on constricted arcs stabilized by a magnetic field, taking into account real gas properties. The use of argon makes it possible to achieve a more accurate comparison. It also makes it possible to bring out the effects of the main magnetofluidynamic parameters on the arc rotating speed, heat transfer to the walls, and the efficiency of the system.

AG84/2/6 **Hot Gas Arc Generators.** (In French.) F.CHARRON.
AGARDograph 84, Pt.2 727-750, 1964.
Describes the development of two heaters with cooled metal cathodes which are an improvement on the d.c. plasma arc heaters also being developed by O.N.E.R.A. The first, capable of achieving 280 kW power, has been in operation several months. Improvements to this are recommended. The second, which is about three times larger than the first, should provide about 1000 to 3000 kW.

AG84/2/7 **Performance Characteristics of a Fully-Developed Constricted Transpiration-Cooled Arc.** E.R.G.ECKERT, J.E.ANDERSON.
AGARDograph 84, Pt.2, 751-795, 11 refs., 1964.
A possible way to increase the peak enthalpy in a gas stream heated by a constricted arc is to make the constrictor wall porous, and to inject gas through the wall for cooling. In this paper, the peak enthalpy of such an arc heater is compared with the peak enthalpy obtainable in a heater with identical geometry, but with a water-cooled constructor wall. The indications are that the latter is less efficient in this respect.

AG84/2/8 **Fundamental Considerations in Arc Heater Design.** R.L.PHILLIPS.
AGARDograph 84, Pt.2, 797-843, 15 refs., 1964.
Design criteria fundamental to the successful operation of an a.c. arc heater facility are discussed in some detail. Three aspects which strongly influence performance are given as (i) electrode endurance, (ii) arc stability and its behaviour as a circuit element, and (iii) the radiative and convective heating of exposed components. These problems are being studied at the University of Michigan and, in order to appreciate these studies a brief description is included of the heater facility at Michigan.

AG84/2/9 **Growth of an Arc Column in Flow and Pressure Fields.** H.E.WEBER.
AGARDograph 84, Pt.2, 845-881, 31 refs., 1964.
Presents a study of the behaviour of an arc discharge in coaxial gas flow downstream of a cathode in a tube. Predictions from the theoretical model are consistent with physical observations, and correlations with experimental and theoretical enthalpy profiles and voltage current characteristics are good.

AG84/2/10 **Arc Heaters Producing Flat Temperature Distributions.** T.PETERS.
AGARDograph 84, Pt.2, 883-902, 3 refs., 1964.
Describes arc experiments employing an a.c. magnetic field configuration with the object of obtaining a flat temperature distribution in the jet. It is shown that applying an a.c. magnetic field produces a high degree of irregular turbulent motion inside the chamber, resulting in a flat temperature distribution of the jet as is desirable for wind tunnel operations.

AG84/2/11 **Motion of the Plasma Column in the Interior and at the Exit of an Arc Jet.** G.KRUELLE.
AGARDograph 84, Pt.2, 903-934, 8 refs., 1964.
To explain pulsations in the operation of arc-jet engines, the transient behaviour of the plasma column in the interior and exit of an engine was studied, using a Fastax high-speed camera. In addition, the transient arc voltage was recorded. Argon, nitrogen, helium, and hydrogen were used as propulsion gases. The results are explained and discussed in detail.

AG84/2/12 **Some Observations of an Electric Arc Magnetically Confined in a Transverse Supersonic Flow.** C.E.BOND, A.M.KUETHE.
AGARDograph 84, Pt.2, 935-979, 24 refs., 1964.
A method has been developed for the magnetic stabilization of a d.c. electric arc in supersonic air flow. Observations are presented of the behaviour of the stabilized arc, including the observation that the positive column of the stable supersonic arc is slanted with respect to the electric field. The experimental set-up in a supersonic wind tunnel is also described.

AG84/2/13 **Development and Use of an Ion Mach Meter to Calibrate an Arc-Heated Low-Density Wind Tunnel.** W.A.CLAYDEN.
AGARDograph 84, Pt.2, 981-1011, 18 refs., 1964.
Gives a method which enables a local measurement to be obtained directly in a flowing partially ionized gas. Experiments have shown that the necessary conditions may be obtained in the R.A.R.D.E. arc-heated low-density tunnel, and the optimum probe sizes are obtained. The method of extrapolating the saturated ion currents to their value at plasma potential is discussed.

AG84/2/14 **Boundary-Layer Motion in a Two-Dimensional Arc-Heated Channel.** S.L.SOO, M.N.BAHADORI.
AGARDograph 84, Pt.2, 1013-1051, 28 refs., 1964.
The study consists of the extension of boundary-layer theory to the case of flow of an ionized gas over a cooled wall. The results suggest that, when applied to the condition at re-entry, substantial electrical and thermal conductivities not too much lower than those of the ionized gas behind the shock wave exist at a cooled wall, although the gas temperature decreases significantly toward the wall.

AG84/S **Arc Heaters and MHD Accelerators for Aerodynamic Purposes.**
AD-446-684 AGARDograph 84, Supplement, 174 pp., 1964.
N64-29122 Three papers representing different aspects of a programme at AEDC to develop a magnetohydrodynamically powered wind tunnel are presented. Abstracts of the individual papers are given in the succeeding items.

AG84/S/1 **General Considerations of MHD Acceleration for Aerodynamic Testing.** L.E.RING.
AGARDograph 84, Supplement, 1-55, 24 refs., 1964.
Estimates of magnetohydrodynamic performance limitations show that velocities of 30,000 to 40,000 ft/sec at high density should be attainable with a Faraday accelerator. Operation near atmospheric pressure using seeded air is suggested; seed material should not affect aerodynamic testing. Increased performance by using non-equilibrium electrical conductivity is a possibility

AG84/S/2 **Development of a Steady Flow J x B Accelerator for Wind Tunnel Application.** K.E.TEMPLEMEYER, A.K.WINDMUELLER, L.E.RITTENHOUSE.
AGARDograph 84, Supplement, 57-126 17 refs., 1964.
Describes aspects of an experimental programme at AEDC to develop a steady-flow, direct-current, J x B accelerator for a wind-tunnel driver. Electric discharge and material tests were made in a supersonic seeded nitrogen plasma at near 3000 deg.K and pressures of 1 atmos. The design of a water-cooled accelerator having 117 pairs of segmented electrodes is described. A prototype 20-pair accelerator has been successfully tested.

AG84/S/3 **Improvements in Design of MHD Accelerator Channels for Aerodynamic Purposes.** J.B.DICKS.
AGARDograph 84, Supplement, 128-174, 10 refs., 1964.
The formulation of a theoretical model of magnetohydrodynamic accelerators and generators together with experiments indicate that it is possible to design a channel of much simpler construction, higher temperature capability, and less expensive than designs initially considered. Practical advantages and disadvantages of this channel design are noted.

AG85 **Wind Tunnel Data Processing.** R.E.COVEY.
AD-476-416 AGARDograph 85, 146 pp., 38 refs., 1964.
N65-22609 This paper is an introduction to the problem of defining and selecting an automated data processing system for a wind tunnel facility. The restraints imposed by speed and accuracy requirements and the characteristics of various facilities and types of testing are discussed. Typical systems and system elements are described. A tabulation listing the present data processing systems for many wind tunnel installations and a sample specification for a modern system are included.

AG86 **Low Temperature Oxidation.** W.JOST (Editor).
AD-642-741 AGARDograph 86, 412 pp., 1965.
N67-13821 As many ignition processes and combustion phenomena can be understood only against a background of the underlying slow oxidation processes, this monograph on the title subject was prepared at the suggestion of the AGARD Combustion and Propulsion Panel. Abstracts of the individual contributions are given in the succeeding items.

AG86/1 **Kinetic Basis of Oxidation Processes.** W.JOST.
AGARDograph 86, 1-34, 39 refs., 1965.
Contents: General remarks; Formal treatment of composite reactions; Some general relations for composite reactions; Chain reactions and reactions with branching chains; Some general results for non-branching chains; General rate expressions with chain branching and chain start or breaking at walls; Questions of stability; The development with time of a branching chain reaction; An example.

AG86/2 **The Oxidation of Hydrogen.** H.RICHTERING.
AGARDograph 86, 37-82, 172 refs., 1965.
The following topics are treated: the low pressure reaction; the reaction at the second explosion limit; the reaction between the second and third explosion limits; the reaction at the third explosion limit; the mechanism of the hydrogen-oxygen reaction at low temperatures.

AG86/3 **The Oxidation of Carbon Monoxide.** T.GREWER.
AGARDograph 86, 83-106, 57 refs., 1965.
Aspects of the title subject which are discussed include: the explosion limits, the reaction outside the explosion limits, the kinetics of carbon monoxide oxidation.

AG86/4 **The Oxidation of Carbon Disulphide.** T.GREWER.
AGARDograph 86, 107-115, 23 refs., 1965.
The following aspects of the title subject are considered: the explosion limits; spectroscopic investigations; the mechanism of CS_2 oxidation.

AG86/5 **The Oxidation of Hydrogen Sulphide.** T.GREWER.
AGARDograph 86, 117-123, 19 refs., 1965.
The mechanism of the process of the oxidation of hydrogen sulphide is discussed with frequent reference to the literature on this subject and the results obtained by other researchers.

AG86/6 **The Combustion of Methane.** D.E.HOARE.
AGARDograph 86, 125-165, 71 refs., 1965.
The following aspects are considered: the oxidation of methane; the oxidation of formaldehyde; interaction of formaldehyde and methane oxidation reactions; the initiation reaction, carbon monoxide oxidation; chain propagation; chain ending reactions; the kinetic scheme; experimental conditions; methane explosions.

AG86/7 **Oxidation by Oxides of Nitrogen and Ozone.** T.GREWER.
AGARDograph 86, 169-190, 55 refs., 1965.
Oxidation by Nitrous oxide; oxidation by nitric oxide; oxidation by nitrogen dioxide (H_2-NO_2 reaction, CO-NO_2 reaction, NH_3-NO_2 reaction, oxidation of hydrocarbons by NO_2); oxidation by ozone (H_2-O_3 reaction, CO-O_3 reaction, oxidation of hydrocarbons by ozone).

AG86/8 **The Oxidation of Hydrocarbons.** L.SIEG.
AGARDograph 86, 191-284, 211 refs., 1965.
The oxidation of the following substances is considered: (i) ethane, ethylene, ethanol and acetaldehyde; (ii) propane, propylene, propanol and propionaldehyde. (iii) n-butane and iso-butane; (iv) pentane; (v) hexane; (vi) olefins; (vii) n-heptane and octanes; (viii) cycloalkanes and cycloolefins; (ix) aromatic hydrocarbons; (x) hydrocarbon mixtures.

AG86/9 **'Knock' in Spark-Ignition Engines.** A.D.WALSH.
AGARDograph 86, 285-327, 68 refs., 1965.
The phenomenon of 'knock' in spark ignition engines, and research into this phenomenon, is discussed with frequent reference to the literature.

AG86/10 **The Mode of Action of 'Anti-Knocks'.** A.D.WALSH.
AGARDograph 86, 329-370, 97 refs., 1965.
Considers in some detail the use of organo-metallic compounds and aromatic compounds as anti-knock agents.

AG86/11 **The Pyrolysis of Organic Compounds.** H.FORMANEK.
AGARDograph 86, 371-397, 128 refs., 1965.
The following subjects are treated: pyrolysis of hydrocarbons (methane, ethane, higher hydrocarbons, unsaturated hydrocarbons, acetylene); pyrolysis of ethers; pyrolysis of alcohols; pyrolysis of aldehydes and ketones (formaldehyde, acetaldehyde, acetone); pyrolysis of peroxides; the influence of additives on the pyrolysis.

AG87/1 **The Fluid Dynamic Aspects of Space Flight.**
AD-642-742 AGARDograph 87, Vol.1, 402 pp., 1964.
N67-13842 This AGARDograph reports the proceedings of the AGARD Fluid Dynamics Panel Specialists Meeting on the title subject which was held during April, 1964 at Marseille. The AGARDograph is published in two separately bound parts. Vol.1 includes eighteen papers on the following subjects: the fluid dynamic aspects of weightlessness; rarefied gas effects in near-space conditions; effects of space environment on space vehicle components; particle impact on surfaces at high velocities. Abstracts of the individual papers in Vol.1 are given in the succeeding items.

AG87/1/1 **Static and Dynamic Behaviour of the Liquid-Vapour Interface during Weightlessness.** E.W.OTTO.
AGARDograph 87, Vol.1, 3-38, 29 refs., 1964.
The problems encountered in attempting to operate systems containing a free liquid-vapour interface in a weightless environment are summarized. The literature reporting the research applicable to or directed toward solutions for these problems is reviewed. Results of the research defining the configuration of the interface as a function of liquid properties and system geometry are discussed. The results of experimental studies of the dynamic behaviour of the interface in response to changes in gravity level, to outflow disturbances, and to acceleration disturbances are presented. This study places particular emphasis on determination of the scaling laws that permit prediction of the interface behaviour as a function of model size.

AG87/1/2 **Preliminary Analysis of Liquid Equilibrium Configurations and Disturbances of Vehicle Motion due to Liquid Sloshing in Space.** D.G.EIDE, W.T.BLACSHEAR, E.G.FOUDRIAT.
AGARDograph 87, Vol.1, 39-59, 8 refs., 1964.
The equilibrium free surface of a liquid contained in a tank undergoing simultaneously translational acceleration and a rotation about an axis fixed with respect to the tank has been investigated. Representative solution curves are presented and discussed for various magnitudes of translational acceleration, rotational rate, liquid to solid contact angle, and vapour volume. The dynamic behaviour of a liquid is also investigated for a region where the inertial forces are of the same order of magnitude as the capillary forces and possible methods of minimizing the sinusoidal variation of the angular motion are presented.

AG87/1/3 **Interaction of Rockets and Satellites with the Ionosphere.** R.N.COX, W.A.CLAYDEN.
AGARDograph 87, Vol.1, 63-74, 15 refs., 1964.
Three distinct flow regions are noted which depend upon the relative sizes of the charged particle and neutral mean free paths and a typical body dimension. The qualitative nature of the flow in these regions is discussed and some laboratory experiments which simulate certain aspects of the

three flow regions are described. In these experiments Langmuir probes were used to measure the redistribution of charged particles about spheres, discs, wires and jets.

AG87/1/4 **Facilities to Simulate the Aerodynamics of Charged Particles in the Ionosphere.** W.A.CLAYDEN.
AGARDograph 87, Vol.1, 75-93, 27 refs., 1964.
A review of the various regimes associated with the Aerodynamics of charged particles in the ionosphere is given together with the details of some preliminary experiments which have been undertaken at R.A.R.D.E.

AG87/1/5 **Aerodynamic Coefficients of Wings and Fuselages in Rarefied Gas Flow.** J.W.BECK.
AGARDograph 87, Vol.1, 95-116, 17 refs., 1964.
The Aerodynamic coefficients (lift, drag, pitching, moment) of symmetrical wing profiles and fuselages (with and without nose radius) are calculated for the free molecular flow. Profiles and fuselages have parabolic contours. The results are given as functions of the speed ration $S = \sqrt{\gamma/2}$, Ma_∞. Good agreement between pressure induced lift and hypersonic approximation has been observed.

AG87/1/6 **On Some New Low Density Installations and their Operation.** (In French.) E.A.BRUN.
AGARDograph 87, Vol.1, 117-125, 1964.
Installations at the laboratories of the C.N.R.S. that are described are (i) a rotating arm apparatus in a rarefied gas chamber and (ii) a low pressure wind tunnel with a flow rate of 40 cu.m/sec. The range of pressures which can be explored with these two facilities extends from 1 micron Hg to 100 microns Hg, the Knudsen numbers being variable between 0.01 to 10. Torsion balances for use in each of these facilities are described, and as examples of the results obtained, details of the drag in a rarefied atmosphere are presented.

AG87/1/7 **The VKIFD Low Density Wind Tunnel.** J.J.SMOLDEREN, J.NAVEAU.
AGARDograph 87, Vol.1, 127-137, 3 refs., 1964.
The new low density wind tunnel at VKIFD is described and some results of initial tests with free expanding cold jets are presented. The future plans for research in the near free molecule flow regime are indicated.

AG87/1/8 **Review of the Influence of Space Environment upon Vehicle Components.** R.SMELT.
AGARDograph 87, Vol.1, 141-165, 18 refs., 1964.
Discusses the problem and hazards which have been encountered in space vehicles up to the present, as a result of environment. Much of the information has been obtained by practical experience of operations of Agena satellites, supported by laboratory work in specific areas.

AG87/1/9 **The Influence of Environment on the Mechanical Behaviour of Metals.** J.R.KRAMER, S.E.PODLASECK.
AGARDograph 87, Vol.1, 167-183, 33 refs., 1964.
Gaseous constituents normally found in the atmosphere affect the plastic deformation characteristics of metals. Modification of the creep and tensile behaviour of metal single crystals and polycrystalline metals ranging from high purity to complex alloys are reported.

AG87/1/10 **High Altitude, High Voltage Breakdown in an Electric Propulsion Flight Test System.** L.R.SITNEY, T.R.SHUKAY.
AGARDograph 87, Vol.1, 185-209, 1964.
Selected data from the first flight test of an Air Force developed electric propulsion flight test system are presented. Arcing in the high voltage section of the flight test system at an altitude of approximately 1000 miles produced failures. Factors which caused the high voltage breakdown at high altitudes and measures which have been taken since the flight to eliminate the cause of this breakdown are described. The first known simulation of a boost phase time-pressure profile of a flight system at the Arnold Engineering Development Center is presented.

AG87/1/11 **Electric Drag on Satellites-Theory and Experiment.** W.C.PITTS, E.D.KNECHTEL.
AGARDograph 87, Vol.1, 211-221, 10 refs., 1964.
Laboratory measurements of electric drag of spherical satellites with conducting surfaces are compared with existing theories. Theories that neglect the shielding effect of the plasma sheath predict high values of electric drag, and theories that neglect the hard collisions of ions predict low values of electric drag. From the theory that is most consistent with the experimental data, three scaling parameters are developed that permit the extension of the laboratory results to realistic satellite conditions.

AG87/1/12 **Modification of Supersonic Flow Fields under near Space Conditions by Cryopumping.** W.D.CLEMENT, J.A.COLLINS, Jr, D.E.ANDERSON.
AGARDograph 87, Vol.1, 223-244, 8 refs., 1964.
Results are presented of a test programme designed to simulate an air-sampling probe utilizing cryosurfaces cooled to liquid helium temperature to capture the impinging gas. Capture coefficients are given for the liquid helium-cooled cryosurface under the conditions of normally directed low density gas flow from a Mach 3 nozzle for both clean polished surfaces and surfaces coated with a thin film of paraffin. Also presented are effects of micro-size particles in the gas on the cryopumping capabilities of the cryosurface.

AG87/1/13 **Impact Physics, Meteoroids, and Spacecraft Structures.** A.C.CHARTERS, J.W.GEHRING, C.J.MAIDEN.
AGARDograph 87, Vol.1, 247-297, 50 refs., 1964.
Consists of two sections, (i) the fields of astronomy and high velocity impact are surveyed for knowledge pertinent to the problem of meteoroid hazard to spacecraft, and (ii) recent results of high velocity impact research at GM Defense Research Laboratories are presented.

AG87/1/14 **Evaluation of the Impact Performance of Realistic Space Structures.** J.L.SUMMERS.
AGARDograph 87, Vol.1, 299-314, 3 refs., 1964.
Small spheres of aluminium and glass were fired at velocities from 4000 to 23,000 ft/sec into a variety of composite structures representative of various types of space vehicle construction. These structures were single-walled and multiple-walled samples having a variety of fillers of different composition and density including structural elements of aluminium honeycomb, and non-metallic materials representative of ablative heat-shield components. The results of these tests are discussed.

AG87/1/15 **Study of High-Speed Impact with the Aid of a Light Gas Gun.** (In French.) C.L.LECOMTE, R.SCHALL.
AGARDograph 87, Vol.1, 315-330, 9 refs., 1964.
Describes experiments in which cylindrical and spherical projectiles of dural and of polyethylene were projected at velocities of up to 9 kc/sec onto semi-infinite targets. Discusses the cratering produced in the target material and factors affecting the speed and direction of the secondary projectiles emitted during the impact.

AG87/1/16 **Experimental Studies of Hyper-Velocity Impact with the R.A.R.D.E. ¼ inch Calibre Launcher.** A.J.CABLE.
AGARDograph 87, Vol.1, 331-341, 3 refs., 1964.
Studies have been made of the hyper-velocity impact at speeds from 20,000 to 30,200 ft/sec of polythene projectiles on semi-infinite aluminium targets at angles of obliquity between 20 and 90 deg to the surface of the targets. The tests were made using a two-stage light gas gun. These tests showed that the crater produced by the impact is hemispherical in shape. An unusual pattern on the surface of the crater was found to be caused by marks on the front surface of the projectile. This gives the possibility of measuring the surface distortion of the crater which occurs during impact.

AG87/1/17 **Summary Report on the Theory of Hyper-Velocity Impact.** J.M.WALSH, W.E.JOHNSON, J.K.DIENES, J.H.TILLOTSON, D.R.YATES.
AGARDograph 87, Vol.1, 343-387, 20 refs., 1964.
This study is devoted primarily to solid-solid impact at velocities in the meteoric range. A continuous Eulerian hydrodynamic code is used to numerically integrate the flow equations for several series of impact problems. One-dimensional and axisymmetric impacts are computed for materials with an ideal-gas equation of state. These calculations provide some important comparisons with analytical work on the problem of hyper-velocity impact. Many of the concepts used in solid-solid impact are already present in the one-dimensional problem. The theory for this well-understood impact is discussed in considerable detail.

AG87/1/18 **Momentum Transfer and Cratering Phenomena Associated with the Impact of Aluminium Spheres into Thick Aluminium Targets at Velocities to 24,000 feet per second.** B.P.DENARDO, C.R.NYSMITH.
AGARDograph 87, Vol.1, 389-402, 5 refs., 1964.
Spheres of 2017-T4 aluminium were launched into semi-infinite targets of 2024-T4 and 1100-0 aluminium. The momentum transfer during impact was measured by means of a simple ballistic pendulum to which the target was attached. The ratio of target momentum to projectile momentum increased with increasing projectile velocity and with projectile diameter. Mass loss due to cratering, penetration, and crater diameter were also obtained for these experiments.

AG87/2 **Fluid Dynamics Aspects of Space Flight.**
AD-853-932 AGARDograph 87, Vol.2, 302 pp., 1964.
N68-28999 The thirteen papers presented in Vol.2 of this AGARDograph deal mainly with space simulation test chambers, and questions relating to rocket exhausts. Abstracts of the individual papers are given in the succeeding items.

AG87/2/1 **Some Selected Critical Problems of Space Simulation Test Chambers.** E.K.LATVALA.
AGARDograph 87, Vol.2, 1-37, 55 refs., 1964.
A survey of the state-of-the-art of space simulation test chambers is presented. Current methods and techniques for simulating the low-pressure and thermal-radiation environments of space are described, and several problem areas are discussed. Space chamber instrumentation and data acquisition and data-processing systems are briefly mentioned. The leakage and contamination problems of space chambers as affected by factors such as vacuum seals, virtual leaks and diffusion pump oil migration are also discussed.

AG87/2/2 **Molecular Flux and Equivalent Pressure in a Space Environment Chamber.** R.L.CHUAN.
AGARDograph 87, Vol.2, 39-47, 2 refs., 1964.
The performance rating of a space simulation chamber as far as interaction between gas molecules and the test specimen is concerned cannot be specified in terms of pressure. The reasons for this are given and a proper definition of the state of the gas in the chamber is discussed.

AG87/2/3 **Removal of Gases by Physical Adsorption and Chemisorption in a Space Simulation Test Chamber.** S.M.KINDALL, E.S.J.WANG.
AGARDograph 87, Vol.2, 49-66, 5 refs., 1964.
The application of these processes to space simulation testing is discussed in terms of the mechanisms involved, the parameters which must be isolated and expressed to yield engineering design data, and the present state of knowledge of these parameters. For physical adsorption a review of the experimental and analytical results obtained for activated charcoal is given. Limited results from chemisorption experiments are presented. Attention is given to the capability of each type of adsorption process to maintain a vacuum within a space simulation chamber when a constant flow rate gas load is introduced into the chamber.

AG87/2/4 **The Radiative Properties of Cryodeposits Exposed to Infrared Radiation.** R.L.YOUNG.
AGARDograph 87, Vol.2, 67-86, 20 refs., 1964.
Describes recent experimental and theoretical investigations conducted at Arnold Engineering Development Center, for the purpose of determining the radiative properties of solidified gases (cryodeposits) under conditions existing in aerospace environmental chambers. Of particular interest is the observation that thick carbon dioxide cryodeposits are transparent to certain wavelength ranges of the incident blackbody radiation while thin water cryodeposits are quite opaque to the incident radiation. Information is also presented on the influence of chamber-wall contaminants on the formation of the cryodeposits.

AG87/2/5 **Parameters, Techniques and Significance of Solar Simulation in Space Simulation Test Chambers.** D.E.LEE, L.STEG.
AGARDograph 87, Vol.2, 87-111, 5 refs., 1964.
A review of the significance of solar simulation (collimation, spectrum, etc.) on a typical satellite is given. Parameters affecting construction and performance of the solar simulation system and its relationship to a large (32 ft x 54 ft) space chamber located at the General Electric Valley Forge Space Technology Center are presented. Performance data of the complete chamber and sun system and early test results of typical satellite systems are reviewed.

AG87/2/6 **Thermal Vacuum Testing of Satellites without True Solar Simulation.** R.W.BLEVINS, I.B.IRVING.
AGARDograph 87, Vol.2, 113-123, 6 refs., 1964.
The simulation of the sun, the greatest source of radiation on a satellite, is a necessary part of a space-flight programme. However, considerable simplification of an overall test plan can be obtained by use of the tests described. Elimination of full scale α/ϵ tests has been shown to simplify procedures without loss of thermal performance. The thermal mock-up enables the thermal design to proceed in parallel with satellite construction. The result is a shortened test schedule and more complete knowledge of the thermal behaviour.

AG87/2/7 **Rocket Exhaust-Plume Problems and some Recent Related Research.** A.R.VICK, J.M.CUBBAGE, E.H.ANDREWS, Jr.
AGARDograph 87, Vol.2, 125-176, 58 refs., 1964.
Some typical problems related to the rocket exhaust-plume phenomena are discussed and a limited survey is made of the work being done. Results are included from recent research on plume contours at high pressure ratios, pressures on flat surfaces oriented both perpendicular and parallel to the axis of exhaust plume, and on heating rates in the backflow from clustered nozzles.

AG87/2/8 **High Altitude Jet Spreading and some Associated Interference Problems on Space Vehicles.** M.PINDZOLA, R.W.HENSEL.
AGARDograph 87, Vol.2, 177-196, 9 refs., 1964.
Spreading characteristics of underexpanded jets into a quiescent atmosphere are presented as obtained in space propulsion test chambers at the Arnold Engineering Development Center. Jet plume boundaries are obtained by three methods: (i) a glow discharge technique, (ii) a seeding technique, and (iii) a temperature measuring technique. Jet boundaries as obtained by the various techniques agree with each other as well as with the analytical boundaries. Recommendations are made regarding separation distance between upper and lower stages, and also for reducing maximum heat flux from the rocket exhaust.

AG87/2/9 **Expansion of Jets into Vacuum.** (In French.) E.ROBERTAND, J.P.MICHARD.
AGARDograph 87, Vol.2, 197-217, 10 refs., 1964.
A method visualizing the expansion of a jet into a near-vacuum environment using luminescent discharge techniques is proposed. The method is compared with classifical visualization methods (strioscopic, interferometric and phase contrast) and agreement is found to be satisfactory. The advantages of the method proposed justified its use for studies of propulsion at high altitudes.

AG87/2/10 **Experimental Investigation of Base Flow Characteristics of Four-Nozzle Cluster-Rocket Models.** B.H.GOETHERT, R.MATZ.
AGARDograph 87, Vol.2, 219-240, 1964.
The physics of the flow phenomena associated with cluster nozzles are briefly reviewed and some typical analytical and experimental data for the base interference presented. It is shown that the detrimental effect of hot-rocket gas backflow can be reduced greatly by shrouding the cluster nozzle assembly.

AG87/2/11 **Thrust Augmentation of Rocket-Propelled Vehicles by Base Pressurization.** J.D.C.COY, B.W.A.RICKETSON.
AGARDograph 87, Vol.2, 241-264, 1964.
Investigations on increasing the thrust of the Black Knight vehicle are reported. It is shown that extension of the skirt will effectively increase the thrust, but the possibility of loss of control force will have to be taken into account. A formula is tentatively postulated which permits base pressure for an extended skirt to be calculated.

AG87/2/12 **The Interaction of a Rocket Exhaust with the Lunar Surface.** L.ROBERTS.
AGARDograph 87, Vol.2, 265-286, 7 refs., 1964.
Particular attention is paid to three phases of the problem, (i) the gas dynamics of the exhaust, (ii) the mechanics of the surface erosion, (iii) visibility through the dust cloud. It is shown that the Mach number of the exhaust flow together with certain dust parameters determine the character of the erosion. The extent of erosion and loss of visibility through the cloud are shown to depend on the size of the particles and the location of the vehicle above the surface.

AG87/2/13 **Analysis of the Impingement of Condensed Rocket Exhaust Products upon Proximate Space Vehicles.** J.R.WROBEL.
AGARDograph 87, Vol.2, 287-302, 9 refs., 1964.
Predicts the approximate size and spatial distribution of condensed combustion products in the rarefied region of the exhaust of a rocket in space with a view to estimating impingement damage to the spacecraft. It is noted that for readily condensible exhausts, such as those containing metallic oxides the particle impingement can dictate definite constraints upon the mission profile.

AG88 **Physics and Technology of Ion Motors.** F.E.MARBLE, J.SURUGUE (Editors).
AD-642-743 AGARDograph 88, 403 pp., 1966.
N67-13831 The proceedings of a technical meeting of the Combustion and Propulsion Panel held during the 13th AGARD General Assembly (Athens, 1963), are presented. Subject areas covered included: ion sources, ion motor technology, energy conversion, and applications of ion motors. Abstracts of the individual papers are given in the succeeding items.

AG88/1 **Surface Ion Source Phenomena and Technology: Pt.1 – Ionization and Transport Phenomena and Performance of Porous Ionizers.** G.KUSKEVICS, J.M.TEEM.
AGARDograph 88, 3-78, 54 refs., 1966.
Topics discussed include: (i) experimental techniques for studying the intrinsic, macroscopic, and microscopic aspects of surface ionization and transport phenomena; (ii) results obtained on such intrinsic properties for caesium on various solid refractory metal surfaces, such as molybdenum, tungsten, together with the role of crystal orientation and surface impurities on such properties, and the consequences of such results for ion source technology; (iii) macroscopic results for such parameters as critical temperatures, current density, neutral fraction, and thermal emissivity obtained for various practical ionizer materials, and the consequences of such results on ion source technology.

AG88/2 **Surface Ion Source Phenomena and Technology: Pt.2 – Porous Material Technology.** J.M.TEEM, H.M.TODD.
AGARDograph 88, 79-101, 13 refs., 1966.
The current status of porous refractory materials technology related to caesium contact ionizers is reviewed from a metallurgical viewpoint. Information is presented concerning ionizer materials requirements, the production of porous materials using wire, sheet, and sintered powder methods, a comparison of the metallurgical and ionizer properties of these various materials, methods of joining such porous materials to the non-porous refractory elements of vapour feed systems and operating problem areas.

AG88/3 **Capillary Emitter of Caesium Ions: Application to Thermionic Converters.** (In French.) H.HUBER, R. LE BIHAN.
AGARDograph 88, 103-137, 25 refs., 1966.
The principle of the capillary emitter as a source of both caesium ions and electrons is expounded. Data derived from a theoretical model are compared with measurements carried out on three structurally different experimental arrangements.

AG88/4 **Physics of Charged Colloidal Particles and the Technology of their Production.** C.D.HENDRICKS.
AGARDograph 88, 139-153, 29 refs., 1966.
A brief history of the development of heavy particle propulsion is presented. The methods of producing charged heavy particles, the scientists, their laboratories and their techniques are briefly surveyed. Advantages and disadvantages of the various methods of particle charging and production are discussed. Emphasis is placed on electrical spraying of liquids. Some of the most recent developments in this particular area are presented.

AG88/5 **Physical Phenomena in Bombardment Ion Sources.** I.KOHLBERG, S.NABLO.
AGARDograph 88, 155-206, 39 refs., 1966.
A discussion of the physical phenomena occurring in electron bombardment ion sources is presented with specific reference to both the Lewis (NASA) geometry and the duoplasmatron configuration. Those phenomena of importance in the development of a working theory of ion source behaviour are evaluated. Detailed treatments of the calculation of the electron distribution function in a weak, magnetically-confined plasma, resonance charge transfer and ion kinetics in the region of low electric field to pressure ratio, the process of anomalous diffusion, and the calculation of the radial potential and plasma distribution for the Lewis source are presented. The applicability of these considerations in interpreting the behaviour of the Lewis type source is then evaluated.

AG88/6 **An Experimental Bombardment Ion Source.** P.C.McNEILL.
AGARDograph 88, 207-222, 5 refs., 1966.
A 2.5 cm diameter Kaufman-type bombardment ion source is described. Details of the performance are given and related to other published data. The maximum overall efficiency of the source was about 45% at a beam current density of about 3 mA/sq.cm. The overall energy per ion was in the region of 10,000 eV. Although this value is large, it is generally consistent with the behaviour of scaled sources as suggested by P.D.Reader.

AG88/7 **Technology and Development of the Contact Ion Engine.** G.R.BREWER.
AGARDograph 88, 225-254, 15 refs., 1966.
A brief introductory description of the operation of this type of electric thrustor is presented, followed by the current status and achievements of the past year or two. Some of the remaining technical problems in ion engine development are discussed. It is shown that the neutral evaporation rate of caesium from the ionizer is perhaps the most important factor in determining engine life and performance.

AG88/8 **Technology and Development of Bombardment Ion Engines.** R.C.SPEISER.
AGARDograph 88, 255-272, 14 refs., 1966.
The low density electron bombardment ion engine has been developed in two versions – the mercury engine developed by NASA Lewis Research Center and the caesium gas discharge ion engine developed at Electro-Optical Systems, Inc. for the NASA Lewis Research Center. The differences in operation are discussed. Both devices have similar performance with overall engine efficiences of 65 to 80% at specific impulses of 5,000 to 8,500 sec.

AG88/9 **Research on Ion Propulsion.** (In French.) J.F.BONNAL, J.CARON, G.MAINFRAY, C.MANUS, G.SPIESS.
AGARDograph 88, 273-303, 18 refs., 1966.
The results of research carried in collaboration by Services de Physique Apliquée du Commissariat à l'Energie Atomique and the Division Atomique de la SNECMA on ion propulsion are reviewed. These studies were carried out on a Kaufman type source using mercury. The experimental

apparatus, the characteristics of the beam produced, and the values of propulsive efficiency obtained are all treated. Also discussed are beam neutralization and ion density distribution in the interior of the source.

AG88/10 **Neutralization and Interaction Phenomena in a Low-Density Ion Exhaust.** J.M.SELLEN, Jr.
AGARDograph 88, 305-317, 21 refs., 1966.
The observed interaction phenomena in the low density plasma beams of electrostatic engines are discussed. The interaction of the electrons in the plasma with the electric field structure in the column, and the electron-magnetic field interaction are reviewed. Further phenomena which are considered include the electron-atom and electron-ion interactions, and the generation of oscillations in the plasma column at the plasma frequency from the two electron-stream instability. The use of the plasma stream for plasma-vehicle studies in a 'plasma wind tunnel' is described.

AG88/11 **Electrostatic Propulsion by Positive and Negative Ions.** (In French.) G.BUSSI, F.FILIPPI.
AGARDograph 88, 319-342, 8 refs., 1966.
Because of the difficulties associated with the neutralization of ion beams, the possibility of propulsion using positive and negative ions is considered. An analysis of the maximum values of the thrust/power ratio is presented. The ratios thrust/surface and thrust/power for the jet of an electrostatic motor are then studied when functioning by simple acceleration or by acceleration-deceleration.

AG88/12 **Density-Time Profiles for an Electric Propulsion Unit Efflux.** I.R.McNAB, P.C.McNEILL.
AGARDograph 88, 343-356, 12 refs., 1966.
The initial particle densities (n_0) obtained from present electrical propulsion units indicate that, at altitude between 50 and 200 miles, the decay of density in the efflux may be obtained using a diffusion approach: numerical density-time profiles are given. When $n_0 < 10^{12}$ ions/cu.cm the effects of recombination and ionization are shown to be negligible, the efflux remaining fully ionized. The results are compared with those obtained by Molmud for free molecular flow and the difference between the two approaches is explained. The effects of such highly ionized exhausts on space-ground radio communication are discussed.

AG88/13 **Thermionic Conversion of Energy.** (In French.) J.E.PICQUENDAR.
AGARDograph 88, 359-374, 1966.
In this survey article the following topics are considered: sources of electrical energy for space uses; principles of thermionic conversion; converters with pure metal emitters; converters with non-homogeneous emitters; solar radiation concentration; conversion of nuclear energy.

AG88/14 **Development Trends in the Field of Thermionic Energy Converters in Germany.**
E.M.KNOERNSCHILD.
AGARDograph 88, 375-389, 14 refs., 1966.
The German activity in the field of thermionic converters encompasses vacuum magnetic triodes, caesium diodes, and noble gas triodes. Theoretical investigations indicate that the important loss mechanism in vacuum triodes with superposed magnetic field is the scattering of electrons on their curved path from emitter to collector. Electron trajectories for two configurations of magnetic triodes are discussed. Some test data are presented. The possibility of intermittently generating ions followed by the emission of electrons is investigated.

AG88/15 **Application of Ion Thrust Motors in Attitude and Position Control of Satellites.** J.H.MOLITOR.
AGARDograph 88, 393-422, 7 refs., 1966.
The first contemplated use of ion propulsion is in the attitude control and station-keeping of a synchronous satellite. Here, the major forces (solar-lunar attraction, Earth's triaxiality, solar pressure, etc.) which tend to perturb the satellite or modify its orientation are reviewed. Mission constraints which affect the engine system design are presented. An evaluation is made of the trade-offs among such critical mission and system parameters as attitude accuracy, average power utilization, energy storage requirements, duty cycle, thrust level, thrust intervals, and satellite mass and moments of inertia. An optimization and preliminary design of an ion engine attitude control and station-keeping system are included.

AG89/1 **V/STOL Aircraft.**
AD-476-417 AGARDograph 89, Pt. 1, 473 pp., 1964.
N65-22900 The Combustion and Propulsion Panel of AGARD sponsored a meeting from 1st to 5th September, 1964 to survey the state of V/STOL developments in the light of NATO and national military requirements; emphasis was placed on recent developments in propulsion. The proceedings have been published in two Parts; the present Part, Pt. 1, contains the unclassified papers, abstracts of which are included in the succeeding items. Pt. 2 includes classified items and so details will not be given in this publication.

AG89/1/1 **The Point of View of SNECMA on Power Units for Short and Vertical Take-Off Aircraft.** (in French.) S.BOUDIGUES.
AGARDograph 89, Pt.1, 1-10, 1964.
The general conclusions reached by SNECMA appertaining to the propulsion of V/STOL are presented. It is concluded that separate lift engines simplify the designer's task; that it is easier to achieve thrust deviation by deflection of the jet than to move the power plant; that when power has to be supplied to lifting propellers or rotating wings, aerodynamic transmissions using the expansion of compressed air or gas appear to be preferable to mechanical declutching systems; that the rotation of propulsive engines to provide lift creates difficult kinematic and technological problems. Detailed conclusions related to the specific case of lift engines are also given.

AG89/1/2 **Propulsion Principles in V/STOL Aircraft.** A.P.ADAMSON, P.G.KAPPUS.
AGARDograph 89, Pt.1, 11-59, 1964.
General conclusions concerning the state of technology, operational readiness, and appropriate timing are made and related to system performance, to operational capabilities, and to V/STOL propulsion cost. Specific conclusions and recommendations regarding the natural field of applicability for cruise engines, direct lift engines, fans, and shaft power are given.

AG89/1/3 **Direct Lift Engines for Tactical VTOL Aircraft.** D.H.JACOBSON.
AGARDograph 89, Pt.1, 61-110, 1964.
In considering the propulsive requirements of tactical VTOL attention is concentrated on the combination of short hover time and high cruise speed and thus only vectored thrust and dual propulsion systems are considered. Power plant requirements for VTOL strike and transport aircraft are discussed; lift engine technology is examined in some detail and future developments are indicated.

AG89/1/4 **The Domain of the Convertible Rotor.** R.HAFNER.
AGARDograph 89, Pt.1, 111-146, 2 refs., 1964.
General considerations affecting the whole VTOL family of aircraft are discussed, including the noise problem and the effect of disc loading. Feasibility studies of the convertible rotor configuration are described from the economic and technical aspects, with emphasis on propulsion and fail-safe techniques. The convertible rotor is shown to be the best solution when economy at high subsonic speed is required.

AG89/1/5 **Survey of Significant Technical Problems Unique to V/STOL Encountered in the Development of the XC-142A.** L.C.JOSEPHS.
AGARDograph 89, Pt.1, 147-183, 6 refs., 1964.
The XC-142A is a tilt-wing deflected slipstream assault transport and is the first U.S. tri-service aircraft development programme. A description of the aircraft is followed by a consideration of the aerodynamic problems (transition, base drag, ground effects), structural dynamics problems (flutter and vibration, transmission system dynamics, dynamic response, aircraft acoustics), flying qualities problems, propulsion system problems, and testing.

AG89/1/6 **Effects of Airframe and Powerplant Configuration on V/STOL Performance.** R.F.CREASEY, N.W.BOORER, R.DICKSON.
AGARDograph 89, Pt.1, 185-221, 1964.
In discussing the large range of layouts that have been studied in relation to both strike and transport V/STOL requirements the following topics are considered: effect of mission requirement on choice of type of powerplant, methods of thrust deflection, aircraft layouts, effect of engine arrangement on STOL performance, effect of engine arrangement on supersonic acceleration, V/STOL growth factors, experimental programmes, engine failure considerations, and future V/STOL composite systems.

AG89/1/7 **Properties and Problems of the Ducted Fan.** (In French.) M.LAZAREFF.
AGARDograph 89, Pt.1, 223-253, 1964.
The following topics are considered: the theoretical possibilities of the ducted fan (hovering and translation); experimental performance of a ducted fan in hovering flight; the problem of the pitching moment during transition.

AG89/1/8 **Applications of Ejectors to Vertical Take-Off.** (In French.) P.GUIENNE, M.FAURE.
AGARDograph 89, Pt.1, 255-275, 4 refs., 1964.
A brief survey is given of the data obtained from tests and studies of the use of ejectors for vertical and short take-off. Exploratory small-scale model testing was devoted to ejector thrust increase and weight and size reduction. Preliminary designs have been outlined. Tests of full-scale ejectors supplied by turbojet exhaust confirmed the small scale test results.

AG89/1/9 **The Canadair Tilt-Wing/Deflected Slipstream V/STOL Prototype Program.** F.C.PHILLIPS.
AGARDograph 89, Pt.1, 277-307, 7 refs., 1964.
Canadair is constructing the prototype CL-84, a V/STOL aircraft of the tilt-wing/deflected-slipstream type. This six-ton aircraft will be suitable for transport and Army combat support missions. The early development work is described and the significant research and developments are outlined. The prototype aircraft, which is expected to fly in 1965, is described in some detail.

AG89/1/10 **The Tri-Service X-19 V/STOL Design Considerations and Flight Test Results.** H.V.BORST.
AGARDograph 89, Pt.1, 309-338, 8 refs., 1964.
The Curtiss-Wright X-19 V/STOL aircraft is capable of high subsonic cruise speeds and has a high load-carrying capacity. The X-19 has fixed tandem wing with four tiltable propellers mounted at the wing tips. The X-19 design concepts are discussed and wind tunnel data are presented.

AG89/1/11 **Flight Tests of the Breguet 940 and 941 Aircraft.** (In French.) J.CZINCZENHEIM, G.JOYEUSE.
AGARDograph 89, Pt.1, 339-368, 1964.
The Breguet 940 and 941 are STOL transport aircraft with a take-off distance of 700 to 1,000 ft. After a brief description of the aircraft, details are given of investigations and preliminary tests conducted prior to flight testing. Problems encountered during flight tests are then described and accounts given of the take-off and landing techniques and performances.

AG89/1/12 **VTOL Testing in the United States.** P.E.HAUETER, L.C.SETTER.
AGARDograph 89, Pt.1, 369-390, 1964.
Current thinking and practice in the area of flight test technique is reviewed and problem areas are defined. The X-19 (Curtiss-Wright tandem-wing tilt-prop V/STOL) and XC-142 (tilt-wing deflected slip-stream assault transport) test plans are summarized to illustrate the procedure and philosophy used.

AG89/1/13 **The Development of VTOL Aircraft with Turbo-Jet Engines in the Federal Republic of Germany.** K.SCHWARZLER.
AGARDograph 89, Pt.1, 391-417, 1964.
In discussing the development and testing of the VJ 101C VTOL aircraft, the following topics are considered: design and constructional philosophy, comparison with extant VTOL aircraft, optimum distribution of thrust between lift and propulsion engines, control during hovering by thrust modulation, the X-1 suspended on a test-ring and result during the first hovering flights, ground effect, and transitional flight.

AG89/1/14 **Modulated Thrust to Improve STOL Aircraft Performance (A Flight Test Evaluation).** G.W.JOHNSTON.
AGARDograph 89, Pt.1, 419-448, 5 refs., 1964.
The potential of utilizing in-flight reverse thrust provided by a vectored-light weight lifting-type engine is reviewed; the object being the simultaneous generation of high lift and high drag during the landing manoeuvre of STOL configurations. The results presented were obtained during a two year programme carried out at de Havilland. The potential of this concept is reviewed under two broad-headings: direct performance improvements, and indirect operational improvements.

AG89/1/15 **VTOL Control Systems, Especially Control by Thrust Modulation.** X.HAFER.
AGARDograph 89, Pt.1, 449-473, 9 refs., 1964.
Considers: control system requirements (flight characteristics, guidance, frequencies, attitude control, behaviour in event of engine failure, reliability); production of control moments (jet-vectoring and -deflection, control by jet nozzles or thrust modulation); optimization of control systems; VJ 101 C X-1 control system.

AG90
AD-476-418
N66-11629 **Mechanism of Noise Generation in the Turbulent Boundary-Layer.** J.LAUFER, J.E.FFOWCS WILLIAMS, S.CHILDRESS.
AGARDograph 90, 78 pp., 84 refs., 1964.
General considerations; classical radiation problem; generalized wave equation; Lighthill's acoustic analogy; the acoustic analogy applied to the turbulent boundary-layer; noise generation at high speed; acoustical models; experimental approach.

AG91
AD-475-660
N66-13014 **The Theory of High Speed Guns.** A.E.SEIGEL.
AGARDograph 91, 313 pp., 117 refs., 1965.
This monograph summarizes the gas dynamics of high-speed guns, utilizing a gas of low molecular weight at high temperature. Theory and test results are presented. The reader is assumed to be an advanced student in engineering. The fundamental ideas and equations are fully developed.

AG92 **Orbit Optimization and Laser Applications.**
AD-652-174 AGARDograph 92, 484 pp., 1964.
N67-29361 A series of lectures under the general heading 'Orbit Optimization and Advanced Guidance Instrumentation' were presented to invitees from NATO countries in Düsseldorf during October 1964. The lectures covered current US practices relating to sensors, guidance systems and the relation between orbit design and the applicable mathematical theory. This AGARDograph is a compilation of the lecture notes used by the speakers. Abstracts of the individual lectures are given in the succeeding items.

AG92/1 **Application of Optimization Techniques.** A.ROSENBLOOM.
AGARDograph 92, 1-21, 7 refs., 1964.
In this consideration of the application of optimization techniques to space dynamics problems, the following topics are treated: survey and characteristics of existing techniques (stochastic problems, constraints, approximation techniques); a booster-powered flight optimization programme (basic equations, boundary equations, convergence of initial conditions, specific results).

AG92/2 **The Application of Dynamic Programming to Orbit Transfer Processes.** F.T.SMITH.
AGARDograph 92, 23-78, 17 refs., 1964.
The following aspects are treated: dynamic programming and multistage decision processes; orbit transfer processes as discrete decision processes; system performance indexes; the optimization of continuous decision processes; a satellite rendezvous problem as a continuous decision process; correction of a 24-hour satellite orbit as a discrete decision process.

AG92/3 **Status of Laser Technology.** R.T.DALY.
AGARDograph 92, 79-108, 28 refs., 1964.
This outline of laser technology is divided into three main sections: (i) a general description of the laser oscillator, a broad classification of types and a discussion of the terms used to describe laser operation and performance; (ii) a detailed description of specific examples of the various laser types; (iii) laser applications (range-finding in the atmosphere, long-range distance measurement, precise measurement).

AG92/4 **Theory, Methods and Application of Optimization Techniques.** E.L.PETERSON.
AGARDograph 92, 109-162, 28 refs., 1964.
Contents: introduction; theory; methods (successive approximation; polynomial approximation); applications (near optimal quasi-linear rendezvous control, direct and indirect solution of a boundary problem, dynamic programming solution of a boundary problem).

AG92/5 **Laser Receiving Systems.** B.J.McMURTRY.
AGARDograph 92, 163-256, 118 refs., 1964.
Two types of laser receiving systems are discussed. The first type involves direct detection of amplitude-modulated (AM), phase-modulated (PM), or frequency-modulated light; the second type involves heterodyne detection. The type of heterodyne receiver used depends critically upon whether the receiver is part of an optical radar system or an optical communications system. Two types of radar receiver are discussed, one uses a fixed frequency local oscillator (LO) and a broad band photomixer, and the other uses a tracking LO and a narrow band photomixer. Receiving system components are also described and quantum mechanical limitations on the channel capacity of a laser communication system are described.

AG92/6 **Status of Guidance and Control Methods, Instrumentation, and Techniques as Applied in the Apollo Project.** W.HAEUSSERMANN, R.C.DUNCAN.
AGARDograph 92, 257-484, 59 refs., 1964.
In this very detailed treatment of the title subject, the following aspects are treated: launch vehicle inertial navigation and guidance, launch vehicle control, 'Saturn' launch vehicle hardware description, space vehicle navigation and guidance methods, space vehicle navigation and guidance systems.

AG93 **Space Simulation Chambers and Techniques.** B.H.GOETHERT (Editor).
AD-476-419 AGARDograph 93, 419 pp., 1964.
N66-11630 A working meeting of the AGARD Inter-Panel Space Information Group, held in Rome in October, 1962 on the subject of 'Space Simulation Chambers and Techniques', identified a number of topics as being crucial for the further development of space chambers. Technical experts were assigned particular subjects and the papers they have prepared on these topics are collected together in this AGARDograph. Abstracts of the individual papers are given in the succeeding items.

AG93/1 **Overall Survey of the Problems of Space Simulation.** B.H.GOETHERT.
AGARDograph 93, 5-76, 20 refs., 1964.
Aspects discussed include: environmental parameters of space flight; problem areas of space vehicle design and operation; simulation of space environment in ground test facilities; pressure and density in space chambers; simulation of thermal radiation in space; special simulation features of space chambers.

AG93/2 **Space Environments and Simulation Requirements.** D.D.CARLSON.
AGARDograph 93, 77-123, 18 refs., 1964.
Presents some of the space simulation parameters that must be analyzed to accomplish successfully the task of space exploration. Includes a consideration of typical space missions regarded as feasible, a discussion of the space and earth environments, and the simulation requirements. Evaluates experimental tests to be conducted in aerospace environmental chambers.

AG93/3 **Thermal Radiation Simulation.** K.ZEBB.
AGARDograph 93, 125-156, 7 refs., 1964.
Topics dealt with include: solar radiation simulation; spacecraft thermal control testing; characteristics of solar radiation; design criteria for solar simulation systems; design of solar simulation systems; energy sources for solar simulation systems; simulation of albedo and planetary thermal radiation.

AG93/4 **Simulation of Heat-Sink Effect of Space.** E.K.LATVALA, C.F.NORMAN.
AGARDograph 93, 157-191, 17 refs., 1964.
From the considerations presented it is concluded that the low temperature heat-sink effect of space can be adequately simulated in a ground test facility using liquid nitrogen cooled walls at a temperature of 100 deg.K or lower.

AG93/5 **Vacuum Pump Apparatus for Space Simulation Chambers.** (In French.) J.SURUGUE.
AGARDograph 93, 193-218, 8 refs., 1964.
Presents descriptions of various types of pumps suitable for the different vacuum regimes (low vacuum, mean vacuum and high vacuum); these include mechanical pumps, ejectors, oil vapour ejectors, diffusion pumps and molecular rotating pumps.

AG93/6 **Use of Cryopumps for Simulation of Space.** J.T.MOLL.
AGARDograph 93, 219-249, 1964.
The theory of vapour and gas condensers (cryopumps) is first treated. The following applications are then described; cryopumps for low pressure wind tunnels, use of cryopumps in space simulation chambers, cryopumps for low ultimate pressures, trapping pumps.

AG93/7 **Vibration Equipment.** R.H.UNDERWOOD.
AGARDograph 93, 251-265, 3 refs., 1964.
In treating vibration testing in space chambers, the sources of excitation in the space vehicle environment (rocket noise, aerodynamic excitation, excitation sources internal to the vehicle, propulsion system vibrations) are first discussed; exciters and space chamber applications are then considered; the two types of exciter used are the electrodynamic shaker and the electrohydraulic shaker.

AG93/8 **Vacuum Leak Detection.** S.P.ANSLEY, Jr. R.B.WILLIAMS.
AGARDograph 93, 267-293, 5 refs., 1964.
The rôle of leak detection in the successful operation of large-scale space simulation chambers is discussed and a general leak detection programme outlined. Methods techniques and equipment capabilities are presented along with the results of an actual leak detection effort conducted on a 10,000 cu.ft space simulation chamber.

AG93/9 **Instrumentation for Space Simulation Chambers.** M.R.MULKEY.
AGARDograph 93, 295-358, 22 refs., 1964.
In this comprehensive state-of-the-art examination of space environmental instrumentation, the following are considered: vacuum measurements, thermal radiation measurements, cryogenic thermometry, test vehicle instrumentation.

AG93/10 **Concepts for the Man-Rating of a Space Environment Simulator.** J.W.ANDERSEN, O.L.PEARSON.
AGARDograph 93, 359-375, 1964.
The NASA Manned Spacecraft Center Space Environment Facility, because of its sheer physical size and complexity, presents unique problems for manned occupancy. In order to appreciate these problems the facility is first described and then the man-rating is discussed. Particular emphasis is placed on the emergency repressurization system and operational concepts.

AG93/11 **System Design of Space Simulation Chambers.** W.R.HOWARD.
AGARDograph 93, 377-419, 1964.
Specific system design problems are illustrated by a consideration of the following vacuum chamber or pressure vessel design; vacuum chamber pumping system design; heat sink or cold wall design, solar radiation system design.

AG94
AD-476-420
N66-11631 **Handbook on the Properties of Niobium, Molybdenum, Tantalum, Tungsten and some of their Alloys.** (in English and French.) R.SYRE.
AGARDograph 94, 299 pp., 234 refs., 1965.
Contains the latest data on the physical, mechanical (at low or elevated temperatures), chemical, welding, fabrication and miscellaneous properties for these four refractory metals and their alloys. Also considers problems of protective coatings and presents the properties of the main protective coatings which are contemplated.

AG95
AD-654-884
N67-29281 **Spread-F and its Effects upon Radiowave Propagation and Communications.** P.NEWMAN (Editor).
AGARDograph 95, 617 pp., 1966.
Papers are reported which were given at a meeting sponsored by the Ionospheric Research Committee. The papers were written by international scientists whose studies are not only based on ionograms, but employ the newest methods of backscatter radar, topside sounding, oblique-frequency sweeping, etc. Abstracts of the papers are given in the succeeding items.

AG95/1 **A Survey of Equatorial Spread-F.** B.R.CLEMESHA, R.W.H.WRIGHT.
AGARDograph 95, 3-27, 34 refs., 1966.
The methods of observation of spread-F irregularities are described, and geomorphology and diurnal, seasonal and sunspot cycle variations are discussed in relation to other ionosphere parameters. The properties of irregularities which have been determined so far are described, including their height of occurrence, motion, distribution and life-time. The directions in which further work should be carried out are outlined.

AG95/2 **Spread-F in the Pacific.** J.B.LOMAX.
AGARDograph 95, 29-58, 6 refs., 1966.
Describes the unusually intense and wide-spread occurrence of spread-F in the mid-Pacific area on October 27, 1962, as observed on both vertical and oblique-incidence ionospheric sounders. A synchronized network of three transmitters and six receivers was operated during 1962 as oblique ionospheric sounders in the frequency range 4 to 64 Mc/s. A total of seventeen oblique paths was employed in an area centred on the magnetic equator at 173 deg. West longitude with a diameter of approximately 6000 Km. Twelve vertical-incidence ionosondes were also operated in this area. The onset and development of spread-F is illustrated with ionograms from the various observing stations.

AG95/3 **Observation of Equatorial Spread-F at Djibouti and Dakar.** (In French.) P.HALLEY, B.GATTY.
AGARDograph 95, 59-65, 5 refs., 1966. (English translation 607-610.)
Spread-F occurrence on ionograms has been studied on the basis of hourly soundings for e years 1951 to 1963. To characterize the phenomena a simple criterion has been used. Significant hourly and seasonal variations of the occurrence of Spread-F were observed. Spread-F occurs only at night and more often in summer than winter. The variation with solar activity was small.

AG95/4 **Preliminary Results on Mid and High Latitude Topside Spread-F.** L.E.PETRIE.
AGARDograph 95, 67-77, 16 refs., 1966.
The topside sounder in the 'Alouette' satellite provides information suitable for the study of spread-F at horizontal intervals of 115 Km, spread echoes can be examined in some detail as a function of latitude. Some configurations of spread echoes appearing on the topside ionogram have been discussed previously. Preliminary statistical results of the world-wide occurrence of topside spread-F have been presented. The results of an investigation of spread echoes at mid- and high-latitudes (geomagnetic latitude <30 deg.N) are reported. The data used for this study were obtained from the following telemetry stations located in both America: Resolute (74.7 deg.N, 94.9 deg.W), Ottawa (45.4 deg.N, 75.9 deg.W), Prince Albert (53.2 deg.N, 105.9 deg.W), College (64.8 deg.N, 147.8 deg.W), and Fort Myers (26.5 deg.N, 81.9 deg.W).

AG95/5 **Topside Spread-F and Field-Aligned Structure.** P.VILA.
AGARDograph 95, 79-87, 11 refs., 1966.
The field-aligned structure of ionization associated with the boundaries of spread-F at middle latitudes can be directly studied by the combining topside and fast sweeping ground based ionograms. A few examples are interpreted by partial ducting of the probing wave. An estimate is given for the corresponding scales of the field-aligned structures.

AG95/6 **The Angular Spread of Spread-F Echoes.** J.REWAY, W.A.FLOOD.
AGARDograph 95, 89-101, 21 refs., 1966.
A 10 kW pulsed transmitter operating at 2.4 Mc/s was used to irradiate the ionosphere and on occasions when the A-scope scan differed markedly from that corresponding to normal ionospheric conditions, the input was recorded. The backscattered echoes were received on 3 half-wave dipole antennas. A limited sample of 15 spread-F cases was recorded and analyzed.

AG95/7 **The Influence of Focusing Upon the Apparent Reflection Coefficient of the F Region.**
L.E.PETRIE, E.L.HAGG, E.S.WARREN.
AGARDograph 95, 103-120, 10 refs., 1966.
The apparent reflection coefficients of the ionosphere for high frequency radio waves have been studied using vertical incidence pulse amplitude data obtained at Prince Rupert. The F layer first hop reflection coefficient increases in magnitude as the degree of spread-F increases. This increase in magnitude can be explained by focusing of the energy scattered from an irregular surface or by propagation of the energy along field-aligned ducts.

AG95/8 **A Note of High Latitude Spread-F.** J.FRIHAGEN, K.FOLKESTAD.
AGARDograph 95, 121-126, 2 refs., 1966.
Results of an analysis of data from oblique incidence soundings during spread-F conditions are presented. Some comments have been made on the fading characteristics of spread-F reflections.

AG95/9 **Some Characteristics of Spread-F in Very High Latitudes.** J.K.OLESEN, S.D.JEPSEN.
AGARDograph 95, 127-136, 2 refs., 1966.
The study is based upon ionograms and F-plots for eight months from Narsarssuaq, Godhavn and Thule in Greenland. To describe the variations, diurnal, annual, latitudinal and through the sunspot cycle a measure for the intensity of spread-F has been used. The results are to a great extent in agreement with those of earlier investigations concerning the occurrence frequency of spread-F, apart from some deviations which need further examination before definite conclusions can be drawn concerning their significance.

AG95/10 **Frequency of Spread-F Occurrence over Antarctica.** R.PENNDORF.
AGARDograph 95, 137-166, 15 refs., 1966.
The frequency of occurrence of spread-F in the Antarctic was studied during the I.G.Y. period. Data from eight stations were used to investigate the diurnal, seasonal and geographic variations. Data from twenty-two stations south of 30 deg geographic latitude were used to describe average seasonal conditions over the Antarctic. The results have been compared with those for the Arctic, and it was found that the conditions in the two polar regions seem to differ in some respects, although the basic features are very similar.

AG95/11 **The Application of the Partial Correlation Analysis to the Study of the Occurrence Probability of Spread-F.** T.SHIMAZAKI.
AGARDograph 95, 167-188, 26 refs., 1966.
In this study the partial correlation coefficients between various ionospheric, solar and geomagnetic parameters and the spread-F occurrence probability are studied for Washington and Wakkanai. The results show that the partial correlation analysis give better and more reasonable results than the simple one in many respects.

AG95/12 **Spread-F and Geomagnetic Activity in Middle Latitude.** M.ANASTASSIADES, D.ILAIS, G.MORAITIS.
AGARDograph 95, 189-204, 20 refs., 1966.
Spread-F data collected between 1961 and 1963 and scintillation data for 1962 and 1963 are analyzed statistically. The spread-F occurrence has maxima around the solstices; the secondary maximum occurs in summer. The diurnal variation shows a maximum after midnight. A negative correlation exists between spread-F and geomagnetic activity in summer and a positive one in winter. Athens belongs to the equatorial belt spread-F during summer but in winter it is situated north of this belt.

AG95/13 **Relations between Night-Time Luminosity and the Presence of Sporadic-E and Spread-F.**
(In French.) A.VASSY, J.C.JEANNET.
AGARDograph 95, 205-214, 5 refs., 1966. (English Translation 611-613.)
Nightglow measurements were made at Hammaguir in February 1961 and October 1962, and also at Valensole every New Moon period since September 1963. The map showing isophotes on the sky, if they have regular shape, are used to determine the altitude of the luminescent layer. When irregular curves are obtained localized disturbances can be detected.

AG95/14 **F-Region Irregularities Studied by Scintillation of Signals.** K.C.YEH, G.W.SWENSON, Jr.
AGARDograph 95, 217-246, 67 refs., 1966.
Scintillation of radio signals from Earth satellites has been studied for five years during the declining phase of the sunspot cycle. It is found that the character of the scintillation, and thus probably, of the ionospheric irregularities that cause them, vary systematically with geomagnetic latitude, season of the year, time of day, and phase of the sunspot cycle.

AG95/15 **Geophysical Aspects of Radio Star and Satellite Ionosphere Scintillations.** J.AARONS.
AGARDograph 95, 247-266, 38 refs., 1966.
To present a coherent picture of analyzed records, data are drawn together only for observations at auroral, sub-auroral, and middle latitudes. Emphasis is placed on the latitudinal structure of amplitude scintillations. A phenomenological model is advanced to describe scintillations which are geophysical in nature. In the interpretation of data the frequency of radio wave observation was considered as an important feature.

AG95/16 **Radio Star Fadeouts and Radio Propagation.** W.A.FLOOD.
AGARDograph 95, 267-287, 15 refs., 1966.
Reviews previous and presents new results obtained from (i) a further analysis of the data collected during 1960-1961; (ii) an analysis of radio star fadeouts observed in Hawaii; (iii) a period of intense scintillation of the radio sources in Cygnus, and Cassiopeia as measured by a 400 Mc/s radiometer in Trinidad, B.W.I.

AG95/17 **Broadband Radio-Star Scintillations.** D.G.SINGLETON.
AGARDograph 95, 289-312, 17 refs., 1966.
Twelve months observations of the scintillations of Cassiopeia A made with a swept frequency interferometer operating in the frequency range 7.6 to 41 Mc/s are examined statistically. An interpretation of the band-width and position-shift features of the scintillations as well as the nature of their association with spread-F, is given in terms of the focusing action of elongated irregularities of electron density in the ionosphere.

AG95/18 **Radio-Star Scintillations and Spread-F in the Auroral Zone.** L.OWREN, E.J.FREMOUW, R.D.HUNSUCKER.
AGARDograph 95, 313-332, 1[illegible] refs., 1966.
After a review of radio-star scintillation observations and information on spread-F, the relationship between the two phenomena are discussed and the auroral results are compared with the temperate latitude results. The observations were made at College, Alaska located at 148 deg.W, 65 deg.N.

AG95/19 **Some Studies of Night-Time F-Layer Irregularities at the Equator Using Very High Frequency Signals Radiated from Earth Satellites.** G.S.KENT, J.R.KOSTER.
AGARDograph 95, 333-356, 9 refs., 1966.
Describes some investigations made in Ghana during 1962 and 1963, into the nature of the night-time irregularities responsible for scintillation of radio signals received from radio stars and Earth satellites. The method used has been to study the diffraction patterns formed on the ground by such waves after they have passed through the ionosphere. Signals were received on three spaced aerials. Numerical methods of correlation analysis, more powerful than the usual graphical methods have been developed to analyze fading of these signals.

AG95/20 **The Diffraction of H.F. Radio Waves by Ionospheric Irregularities.** J.P.DEBARBER, W.J.ROSS.
AGARDograph 95, 357-371, 5 refs., 1966.
A discussion is presented on the statistical properties of the scintillation pattern and of their relationship to parameters of the irregular ionosphere. The results are then applied to the interpretation of a body of experimental data, and to the justification of certain approximations made in the early discussion.

AG95/21 **Observations of Ionospheric Scintillations by VHF Radar Reflections from Earth Satellites.** G.H.MILLMAN, A.J.MOCEYUNAS.
AGARDograph 95, 373-381, 11 refs., 1966.
The experimental observations were conducted at the US Air Force Trinidad test site, West Indies (22 deg geomagnetic north latitude), during 1961. An analysis of the scintillation data has indicated that the perturbations were most likely caused by the presence of ionospheric irregularities along the radar satellite transmission paths. An estimate is made of the possible extent of the irregularities. The correlation of the experimental data with solar-geophysical conditions existing during the time of the radar measurements is also presented.

AG95/22 **The Scintillation of Radar Signals from the Discoverer 36 Satellite.** W.J.G.BEYNON, E.S.O.JONES.
AGARDograph 95, 383-394, 10 refs., 1966.
The results of measurements on 'scintillation' observed on 20 Mc/s radio signals from this satellite are presented. The observations cover geomagnetic latitudes 44 deg to 67 deg.N and show a steady increase in the scintillation intensity with latitude. Data are presented on the diurnal variation in the lower latitude limit of scintillation and its variation with magnetic activity.

AG95/23 **A Study of the Occurrence of Satellite Scintillation Observed in the Auroral Zone.** L.LISZKA.
AGARDograph 95, 395-408, 13 refs., 1966.
Studies have shown that the scintillation phenomenon depends both on the time of observation and on magnetic activity. The shape of this dependence may be [illegible]ined by assuming diurnal changes in the scintillation rate spectrum. Also considered were t.. geographical distribution of activity above northern Scandinavia, and the northern extent of the phenomenon.

AG95/24 **Large-Scale Structure of the Auroral Zone F-Layer.** L.LISZKA.
AGARDograph 95, 409-421, 15 refs., 1966.
Large-scale structure of the F-layer has been studied at Kiruna Geophysical Observatory by observing Faraday rotation of satellite signals. Large irregularities in the total electron content, about one order of magnitude larger than at moderate graphical latitudes, were observed. A differential method using Faraday rotation records made at two stations spaced about 100 km were also applied in this study.

AG95/25 **Ionospheric Inhomogeneities Over Wallops Island.** I.CHIDSEY.
AGARDograph 95, 423-435, 5 refs., 1966.
Employing dispersive Doppler from two frequency beacons, on several high altitude research rockets launched at Wallops Island in the period 1959 to 1960 on magnetically quiet days, electron density profiles were obtained. One of these gave clear evidence of inhomogeneities

AG95/26 **The Effect of Spread-F on the Propagation of Radiowaves Near the Equator.** K.DAVIES, A.F.BARGHAUSEN.
AGARDograph 95, 437-466, 30 refs., 1966.
A phenomenological description is given of certain aspects of high-frequency radio propagation studies via the ionosphere, in Africa. Using the ionosonde technique with oblique propagation and a frequency measuring technique the following phenomena were studied, primarily from an engineering view point (a) F scatter, (b) flutter fading, (c) accuracy of MUF calculations. The measurements were carried out at two epochs of the sunspot cycle.

AG95/27 **Oblique Sounding of a Transequatorial Path.** D.NIELSON.
AGARDograph 95, 467-492, 14 refs., 1966.
Discusses the effect on radiowaves of equatorial anomalies and, in particular, the sounding of a transequatorial path by means of an oblique ionospheric sounder. Some of the propagation characteristics of a well oriented transequatorial path are also described to supplement previous reports.

AG95/28 **Travelling Waves in the F-Region over Arecibo Associated with a Magnetic Disturbance.** G.D.THOME, W.E.GORDON.
AGARDograph 95, 495-504, 7 refs., 1966.
The ionospheric backscatter technique is used to study intense fluctuations observed above Arecibo during geomagnetically disturbed conditions. The ionosphere between 100 and 600 kilometers is examined over a seventeen-hour period. The fluctuations clearly exhibit the characteristics of a wave travelling from east to west at about 150 metre/sec. The observed fluctuations of electron density at a given height appear to be caused primarily by vertical motions of the layer as a whole.

AG95/29 **Seasonal Dependence of Movement and Turbulence Phenomena in Equatorial F-Layer Ionization.** K.PIBL.
AGARDograph 95, 505-516, 6 refs., 1966.
Investigates the oscillatory movements of the F-region ionization which are said to be very important in the study of ionization behaviour in the F-region. These oscillations have maximum amplitudes and long periods at equatorial regions. Thus, the use of hourly values of f_0F_2 and MUF 3000 F_2 is adequate for the study of large scale movements of ionization in low latitudes.

AG95/30 **Study of Ionospheric Irregularities and Related Phenomena in the F-Region.** R.N.SINGH.
AGARDograph 95, 517-525, 14 refs., 1966.
Observations of ionospheric irregularities in the F-region during the night hours were made at Banaras (Geomag. lat. 25.31 deg.N, Geomag. long. 83 deg.E) for the years 1958-60. Three

spaced receiver fading records are grouped into two classes: first giving rise to the velocity in the line of sight, and second, characteristics of irregularities present in the F-region. Analysing these records, the size of the irregularities and the spread of the incident wave scattered from them are found.

AG95/31 **Detection of Apparent Ionospheric Movements by Backscatter Techniques.** B.DUENO.
AGARDograph 95, 527-538, 5 refs., 1966.
Unusual echoes from the south direction obtained by means of a frequency swept sounder, and a rhombic antenna are discussed. In some cases these unusual echoes are observed to decrease their apparent range, and in some cases increase their apparent range systematically with time. A qualitative explanation of these unusual echoes in terms of the flat Earth and ionosphere approximation is given assuming that all these echoes are due to a time-delay focusing mechanism.

AG95/32 **A Research on the F_2 Irregularities by Means of the Backscatter Technique.** I.RANZI.
AGARDograph 95, 539-542, 2 refs., 1966.
Since August 1957, the backscatter sounding on fixed frequencies with fixed or rotating Yagi antennas, has been performed at the experimental station of Torrechiaruccia (42.03 deg.N; 11.83 deg.E; at about 55 Km north-west from Rome). The most important results as to the study of the F_2 irregularities are summarized.

AG95/33 **A Possibility to Observe Irregularities Near the Maximum of the F_2 Layer and Their Travelling Velocities.** R.W.EYFRIG.
AGARDograph 95, 543-549, 10 refs., 1966.
From recordings of the characteristics of MUF (3000) F_2 by means of a panoramic ionosonde time shifts may be observed between the ordinary and extraordinary component in cases of typical 'events'. These are interpreted by theoretical considerations. Moreover, it is indicated how the direction and velocity of the front of disturbances may be determined.

AG95/34 **The Production of Spread-F Irregularities.** D.G.SINGLETON.
AGARDograph 95, 553-565, 37 refs., 1966.
The main properties of the irregularities responsible for spread-F are briefly reviewed, and current theories of irregularity production are critically discussed in terms of these properties. Several of the theories do not appear to fit experimental facts. One which does appear compatible with observation, is the theory of hydromagnetic disturbance initiation of drifting layer instability.

AG95/35 **A Charged Particle Production Mechanism for Spread-F Irregularities.** J.R.HERMAN.
AGARDograph 95, 567-578, 39 refs., 1966.
The formation of spread-F irregularities in the Polar regions is treated. It is suggested that these are formed by incoming charged particles, probably protons, with energies of the order of 10 keV. The validation of the proposed mechanism is supported by observational evidence.

AG95/36 **Origin of Field-Aligned Irregularities in the F_2 Layer.** S.A.BOWHILL.
AGARDograph 95, 579-590, 11 refs., 1966.
Discusses, in detail, the thermal transfer processes in the night ionosphere, and estimates the protonospheric heat flux and its effect on the ionospheric plasma temperature. The results are compared with experimental measurements of electron temperature and the effects on the topside electron density are estimated.

AG95/37 **F-Region Irregularities After High Altitude Detonation of July 9, 1962.** P.NEWMAN, B.JONES, L.McCABE.
AGARDograph 95, 591-602, 12 refs., 1966.
This detonation at Johnston Island was followed by strong ionospheric effects. A brief summary is given of spread-F effects found in the Pacific area surrounding Johnston Island. A more detailed description is given of the results found at the AFCRL station at Palmyra.

AG96 **Instrumentation for High Speed Plasma Flow.** A.E.FUHS.
AD-642-744 AGARDograph 96, 180 pp., 146 refs., 1965.
In this monograph, attention is concentrated principally on electrodeless instruments which use magnetic or electromagnetic fields to probe the plasma. Electrostatic probes are briefly surveyed, and the features of different plasma flows (re-entry vehicle sheaths, rocket exhaust, ballistic ranges and mhd generators) are related to the instrumentation theory and design. Instruments for determining both macroscopic and microscopic plasma properties are described in detail. Sufficient theoretical background is given to enable the reader to select and design instruments for particular applications.

AG97/1 **Recent Developments in Boundary Layer Research: Pt.1.**
AD-711-656 AGARDograph 97, Pt.1, 566 pp., 1965.
N65-34635 The AGARD Specialists Meeting on the title subject was held in Naples, Italy from 10th to 14th May, 1965. The proceedings are published in the four parts of this AGARDograph. Pt.1 treats turbulent boundary layers and stability, transition and stabilization. Abstracts of the individual papers are given in the succeeding items.

AG97/1/1 **Introduction (to Recent Developments in Boundary Layer Research).** P.A.LIBBY.
AGARDograph 97, Pt.1, ix-x, 1965.
In this introductory article, the circumstances which led to the convening of the meeting of the Fluid Dynamics Panel on boundary layer research (Naples, May, 1965) are recapitulated. The large number of papers presented is regarded as an indication of the high level of activity in this topic in NATO countries. The efforts of various AGARD members who assisted in making the arrangements for this meeting are gratefully acknowledged.

AG97/1/2 **The Three-Dimensional Structure of the Viscous Sublayer.** J.STERNBERG.
AGARDograph 97, Pt.1, 1-33, 12 refs., 1965.
A simplified form of a theory for the fluctuations in the viscous sublayer of a turbulent flow was presented by the author in J.Fluid Mech., 13, 241, 1962. Here, the analysis is extended to include additional terms in the equations representing the convective effect of the mean flow on the fluctuation field. It is found that there is a strong effect of obliquity on the structure of the elementary components. Comparisons with experimental data indicate that the energy-containing disturbances are strongly aligned with the flow direction.

AG97/1/3 **Heat Transfer and Temperature Distribution in Turbulent Boundary Layers at Supersonic and Hypersonic Flow.** J.C.ROTTA.
AGARDograph 97, Pt.1, 35-63, 19 refs., 1965.
Theories for predicting the rate of heat transfer and temperature distribution are reviewed, and available experimental data are examined in the light of these theories. Particular attention is paid to the temperature distributions in relation to the velocity distributions. The significance of the results obtained is discussed.

AG97/1/4 **Some Results on the Thermal Characteristics of Turbulent Boundary Layers at High Temperatures.** (In French.) R.MICHEL, P.MENTRÉ.
AGARDograph 97, Pt.1, 65-95, 13 refs., 1965.
Presents an analysis of turbulent boundary layers at temperatures sufficiently high for dissociation to occur. Studies enthalpy distributions and concentration in a flat plate boundary layer by means of a combination of the local boundary layer equations in the cases of a perfect gas and of a real gas either frozen or in equilibrium. The ratio of the heat flux to the wall friction is thus deduced. The results obtained are used to calculate the heat transfer on rounded fore-bodies by integration of the global energy equation.

AG97/1/5 **Measurements of Turbulent Skin Friction at High Reynolds Numbers at Mach Numbers of 0.2 and 2.2.** K.G.WINTER, K.G.SMITH, L.GAUDET.
AGARDograph 97, Pt.1, 97-123, 7 refs., 1965.
The measurements, taken on the sidewall of the RAE 8 ft x 8 ft wind tunnel, consist of surface shearing stress using a large force balance and velocity and temperature distributions through the boundary layer. The maximum effective length Re obtained are 2.2×10^8 at M = 0.2 and 1.1×10^8 at M = 2.2. The results agree moderately well with the empirical correlation proposed by Spalding and Chi. The variation of skin friction with Re is however less than that given by most of the accepted formulae.

AG97/1/6 **The Turbulent Wall Jet in a Moving Stream.** G.L.HARRIS.
AGARDograph 97, Pt.1, 125-158, 7 refs., 1965.
The two-dimensional incompressible turbulent wall jet on a plane surface beneath a moving stream of arbitrary pressure gradient has been treated analytically by integral methods. The solution has been programmed for the IBM 1620 digital computer and the results thereby obtained compared with experimental data.

AG97/1/7 **The Calculation of Shape-Factor Development in Incompressible Turbulent Boundary Layers with or without Transpiration.** B.G.J.THOMPSON.
AGARDograph 97, Pt.1, 159-190, 24 refs., 1965.
The predictions of shape-factor development given by existing auxiliary equations are shown to vary widely and are in some cases very inaccurate. A new entrainment equation is described and is shown to give improved agreement with experiment, especially in equilibrium conditions. A feature of this new approach is the use of an explicit term to account for the effects of small three-dimensional flows that appear to be present in measured layers.

AG97/1/8 **The Kinetic-Energy-Deficit Equation of the Turbulent Boundary Layer.** D.B.SPALDING.
AGARDograph 97, Pt.1, 191-244, 36 refs., 1965.
It is shown that formal relations exist between the 'entrainment function' appearing in the theory of Head (1960) and others, and the 'dissipation integral' appearing in the theories of Rotta (1950), Truckenbrodt (1951) and others. Use of the relations, and of knowledge of free turbulent flows enables improved expressions to be recommended for the dissipation integral, valid for near-flat plate flows, for nearly separating boundary layers, and for flows for which the velocity profiles exhibit maxima.

AG97/1/9 **Turbulent-Boundary-Layer Behaviour and the Auxiliary Equation.** J.F.NASH.
AGARDograph 97, Pt.1, 245-279, 28 refs., 1965.
In addition to the von Kármán momentum-integral equation, two further equations are required for calculating the development of the incompressible turbulent boundary layer – a 'skin-friction law' and an 'auxiliary equation'. As a contribution to the elucidation of the problem of deriving the latter, an examination is made of several sets of experimental data covering differing types of pressure distribution. Simple forms of auxiliary equation are postulated; the most satisfactory is a second-order differential equation involving the shape factor. Comparisons with experiment indicate that values can be ascribed to the free constants in the equation which lead to quantitatively acceptable predictions.

AG97/1/10 **The Mean Flow in the Outer Region of Turbulent Boundary Layers.** T.N.STEVENSON.
AGARDograph 97, Pt.1, 281-314, 23 refs., 1965.
A dimensional analysis is used to indicate the equation for the mean velocity distribution in the outer region of incompressible turbulent boundary layers in terms of a function, F . Experiments in boundary layers in zero pressure gradient, with injection and at separation, show that F is virtually a function of y/δ only. The similarity flow in which F is a function of y/δ only is then considered for boundary layers in small pressure gradients. The theoretical total shear stress variations across boundary layers with injection and at separation are consistent with measured distributions.

AG97/1/11 **The Turbulent Asymptotic Layer.** H.TENNEKES.
AGARDograph 97, Pt.1, 315-327, 11 refs., 1965.
Properties of turbulent asymptotic layers in zero pressure gradient with uniform suction, which are equilibrium layers in the sense defined by Clauser, are discussed. A provisional skin friction law for asymptotic layers is given. It is shown that mixing length theory is unable to account for the similarity of the experimental data. The assumption of a constant eddy viscosity in the outer part of the asymptotic layers leads to a fair representation of the experimental data.

AG97/1/12 **The Stability of the Compressible Laminar Boundary Layer According to a Direct Numerical Solution.** L.M.MACK.
AGARDograph 97, Pt.1, 329-362, 16 refs., 1965.
Two direct numerical methods are used to obtain eigenvalues and eigenfunctions of the complete linearized stability equations and of the inviscid stability equations. For the inviscid equations, new families of amplified solutions are found. The maximum amplification rates and frequencies of these solutions are computed as functions of M_1, the free-stream Mach number, and as functions of wall temperature (cooled wall only) at $M_1 5.8$. For finite Re , neutral stability curves are computed, and at a fixed Re the maximum amplification of disturbances of constant frequency is computed as a function of M_1 and of the wall temperature at $M_1 5.8$.

AG97/1/13 **The Effect of Compliant Walls on Boundary Layer Stability and Transition.** M.T.LANDAHL, R.E.KAPLAN.
AGARDograph 97, Pt.1, 363-394, 25 refs., 1965.
Recent theoretical progress in the field of boundary layer stability and transition, as influenced by a compliant surface, is reviewed. The main physical mechanisms involved in boundary layer instability are explained, and it is demonstrated that for any stabilization method to be effective the net dissipation associated with an instability wave must be reduced. Results of extensive numerical calculations show that for certain combinations of compliant surface parameters it is possible to reduce the spatial amplification rates substantially, although the increase in critical Re is usually small. The main practical difficulty with this method of boundary layer stabilization is to find a compliant surface material of low mass density. The qualitative effects of wall flexibility on the later non-linear stages of transition are also discussed.

AG97/1/14 **Streamwise Vortices in Laminar Flow.** J.J.GINOUX.
AGARDograph 97, Pt. 1, 395-422, 9 refs., 1965.
Earlier investigations have revealed the existence of strong, regular and repeatable three dimensional perturbations in the boundary layer of two-dimensional laminar reattaching flows. These perturbations

were present in various types of separated flows, such as flows over backward and forward facing steps, ramps and cavities, and also in shock wave boundary layer interactions and were observed over the range Mach 1.5 to 7.0. The purpose of the present investigation was first to determine by refined surveys of reattaching supersonic flows behind backward facing steps, the nature of the three-dimensional configuration of the flows and second to verify, by direct measurement, that large peaks in heat transfer rates were present at flow reattachment.

AG97/1/15 **Heat Transfer in Laminar Boundary Layers with Oscillating Outer Flow.** K.GERSTEN.
AGARDograph 97, Pt.1, 423-475, 28 refs., 1965.
Deals with the solution of the equations for the velocity as well as the temperature distribution in laminar boundary layers for the case when small periodic perturbations are superimposed on the steady outer flow. Emphasis is laid on the second-order terms which lead to a change in net skin friction and in the average rate of heat transfer.

AG97/1/16 **Transition Reversal on a Flat Plate at Hypersonic Speeds.** R.E.RICHARDS, J.L.STOLLERY.
AGARDograph 97, Pt.1, 477-501, 25 refs., 1965.
The variation of transition Re with wall temperature has been studied experimentally using a sharp-edged smooth flat plate. Early measurements were made at Mach 7.5 and 10 in a conical flow. More recently data were obtained at Mach 8.2 in a more uniform stream; these new data are reported in this note, and their significance is discussed.

AG97/1/17 **Boundary-Layer Disturbance by Isolated Protuberances of Variable Height on a Cylinder Nose.** E.DOBBINGA.
AGARDograph 97, Pt.1, 503-521, 1 ref., 1965.
Describes measurements at low speeds of the transition of a boundary-layer in a favourable pressure-gradient, as affected by isolated protuberances. Gives a general picture of the behaviour of four types of roughness elements. The character of the disturbance changes markedly if the critical height of the protuberances increases beyond a crucial value which is smaller than the boundary-layer thickness. The effect of protuberances appears to be very sensitive to the shape of the top.

AG97/1/18 **Some Problems of Flow Laminarization on a Slender Delta Wing.** N.GREGORY, E.M.LOVE.
AGARDograph 97, Pt.1, 523-566, 7 refs., 1965.
The problems are discussed in the light of an experimental investigation made in a low-speed wind tunnel on a slender delta wing with sharp leading edges and AR = 1. The application of the results obtained to a supersonic aircraft is also considered.

AG97/2 **Recent Developments in Boundary Layer Research: Pt.2.**
AD-476-421 AGARDograph 97, Pt.2, 513 pp., 1965.
N65-34653 Pt.2 treats three-dimensional boundary layers and interaction effects at hypersonic speeds. Abstracts of the individual papers are given in the succeeding items.

AG97/2/1 **Three-Dimensional Boundary Layers on Rotating Bodies and in Corners.** J.STEINHEUER.
AGARDograph 97, Pt.2, 567-611, 25 refs., 1965.
Results of experimental and theoretical investigations are presented for (i) boundary layers on rotating bodies of revolution in axial flow including the rotating disc; and (ii) boundary layers in a rectangular corner between two plane walls including transition and separation, and flow on a flat plate with a vertically-mounted cylinder.

AG97/2/2 **Examples of Boundary Layers in Rotating Flows.** N.ROTT, W.S.LEWELLEN.
AGARDograph 97, Pt.2, 613-635, 25 refs., 1965.
Approximate momentum-integral methods and exact similarity solutions for the boundary layers are discussed, with particular attention focused on the 'terminal' similarity problem at the axis of rotating flow; it is shown that, in general, viscous effects cannot be ignored. To illustrate these effects, a driven vortex is considered which is confined by a cylindrical chamber, and also the flow between a stationary and rotating disk is dealt with.

AG97/2/3 **Auxiliary Functions of Three-Dimensional Turbulent Boundary Layers.** S.L.SOO.
AGARDograph 97, Pt.2, 637-665, 11 refs., 1965.
Aspects of three-dimensional motion over a body of revolution were explored by extending the momentum integral method. Auxiliary function and separation of a turbulent boundary layer in the three-dimensional motion were determined by introducing pertinent shape factors with extension of two-dimensional relations and by computation from recent experimental results. Designs based on imminent separation were illustrated.

AG97/2/4 **Laminar Boundary Layer Flow at Surfaces with Longitudinal Curvature.** F.SCHULTZ-GRUNOW.
AGARDograph 97, Pt.2, 667-674, 4 refs., 1965.
A boundary layer theory is presented which considers terms of the order of the inverse square root of the Reynolds number and exactly the Lamé coefficients. In order to provide analytic solutions conditions for similar profiles are derived including as limiting cases the flat plate, the wedge and stagnation point flow.

AG97/2/5 **On Some New Classes of Similar Three-Dimensional Incompressible Boundary Layers.**
L.G.NAPOLITANO, F.MANZO.
AGARDograph 97, Pt.2, 675-714, 21 refs., 1965.
Two new classes of similar solutions for a three-dimensional incompressible laminar boundary layer over a non-developable surface in a flow without axial symmetry are dealt with. The pertinent systems of total differential equations derived are solved for a number of indicative values of the three parameters by means of electronic computing machines. A detailed analysis of the results in terms of velocity profiles and shear stresses at the wall, completes the paper.

AG97/2/6 **Heat and Mass Transfer on Sweptback Circular Cylinders in Supersonic Flow.** (In French.)
E.A.BRUN, G.-B.DIEP, B. LE FUR.
AGARDograph 97, Pt.2, 715-753, 23 refs., 1965.
Presents the main data obtained from a comprehensive study of heat and mass transfer from sweptback circular cylinders in a Mach 2.42 wind tunnel, the Reynolds number referred to cylinder diameter being 100,000. The mass transfer investigated was naphthalene sublimation.

AG97/2/7 **Three-Dimensional Effects in the Hypersonic Laminar Boundary Layer.** M.TRELLA, F.CALABRIA.
AGARDograph 97, Pt.2, 755-794, 5 refs., 1965.
Investigates three-dimensional effects in laminar boundary layers for the relatively simple problem of flow in the neighborhood of a plane of symmetry; external hypersonic conditions and similar solutions are considered.

AG97/2/8 **The Three-Dimensional Boundary Layer in the Turbulent Regime of a Compressible Fluid; The Case of the Athermanous Wall.** (In French.) E.A.EICHELBRENNER.
AGARDograph 97, Pt.2, 795-828, 15 refs., 1965.
The characteristic values of compressive boundary layers in a turbulent [illegible], with athermanous walls, are calculated by an integral method, on three-dimensional obstacles. The equations are solved by an iterative method. A few partial results obtained so far are promising; a rather complex calculation (flattened ellipsoid with incidence) is in progress.

AG97/2/9 **Experimental Measurements in a Three-Dimensional Turbulent Boundary Layer in Supersonic Flow.**
M.G.HALL.
AGARDograph 97, Pt.2, 829-853, 11 refs., 1965.
Measurements of mean values in time of pitot pressure and flow direction have been made in the boundary layer over the insulated side-wall of a supersonic nozzle. The external flow first accelerated and then decelerated, and the cross-wise pressure gradients were such that the boundary layers cross-flow was first in one direction and then in the opposite, as happens over wings with swept leading-edges. The external Mach number ranged between 1.6 and 2.0. The results were supplemented by measurements of skin friction using surface-tubes.

AG97/2/10 **Inner and Outer Law Descriptions of Temperature and Velocity in Two and Three-Dimensional Boundary Layers.** E.BRUNDRETT, W.D.BAINES, J.PEREGRYM, P.R.BURROUGHS.
AGARDograph 97, Pt.2, 855-880, 9 refs., 1965.
Temperature and velocity measurements have been performed for incompressible air flow with moderate heat transfer rates, for turbulent flow over a plate, and in a square duct. The inner and outer law correlations for the velocity and temperature profiles above the plate were combined to yield a relationship for the heat transfer and friction coefficient. The relationship was extended to include pipe and non-circular duct flow.

AG97/2/11 **Experimental and Theoretical Results of Heat Transfer at the Leading Edge of Strongly Swept Wings in Hypersonic Flow.** (In French.) J.VALENSI, R.MICHEL, D.GUFFROY.
AGARDograph 97, Pt.2, 881-907, 8 refs., 1965.
The results of pressure and heat transfer rate measurements at the stagnation line of leading-edges at Mach numbers 4, 7 and 10 are presented. Two techniques of theoretical analysis are described and illustrated; they are based on the solution of the local and global boundary layer equations respectively. The theoretical and experimental results are in satisfactory agreement in the case of large sweep angle but the effect of strong entropy gradient due to the curvature of the shock-wave is evident in the case of medium sweep at high speed.

AG97/2/12 **The Laminar Boundary Layer on an Inclined Cone.** J.C.COOKE.
AGARDograph 97, Pt.2, 909-931, 7 refs., 1965.
A solution to the problem of incompressible conical flows past a cone is presented, in which the boundary layer equations are solved by an implicit finite difference procedure. Comparisons are made with experiments by others. The present calculations agree reasonably well with experiment and show that approximate method gives a fair overall picture. The equations for the extension to compressible flow are given and can be solved by the same technique.

AG97/2/13 **Turbulent Boundary-Layer Studies on a Waisted Body of Revolution in Subsonic and Supersonic Flow.** K.G.WINTER, K.G.SMITH, J.C.ROTTA.
AGARDograph 97, Pt.2, 933-961, 11 refs., 1965.
Experiments made on the body at Mach numbers between 0.6 and 2.8 at a length Reynolds number of 10^7 are compared with calculations. The experimental measurements are the skin friction distribution along the body, and boundary-layer surveys at six stations. These support the general characteristics of the calculations except at the two highest Mach numbers (2.4 and 2.8).

AG97/2/14 **Viscous Interaction Effects in Low-Density, Supersonic Streams.** E.W.E.ROGERS, S.C.METCALF.
AGARDograph 97, Pt.2, 963-985, 11 refs., 1965.
The nature of viscous interactions in low-density, near-continuum flows is discussed and illustrated by experiments. A distinction is drawn between leading-edge effects, associated with the rapidly-growing laminar boundary near the front of the body, and trailing-edge effects caused by the upstream penetration of the wake pressures and usually resulting in some modification to the boundary-layer profile. Some discussion of the influence of low Reynolds number on lifting bodies is included.

AG97/2/15 **Viscous-Inviscid Interactions Along a Corner.** M.H.BLOOM, R.J.CRESCI, S.G.RUBIN.
AGARDograph 97, Pt.2, 987-1006, 15 refs., 1965.
A theoretical and experimental study of hypersonic flow along a corner is presented. The first order 'inner' or boundary layer equations for the constant-density flow are discussed and similar solutions constructed for 'outer' flows of the Falkner-Skan type. The nature of the cross-flows, and their effect on the boundary layer equations in the cross-plane, is described. Pressure and heat transfer measurements for interaction parameters as high as 20 are included.

AG97/2/16 **Preliminary Studies of the Flow around Two-Dimensional Bodies at High Mach Numbers and Low Reynolds Numbers.** S.M.ROGDONOFF, I.E.VAS.
AGARDograph 97, Pt.2, 1007-1024, 4 refs., 1965.
A series of exploratory studies have been carried out to examine in detail the flow around bodies at high Mach (M = 24) and low Re numbers. The studies were primarily concentrated on the leading edge region where the shock wave and the viscous region caused by the body itself interact. The facilities, models, instrumentation and test conditions are described, and results included for (i) static pressure distribution over a sharp flat plate and over a blunt plate, and (ii) boundary layer and shock wave studies.

AG97/2/17 **Laminar and Turbulent Boundary Layers on Slightly-Blunted Cones at Hypersonic Speeds.** R.E.WILSON.
AGARDograph 97, Pt.2, 1025-1048, 14 refs., 1965.
A momentum-integral method previously given by the author for laminar flow is extended to turbulent flow. In addition: (i) transition data on cones at hypersonic speeds are examined, (ii) agreement between measured and calculated cone drag coefficients for fully laminar flow is demonstrated and (iii) friction and boundary-layer thickness calculations are shown to agree with ballistic range data.

AG97/2/18 **The Three-Dimensional Separation of a Plane Incompressible Laminar Boundary Layer Produced by a Circular Cylinder Mounted Normal to a Flat Plate.** D.J.PEAKE, R.D.GALWAY.
AGARDograph 97, Pt.2, 1049-1080, 15 refs., 1965.
The properties of a laminar, incompressible boundary layer in proximity to a circular cylinder protruding from a flat wall have been investigated by experiment and by calculation to yield the limiting streamlines and the three-dimensional primary separation line. Use was made of the N.A.E. water tunnel for the experiment. Fluorescent dye filaments emitted from wall orifices enabled the limiting streamlines and the primary separation line to be observed.

AG97/3 **Recent Developments in Boundary Layer Research: Pt.3.**
AD-476-426 AGARDograph 97, Pt.3, 119 pp., 1965.
N65-24864 Presents two papers dealing with boundary layer transition under hypersonic conditions and
N66-12667 hypersonic viscous effects. Abstracts are given in the succeeding two items.

AG97/3/1 **Boundary-Layer Transition Under Hypersonic Conditions.** J.L.POTTER, J.D.WHITFIELD.
AGARDograph 97, Pt.3, 1-61, 37 refs., 1965.
Presents a current discussion of experimental data concerning the dependence of boundary-layer transition upon certain factors. In general, hypersonic conditions are considered, and the data presented correspond to free-stream Mach numbers up to 18. However the greater part of the data correspond to local Mach numbers, M_δ, below 8.5.

AG97/3/2 **Theoretical and Experimental Studies of Hypersonic Viscous Effects.** C.H.LEWIS, J.D.WHITFIELD.
AGARDograph 97, Pt.3, 63-119, 36 refs., 1965.
The effects of viscous interaction and transverse curvature on the heat-transfer and pressure distributions and zero-lift drag are presented for a 9 deg spherically blunted cone with a nose-to-base radius ratio of 0.3 at $M_\infty = 9$ and 18 over a range of Reynolds numbers.

AG97/4 **Recent Developments in Boundary Layer Research: Pt.4.**
AD-463-748 AGARDograph 97, Pt.4, 147 pp., 1965.
N65-23650 Presents papers relating to results of the X-21A programme and laminar flow control at supersonic speeds. Abstracts of these papers are given in the succeeding items.

AG97/4/1 **Some Results from the X-21 Program: Pt.1 – Flow Phenomena at the Leading Edge of Swept Wings.** W.PFENNINGER.
AGARDograph 97, Pt.4, 41 pp., 19 refs., 1965.
After discussing the discovery of the existence of turbulent flow at the leading edge of the X-21 wing during the early phase of the flight experiments, methods are described which re-established laminar flow at the front attachment line of swept wings.

AG97/4/2 **Some Results from the X-21A Program: Pt.2 – Laminar Flow Control Flight Test Results on the X-21A.** L.R.FOWELL, P.P.ANTONATOS.
AGARDograph 97, Pt.4, 76 pp., 24 refs., 1965.
Full-scale subsonic flight tests have been made since the summer of 1963 with the X-21A laminar flow control research aircraft having swept, slotted suction wings. Results have been obtained concerning the stability, transition and stabilization of the boundary layers over the wings under adverse influences such as sweep effect, high Reynolds numbers, acoustic disturbances, surface roughness, panel vibration, atmospheric particles and meterological influences.

AG97/4/3 **Laminar Flow Control at Supersonic Speeds.** E.E.GROTH, S.R.PATE, J.P.NENNI.
AGARDograph 97, Pt.4, 18 pp., 16 refs., 1965.
Describes boundary layer suction experiments at supersonic speeds. A flat plate, swept wing models and bodies of revolution were investigated. Laminar flow and low drag coefficients were obtained at Mach numbers between 2.5 and 3.5 and high length Reynolds numbers. The measured drag coefficients (which included the suction drag) were 20 to 40% of the friction coefficients of a turbulent plate.

AG98 **Graphical Methods in Aerothermodynamics.** O.LUTZ, G.STOFFERS.
AD-669-416 AGARDograph 98, 302 pp., 1967.
N68-23693 A survey is presented of diagrams and graphical methods used in thermodynamics, especially those that are important in the field of jet propulsion; the work is the result of an extensive literature search. Sections deal with (i) changes of state; (ii) heat transfer processes; (iii) the pressure-velocity diagram for ideal gases, and new types of diagram valid, for example, for gases with varying specific heats. There are numerous literature references.

AG99 **Simulation for Aerospace Research.** C.W.HARPER (Editor).
AD-475-661 AGARDograph 99, 187 pp., 1964.
N66-12667 The papers presented at the 24th AGARD Flight Mechanics Panel Meeting, February, 1964, are reproduced. A discussion of the simulation research problem from a human engineering standpoint precedes a consideration of: (i) electro-mechanical-optical systems forming the simulation hardware and associated computing facilities; (ii) examples of simulation research applied to aircraft problems; (iii) examples of simulation research applied to spacecraft problems. Abstracts of the individual papers are given in the succeeding items.

AG99/1 **Pilot-Vehicle System Simulation.** S.E.BELSLEY.
AGARDograph 99, 1-32, 41 refs., 1964.
A procedure for conducting a meaningful simulation of a pilot-flight vehicle system is presented and illustrated by various specific examples. The relationship of the various types of simulators to their use is outlined and desirable detailed characteristics are delineated. The compromises between simulator complexity, realism and the interrelation of various feedback sensing cues (motion, visual or tactile) are discussed, and the necessity of validating the simulation by use of a variable-stability and variable-control-system aircraft is noted.

AG99/2 **Manned Flight Simulation Facilities.** J.C.DUSTERBERRY.
AGARDograph 99, 33-59, 22 refs., 1964.
Describes solutions to the problems of providing research simulators, based on experience at the Ames Laboratories. Considers the major cues to be given to the pilot (centrifuge with gimballed cab, translating table with gimballed cab, miscellaneous motion systems); visual cues (processing the scene, presenting the scene); inside cockpit visual cues; miscellaneous cues; interfaces between systems.

AG99/3 **Computer Requirements for Manned Aerospace Research Simulation Facilities.** R.M.BARNETT.
AGARDograph 99, 61-73, 12 refs., 1964.
Examines some of the characteristics of the research in simulation of aerospace vehicles as they bear on computer requirements, and then considers the characteristics of analogue and digital computers. It is pointed out that the inadequacies in these two classes of computers in respect of manned simulation computational demands has led to the development of hybrid computers; developments in this latter field are discussed in the light of experience gained at Ames Research Center.

AG99/4 **Experiences with Visual Simulation in Landing and Take-Off Research.** R.S.BRAY.
AGARDograph 99, 75-91, 7 refs., 1964.
For the past two years, the simulation group at Ames Research Center has used a closed-circuit television visual simulator to study problems related to performance, stability and control in landing and take-off of various aircraft. The scope of this work is described, and some sample results are presented.

AG99/5 **Simulation Techniques for the Study of V/STOL Problems.** H.C.QUIGLEY.
AGARDograph 99, 93-112, 18 refs., 1964.
Reviews recent experiences and techniques used in V/STOL simulation, with particular reference to experience gained at the Ames Research Center. Other work is referenced where techniques and type of simulators are different.

AG99/6 **Piloted Simulator Studies of New Aircraft Missions.** G.W.STINNETT.
AGARDograph 99, 113-129, 3 refs., 1964.
Examples of piloting tasks which have been studied through research simulation at the Ames Research Center are the flight profile of the supersonic transport, the low-level, high-speed, terrain-following mission of the tactical fighter-bomber, and the 'all-weather' or 'blind' landing task. This paper describes briefly the use of simulators in studying these flight-path control problems, and the usefulness of cab-motion pilot cues as it applies to these studies.

AG99/7 **Piloted Simulations for Atmosphere Re-Entry of Space Vehicles.** R.C.WINGROVE.
AGARDograph 99, 131-155, 56 refs., 1964.
A review of piloted re-entry simulation studies in general research and in support of the X-15 and 'Mercury' projects is presented. Fixed-cockpit simulators have been found to be sufficient for most atmosphere re-entry simulation problems. Flight simulations utilizing a centrifuge, wherein the acceleration forces would be impressed on the pilot, have been useful primarily in the familiarization of the pilot to the re-entry accelerations and also in the early systems design research. Motion simulators and variable stability aircraft have been found to be necessary only for control problems.

AG99/8 **Midcourse Navigation, Guidance and Control Simulation Techniques for a Manned Spacecraft.** D.W.SMITH.
AGARDograph 99, 157-187, 8 refs., 1964.
Current work at Ames Research Center on the rôle of the crew in midcourse navigation and guidance for a typical lunar mission is described. Investigations are being undertaken to obtain basic information on the ability of a spacecraft navigator to measure accurately with optical instruments on-board the spacecraft angles between various planets, the Moon and the stars. Also being studied is the capability of the pilot to correct the trajectory manually using simple optical sighting devices with only the outside visual scene as a reference.

AG100 **Radar Techniques for Detection, Tracking and Navigation.** W.T.BLACKBAND (Editor).
AD-642-745 AGARDograph 100, 608 pp., 1966.
N67-13921 This record of the Proceedings of the 8th Symposium of the AGARD Avionics Panel, held in September 1964, contains thirty-one papers devoted to the study and review of current radar methods of target acquisition and also its application to navigation.

AG100/1 **A New Philosophy of Radar.** M.H.CARPENTIER.
AGARDograph 100, 1-7, 1966.
Conventional radars are based upon pulse train modulation, and they measure range in terms of pulse delay. The measurement of this may be made by the use of either correlators or matched filters. The choice of transmitter modulation is discussed. This choice should take into account the modulation effects of a scanning antenna. The receiver should be matched to the signal reflected from the target, which for large moving targets may differ appreciably from the transmitted signal.

AG100/2 **Parametric Analysis of Spaceborne Radar Applications.** R.J.ORFORD.
AGARDograph 100, 9-19, 9 refs., 1966.
The significant relationships between radar parameters and mission parameters pertaining to search and acquisition are indicated. The most important of these is the linear variation of radar power-aperture product with detection range, closing velocity and search area, and the optimization of search frame time. The linear variation with range was unexpected and indicates a tradeoff between detection range and spacecraft propulsion requirements. Curves are presented for numerical analysis of situations with Swerling Case I type targets.

AG100/3 **The Analysis of Uncooperative Radar Targets.** R.M.GOLDSTEIN.
AGARDograph 100, 21-34, 10 refs., 1966.
Discusses the special modulation and detection processes which enable the target to be analyzed in two dimensions simultaneously. Such a system was used with Venus as the target during the conjunction of 1962, and a much improved version will be in operation for the conjunction of June 1964. It is expected that this system will yield very accurate measurements of the range of Venus, as well as the rotation rate, direction of the axis of rotation, and the detection of surface features on Venus.

AG100/4 **Pulse Compression Research in the United Kingdom.** E.H.BOYENVAL.
AGARDograph 100, 35-46, 1966.
Experimental transmissions have been made with alternate pulses of single frequency and with frequency modulation. These have shown the marked advantage of even a crude pulse compression system over the normal radar when clutter returns are present. The design of an experimental pulse compression system is discussed. A distortion measuring equipment has been developed which displays amplitude and phase errors measured on a single pulse. An adjustable compensating network has been developed.

AG100/5 **Statistical Methods of Radiodetection.** (In French.) R.REBOUL.
AGARDograph 100, 47-74, 1966.
A theory of detection is presented which leads to a criterion for optimum detection, that is the highest probability of detection for a given false alarm rate. The analysis is divided into four parts of increasing complexity i.e. (i) the ideal problem of detection, (ii) the stochastic problem of detection, (iii) the problem of estimation, and (iv) the problem of discrimination and resolution.

AG100/6 **Target Resolution: Capabilities of Modern Radar and Fundamental Limits.** A.W.RIHACZEK.
AGARDograph 100, 75-95, 7 refs., 1966.
The study starts with an interpretation of the radar uncertainty relation in its significance for target resolution, showing the role of waveform designs as a means of achieving a match between the transmitted signal and the characteristics of the target environment. It is shown that the achievable target resolution depends on the characteristics of the target environment in which radar operates, the number of targets, and the size of the delay-Doppler space they occupy. Two practical examples are given.

AG100/7 **Measurements of the Reflection from the Ground of S-Band Signals.** A.R.DOMVILLE.
AGARDograph 100, 97-109, 1966.
Describes and gives the results of a series of experiments carried out to measure the reflection of S-band radio transmissions from various types of ground surface including water, forest, different types of terrain, snow, and urban districts. The measurements were made at near-vertical incidence with pulse signals.

AG100/8 **Some Information on the Nature, Size and Velocity Distribution of Random Scatterers Gathered by a Pulse Radar on Two Wavelengths using Vertical Fixed Beams.** W.FOGY.
AGARDograph 100, 111-140, 24 refs., 1966.
Some results of a series of experimental runs of the DVL developed vertical-beaming cloud radar are presented and discussed. This radar operates on two wavelengths simultaneously (X- and K_a-band). An attempt is made to read out information about the nature and some statistical parameters of cloud, rain, and snow by comparison with other meteorological data.

AG100/9 **Moving Target Indication: A Survey of Developments Since 1948.** P.BRADSELL.
AGARDograph 100, 141-172, 26 refs., 1966.
It is the aim of this paper to survey the principle developments in theory and technique which have made possible the considerable progress during the past fifteen years. Topics discussed include components from M.T.I., improvements in techniques, M.T.I. measurements, the state-of-the-art in COHO-STALO M.T.I., airborne M.T.I., complex transmitted waveforms, pulse-doppler radar, area M.T.I. and the outlook for the future. An appendix deals with the analysis of two- and three-period staggered P.R.F. M.T.I. systems.

AG100/10 **The SDS Surveillance Radar Designed for the Detection of Moving Objects on the Ground: Extension to the Detection of Low Flying Aircraft.** (In French.) G. VAN DEN BROEK.
AGARDograph 100, 173-184, 1 ref., 1966
An account is given of a radar designed to fulfill the following functions: (i) the detection of moving targets on the ground with a range of 30 km for vehicles and 15 km for a man; (ii) the measurement of bearing, elevation and distance of the target with a precision of 5 milliradians and 40 metres respectively; (iii) the identification of the nature of the targets (wheeled vehicles, tracked vehicles, pedestrians singly or in groups etc.); (iv) the identification of friendly targets.

AG100/11 **Sideways Looking Airborne Radar.** J.HIGHCOCK.
AGARDograph 100, 185-202, 1966.
Describes the principle and purpose of this radar which was developed by the R.R.E. Basically the concept is simple, a long aerial is mounted along the side of the aircraft so that it looks at right angles to the flight path. The picture, produced on photographic film, is of a strip of ground to one side of the aircraft and parallel to the flight path, the resolution of the map being a function of the beamwidth along track and pulse length across track.

AG100/12 **Airborne Early Warning Radar: Some Basic Considerations.** S.MATT.
AGARDograph 100, 203-215, 1966.
This is a brief history of radar surveillance, commencing from the 1935 UK installations on the East coast of England. The US Navy's E-2A 'Hawkeye' which is fitted to carrier-based aircraft is quoted as a modern development. Basic considerations in designing early warning radar are included in the text.

AG100/13 **Airborne Doppler Navigation Techniques.** T.TRAY.
AGARDograph 100, 217-234, 4 refs., 1966.
Information on existing techniques is collated and the advantages and disadvantages of each technique for specific purposes are indicated. Possible configurations and the various transmission methods are described. A section is included on the methods of computing information provided by the basic Doppler system. The effect of recently developed components and techniques on Doppler design is also discussed.

AG100/14 **Scanning Beam Guidance for Approach and Landing.** J.E.WOODWARD.
AGARDograph 100, 235-252, 1966.
An account is given of a radio guidance system for aircraft which is a combination of the usual ILS and a precision approach radar. Two ground stations are used in order to give control in azimuth and glide angle. These are sited one at each end of the runway. A similar system could be applied to landings on aircraft carriers.

AG100/15 **An Automatic F.M. C.W. Surveillance Radar.** C.S.E.PHILLIPS.
AGARDograph 100, 253-265, 5 refs., 1966.
The paper describes a proposed fully automatic radar system which can detect and track targets both at low level and, at higher elevation angles, at ranges out to some 150 km. Its computer has the dual role of (i) associating azimuth angle, elevation angle, Doppler frequency and range measurements so as to form tracks, and (ii) controlling the aerial system, the transmitted waveform, the radar receiver and the auto-extraction equipment so as to provide the data in the most efficient manner.

AG100/16 **Doppler System for Measuring the Flight Performance of Small Rockets and Light Ammunition.** C.O.LUND.
AGARDograph 100, 267-279, 1966.
The basis of this system is a conventional Doppler radar with a CW magnetron transmitter and a receiver with IF amplifier. The radar can measure the velocity of most missiles and projectiles over a good proportion of their maximum range. Precautions to obtain high reliability are also enumerated.

AG100/17 **Integrated Trajectory System.** G.F.BIGELOW.
AGARDograph 100, 281-306, 14 refs., 1966.
A medium to high accuracy, multiple target tracking system is being developed at White Sands Missile Range. Range and angle measuring equipment will employ continuous wave (CW) phase comparison measurements. Velocity measuring equipment will employ CW Doppler measurements.

AG100/18 **Methods for Obtaining Velocity and Range Information from CW Radars.** M.EASTERLING.
AGARDograph 100, 307-326, 16 refs., 1966.
Continuous wave radars are particularly suited to obtaining velocity and range information on single targets at extreme ranges whether they be spacecraft in orbit about the Earth or en route to the Moon or another planet, or natural celestial bodies such as the Moon or inner planets. The methods of applying such radars are discussed, and experimental results given to show the performance which can be attained.

AG100/19 **A Description of a High-Performance Microwave Experimental Facility.** H.G.WEISS.
AGARDograph 100, 327-371, 1966.
A versatile new ground station has been developed for experimental space communications, radar and radio physics investigations. This installation, which has been named HAYSTACK, employs, a precise 120 ft diameter Cassegrain antenna with a surface tolerance which should permit very efficient operation of wavelengths of 3 centimetres and a useful capability at wavelength as short as 9 millimetres.

AG100/20 **The Design of a Very High Power, Very Low Noise Cassegrain Feed System for a Planetary Radar.** P.D.POTTER.
AGARDograph 100, 373-395, 20 refs., 1966.
A modified Cassegrain feed for an 85 ft diameter antenna, planetary radar system is described. The equipment and techniques involved are being developed for use in the NASA/JPL deep space instrumentation facility. The system operates at a frequency of 2400 Mc/s in a duplex mode with a transmitter power of 100 kWcW and an overall receiving system noise temperature of about 28 deg.K. Detailed design and performance information is presented.

AG100/21 **Electronically Scanned Antenna System: Pt.1.** M.A.DIAB, T.MAGGIO.
AGARDograph 100, 397-415, 13 refs., 1966.
Previous development has led to the production of a variety of beam-scanning and beam-forming techniques. The purpose of this report is to acquaint the reader with the various forms and implementation of those techniques which have been developed to-date. A bibliography of these techniques which have appeared in print is included.

AG100/22 **Electronically Scanned Antenna Systems: Pt.2.** A.E.KILLICK, D.E.N.DAVIES.
AGARDograph 100, 417-431, 1966.
A general account is given of the basic methods of electronic scanning of aerial beams. The feed complexity of a large phased array can be reduced by the grouping of elemetns which are fed together. Other simplifications result from space tapering and array thinning. The phase relationships in the array may be varied or quantized phase shifters. Frequency scanning can achieve the same result. An account is given of various techniques for the formation of multiple beams.

AG100/23 **High Power CW Radar Transmitter.** W.S.BAUMGARTNER.
AGARDograph 100, 433-465, 1966.
The system in which the transmitter functions is described and its use as a planetary radar and as a proving ground for equipment is discussed. The design parameters for such a transmitter are delineated and the history of its development is traced. Particular attention is given to problems encountered and to their solutions. There is a detailed description of the hardware involved. Plans for increasing the radiated power and upgrading the transmitter system are presented.

AG100/24 **Transmitter Research in the UK.** N.S.NICHOLLS.
AGARDograph 100, 467-472, 1966.
A survey is given of the in-house and extra-mural activities of the Electronic Group, R.R.E., in the field of devices and techniques for pulsed radar transmitters.

AG100/25 **Phase Shifters for Phased Array Antenna.** H.A.HAIR.
AGARDograph 100, 473-483, 2 refs., 1966.
Fast switching mivrowave phase shifters are described for use in high power array radars. Drive control techniques which minimize temperature sensitivity and which allow unique phase variation control with a minimum drive power requirement are described. Peak and average power capability of the phase-shifters are discussed.

AG100/26 **Dispersions for Pulse Compression Systems.** P.S.BRANDON, O.E.KEALL, W.S.MORTLEY.
AGARDograph 100, 485-514, 5 refs., 1966.
This paper deals with two types of apparatus for producing the dispersion required in a pulse compression system. The first type is composed of lumped electric circuits and has reached an advanced level of development; the second makes use of ultrasonic techniques and is in the experimental stage. The design of the electric circuit dispersion is dealt with in Part 1, and the realisation of a typical design Part 2. Part 3 deals with the ultrasonic dispersor.

AG100/27 **Radar Data-Handling and Display Systems for use with Pulse Radars.** A.P.YOUNG.
AGARDograph 100, 515-523, 1966.
The flow of data in a military radar system is illustrated. This is said to have much in common with systems for civil air traffic. The method of track initiation and marker positioning using a tracker ball and push button control is briefly described together with general design problems of the computing system.

AG100/28 **Digitalisation of Radar Signals and their Evaluation by a Computer for Automatic Tracking of Targets.** K. VON SCHLACHTA, H.SPRINGER, W.STORZ, W.D.WIRTH.
AGARDograph 100, 525-539, 1966.
This development was intiated as part of an attempt to automate civil air traffic control. Described are the digital radar system including that of the digital detector and the computer programme for radar data processing. Emphasis is given to the tactics of atuomatic target tracking and those of continuous acquisition of new targets.

AG100/29 **Evaluation of Track-While-Scan Computer Logics.** L.LETH-ESPENSEN.
AGARDograph 100, 541-563, 1966.
The knowledge of positions, vectorial velocity, height and identification of all flying objects is important to civil air traffic control as well as for military purposes. The evaluation of the tracking performance of several systems has been undertaken by the SHAPE Technical Centre and this paper highlights the important points which led to the method finally adopted.

AG100/30 **Tracking in an Air Traffic Control Environment.** B.W.OAKLEY.
AGARDograph 100, 565-583, 1966.
This paper considers the essence of the tracking problem; why is it necessary to track, and what are the difficulties? It then considers the differences that arise between a co-operative A.T.C. environment on which most tracking work has been concentrated in the past. Methods of co-operative tracking are considered, and the implication for conventional primary radar tracking of improvements in radars and tracking logics are reviewed.

AG100/31 **Provision and use of Alphanumeric Display of Primary and Secondary Radar Tracking Data in Expanding Air Traffic Control System Capacity.** L.E.SHOEMAKER.
AGARDograph 100, 585-600, 1966.
To satisfy automation requirements for air traffic control in the most economically feasible manner, two basic configurations have been selected for progressive system implementation of automation in the United States. The systems, which are described, are called the Terminal and Center-Metroplex configurations. A summary of operational improvements is included.

AG101 **Nuclear, Thermal and Electric Rocket Propulsion: Fundamentals, Systems, and Applications.**
AD-662-935 AGARDograph 101, 637 pp., 1967.
N68-12184 The purpose of this book is to present the lectures, and discussions which took place in November 1962 and September/October 1964, and which formed the AGARD/NATO First and Second Lecture Series in cooperation with The Université Libre de Bruxelles. In general, the lectures dealt with basic principles of nuclear propulsion, nuclear-thermal propulsion system and nuclear-electric propulsion systems. Abstracts of the individual lectures are given in the subsequent items.

AG101/1 **A European View of Nuclear Propulsion.** A.L.JAUMOTTE.
AGARDograph 101, ix-xii, 1967.
As an introduction to this AGARDograph Professor Jaumotte confines himself to the problems faced purely by the European countries. The types of reactor, costs and time spent on research and development programmes. It is evident that the manpower and money required for research in nuclear and electric propulsion exceeds the possibilities of individual European countries, and international collaboration will be indispensable. The way in which such collaboration could take place is outlined as well as which method of propulsion the European organisation should use.

AG101/2 **The Role of Nuclear Energy in Space Flight.** R.W.BUSSARD.
AGARDograph 101, 1-18, 1967.
Propulsion requirements for future practical manned space vehicles exceed the capabilities of the chemical rocket, but can be achieved effectively by the use of nuclear energy. A survey of the technical possibilities indicates that nuclear/thermal rockets will be suitable in the next two decades, that nuclear/electric systems offer promise for the last two decades of this century, and that fusion propulsion may provide the eventual system for manned flight early in the twenty-first century and later allow the first attempts at interstellar probes and travel.

AG101/3 **Fundamentals of Nuclear Propulsion.** R.W.BUSSARD.
AGARDograph 101, 21-83, 44 refs., 1967.
This paper is divided into six sections as follows (i) Performance analysis including external and internal ballistics, (ii) reactor neutronics dealing with the basic principles of fission reactions, and criticality and time-dependence, (iii) radiation leakage and shielding, (iv) heat transfer and fluid flow which includes the heat exchanger and nozzle performance, (v) material requirements and properties i.e. propellants and their performance, fuel element materials, moderators and reflectors, (vi) reactor design and engine cycle considerations.

AG101/4 **Isotope/Thermal Thrusters and Applications.** J.S.MARTINEZ.
AGARDograph 101, 87-154, 5 refs., 1967.
A radioisotope thruster is a low-thrust, direct-cycle rocket engine utilizing the thermal energy generated by isotope decay to heat hydrogen which is then expelled through a nozzle. A description is given of typical systems (including comparison with other systems), isotope heat sources, thruster design, stage design, low thrust orbital mechanics and mission analyses, and safety considerations.

AG101/5 **Fast and Moderated Reactors and Applications of Low-Power Nuclear Rockets.** F.E.ROM.
AGARDograph 101, 155-241, 73 refs., 1967.
Two basic types of reactor were considered -- the thermal and the fast reactor. A discussion of the materials which must be used for nuclear rocket reactors included their suitability for the thermal and fast types. Several reactor concepts utilizing these materials were discussed and compromises which may be necessary to achieve feasible propulsion systems were outlined. Performance estimates of the various concepts were made. Potential applications of small fast and thermal nuclear rockets were given. Solar and planetary missions and deep-space probes were discussed to point out velocity increment requirements. The power and operating time requirements were computed, and the capability of the various concepts to accomplish these missions were determined to indicate the potential of fast and moderated nuclear rockets.

AG101/6 **Nuclear Rockets Based on Graphite Reactor Technology.** H.B.FINGER, P.G.JOHNSON, J.E.MORRISSEY, A.R.SIEGEL.
AGARDograph 101, 242-337, 59 refs., 1967.
Described the present Nuclear Rocket for Vehicle Application (NERVA), its configuration and the major technical considerations that determined the configuration of the engine. Technical considerations were discussed that determine and limit the operating characteristics and performance of the overall engine system including considerations of steady state performance and transient operation. The status of the reactor and non-nuclear components and overall system development and operation was described. Work that is underway aimed at developing higher power reactor systems was described, and the potential use of clustered engines in actual space missions discussed. The objective is to use [illegible] units for lunar, solar, and planetary missions.

AG101/7 **Operational Safety of Nuclear Rockets.** G.P.DIX.
AGARDograph 101, 338-357, 12 refs., 1967.
This work is in support of the nuclear rocket safety programme sponsored by the US Atomic Energy Commission and NASA. The study includes the safety philosophy; an analytical model of the nuclear rocket engine, the vehicle, nuclear rocket missions, and environment; conceptual operations and countermeasures for ground testing, flight testing, and operational flights, and details of safety engineering for the nuclear rocket.

AG101/8 **Nuclear Space Power Systems: Reactors, Conversion Equipment, and Power Systems Technology.** H.M.DIECKAMP.
AGARDograph 101, 361-504, 79 refs., 1967.
A reactor criticality survey identifies the preferable concepts, configurations, and materials. Beyond criticality, reactor size and weight are determined by heat transfer and fuel material radiation damage limitations. The allowable operating temperature range is determined by the physical properties of reactor materials. These considerations show the reactor concepts that are appropriate for space power and indicate the temperature and power regions of applicability.

The physical principle of thermoelectric, Rankine cycle, Brayton cycle and thermionic power conversion defines the capabilities and limitations of each concept is surveyed. The final selection of power conversion is influenced by power level, reliability requirements, and other system constraints. The extreme temperature dependence of the radiator area and weight dictates the concept progression required for increased performance (i.e. lb/kW). However, temperature is an all important factor in determining power system availability.

The development status of the U.S. AEC's SNAP programmes defines the current and projected 'state-of-the-art'. SNAP (Systems for Nuclear Auxiliary Power) encompasses epithermal and fast reactors with direct and dynamic conversion in the power range from 500 watts to megawatts. Safety considerations need not impede the use of nuclear power in space. SNAP units should fill a range of applications for the future exploration and utilization of space.

AG101/9 **Advanced Technology for Large Space Power Systems.** M.A.ZIPKIN.
AGARDograph 101, 505-539, 1967.
The paper reviews recent programmes and results of the General Electric Company in the field of large turbo-nuclear Rankine cycle alkali metal working fluid space power system technology. The presentation is limited to a discussion of developments relating to energy conversion components considering the materials, boiling and condensing of alkali metals, electromagnetic liquid metal pumps, bearings, and the potassium vapour turbine.

AG101/10 **Electric Propulsion: Systems, Flight Mechanics, Power Source, and Mission Applications.** E.STUHLINGER.
AGARDograph 101, 540-625, 52 refs., 1967.
Electric energy can be used in several ways to accelerate propellant material. Experimental work on such systems has progressed to a point where efficiencies, lifetimes, and certain design parameters can be estimated; such systems were shown to be attractive for a number of space missions. Included in the electric thrustors mentioned are the resisto-jet, arc-jet, thermionic and electrodynamic systems.

Low thrust and long operating times make design and performance calculations of electric rocket systems different from those of high thrust rockets. Power supplies of at least 0.1 kW/kg appear to be within our capabilities for electric propulsion. The most promising systems are reactor-thermodynamic, and reactor-thermionic units. These systems have promise for lunar ferries, deep space probes, planetary flyby and orbiters, manned planetary return vehicles, out-of-the-ecliptic probes, and others.

AG102 **Supersonic Inlets.** I.D.V.FARO.
AD-476-422 AGARDograph 102, 157 pp., 61 refs., 1965.
N66-11632 The design and operation of supersonic inlets is discussed. The means by which the incoming flow may be decelerated to a subsonic velocity are enumerated and evaluated. Diffusers which employ internal compression, external compression, or a combination of the two, are treated. Experimentally determined values of the total pressure recovery, the capture-area ratio and the inlet drag are compared with those determined from available theories for all types of diffusers. Some specific problems of two-dimensional diffusers are considered. The effects of the boundary layer and of oscillating flow are also treated.

AG103/1 **Aerodynamics of Power Plant Installation.** Pt.1.
AD-656-569 AGARDograph 103, Pt.1, 372 pp., 1965.
N66-22306 This AGARDograph contains a collection of papers presented at the AGARD Specialists' Meeting on the title subject, held at Arnold Engineering Development Center, Tennessee, 25th to 27th October, 1965. Pt.1 includes an introductory paper, papers on general development trends and on air inlets and nozzles. Abstracts of the individual papers are given in the succeeding items.

AG103/1/1 **The Engine Designer's Point of View.** L.G.DAWSON.
AGARDograph 103, Pt.1, 1-22, 1965.
In this introductory paper, the way in which the engine is affected by the state of the air delivered to it by the power plant installation is reviewed. The object is to persuade engine designers to give more attention to the way they deliver engine air to the compressor face.

AG103/1/2 **A Discussion of Selected Aerodynamic Problems on Integration of Propulsion Systems with Airframe on Transport Aircraft.** W.C.SWAN.
AGARDograph 103, Pt.1, 23-68, 24 refs., 1965.
Surveys current knowledge on integration of engine nacelles on transport aircraft with special emphasis on the aerodynamic forces which produce lift and drag. The subsonic case is treated first, showing how current drag estimates are made, and where the theory is weak. The supersonic case is then explored with emphasis on pressure drag due to volume and lift. Proposals are made for future analytical research.

AG103/1/3 **The Feasibility of Supersonic Combustion Ramjets for Low Hypersonic Speeds.** R.HAWKINS.
AGARDograph 103, Pt.1, 69-115, 27 refs., 1965.
The performance of a supersonic combustion ramjet is examined in relation to that of a conventional subsonic ramjet. At low hypersonic speeds the internal performance of the two cycles are comparable, but at speeds above Mach 7, the supersonic combustion cycle should offer superior performance. Beyond Mach 9 the lack of reliable intake data makes the estimation of performance highly conjectural. Typical entry conditions for a supersonic combustor are deduced. A detailed appraisal of available data on mixing and reaction rates is made in order to assess the feasibility of supersonic combustion, particularly at low hypersonic flight speeds. An attempt is made to outline the most important areas for further research on supersonic combustion.

AG103/1/4 **The Blunt Trailing Edge Axial-Flow Supersonic Compressor.** F.BREUGELMANS.
AGARDograph 103, Pt.1, 117-152, 17 refs., 1965.
A 40 cm tip-diameter rotor, using blunt trailing edges, was designed to produce a total pressure ratio of 3.5 at tip Mach number 1.70. General observations are made on flow in pipes of constant area, ducts of the P-A power family and flows through sudden area enlargements. Subsonic and supersonic Mach numbers are considered. The effect of Mach number, channel divergence, sudden area increase and back pressure on the flow is discussed. Supersonic cascade experiments are presented from the point of view of pipe flow. Blade section performance is analyzed and compared with theoretical results.

AG103/1/5 **Measurements of Relaxation Effects in Nozzle Flow of Hot Combustion Gases by Means of a Shock Tube Technique.** T.JUST.
AGARDograph 103, Pt.1, 153-171, 5 refs., 1965.
Describes a modified line reversal technique which permits measurement of temperatures during short time intervals in relaxing nozzle flows. The high temperatures of combustion gases needed were produced by shock-driven detonations in a shock tunnel. Preliminary results are given.

AG103/1/6 **Aircraft Performance Problems Associated with Engine and Intake Installation.** J.WEIR.
AGARDograph 103, Pt.1, 173-194, 7 refs., 1965.
The compromise between subsonic and supersonic requirements of the intake and after-body design is discussed for aircraft which spend most of their time at subsonic cruise conditions but which still retain the ability to accelerate rapidly to Mach 2 plus. The usual approach of designing the intake and nozzle for supersonic speeds and then minimizing the penalties that result at subsonic speeds is questioned. The approach which first fulfils subsonic requirements, accepting some supersonic penalties, is considered in more detail.

AG103/1/7 **Low-Drag Installation of Twin Propulsion Nozzles in the Rear of the Fuselage for Transonic and Supersonic Flight.** H.LANGFELDER.
AGARDograph 103, Pt.1, 195-216, 2 refs., 1965, International.
For the specific case of a projected fighter aircraft, various models with twin engine nozzles in the rear of the fuselage were tested by Entwicklungsring Süd. Pressure measurements were made on the afterbody, the base and the internal and external nozzle surfaces. The influence of ejector nozzles with venting of base areas was also investigated. The results of investigations on boat-tail and base pressure drags, and of the secondary ejector drag are presented and discussed, together with some comments on ejector nozzle behaviour.

AG103/1/8 **Method of Net Thrust Measurement in Supersonic Flight.** T.W.DAVIDSON.
AGARDograph 103, Pt.1, 217-244, 3 refs., 1965.
The feasibility and accuracy of the Traversing Rake System which samples pressures and temperatures through the engine exhaust has been established. Initial results show data to be within 2 to 3% gross thrust and 4 to 5% net thrust. This accuracy is expected to be maintained with the new automatic data acquisition and processing system. This system, which uses airborne magnetic tape, analyzes and plots thrust and drag data in a matter of minutes. The rake promises developmental and research application by-passing extensive engine test cell calibrations.

AG103/1/9 **Past Flight Experience and Recent Developments in Combinations of Ramjet and Turbojet Engines.** A.GOZLAN.
AGARDograph 103, Pt.1, 245-270, 1965.
A general approach to the problem of compound powerplants is presented, the experience gained with the flight-testing of the turbo-ramjet powered Mach 2.2 'Griffon' experimental aircraft is summarized, and the results of the latest research work are given. It is shown how additional sophistication involving the use of cryogenics, might extend the efficient operating range into the hypersonic regime.

AG103/1/10 **Additive Drag on Inlet Cowls and its Effect on Aircraft Performance.** J.S.MOUNT.
AGARDograph 103, Pt.1, 271-300, 4 refs., 1965.
It is well known that under many flight conditions the theoretical additive drag force is partially cancelled out by a change in the suction forces acting on the cowl lip. This paper presents the results of some recent tests aimed at obtaining empirical design data on the magnitude of this suction force.

AG103/1/11 **Intake Design and Performance Around a Mach Number of 2.2.** M.C.NEALE.
AGARDograph 103, Pt.1, 301-323, 5 refs., 1965.
Considers the selection of a shock geometry for a two-dimensional intake for operation at Mach 2.2. Either combined external/internal compression or all external compression arrangements are possible, and preliminary theoretical arguments point the need for experimental information to assist the choice. Appropriate test programmes are described. It is concluded that the external compression geometry is to be preferred. Some areas for further research are indicated.

AG103/1/12 **Operation of the Internal Boundary Layer Trap of an External Supersonic Compression Air Intake.** (In French). J.LEYNAERT.
AGARDograph 103, Pt.1, 325-343, 1965.
The following aspects are treated; general description of the flow in the intake; operation of the internal boundary layer trap (regulation of the aspiration by the trap, compensation of fluctuations in the principal flow, operational limits); overall characteristics; effect of geometric parameters on the overall characteristics.

AG103/1/13 **A General Method for Calculating Low Speed Flow about Inlets.** J.L.HESS, A.M.O.SMITH.
AGARDograph 103, Pt.1, 345-371, 6 refs., 1965.
A set of digital computer programmes has been developed that can calculate with high accuracy the inviscid incompressible flow about arbitrary two-dimensional, axisymmetric, and three-dimensional bodies. This paper describes how these programmes can be used as design tools in problems involving inlets or power plant installations in general and illustrates their effectiveness in these applications. The ability of the method to predict real flow is exhibited by comparing calculated and experimental pressure distributions on a variety of configurations. Several applications of this method to design problems are presented.

AG103/2 **Aerodynamics of Power Plant Installation: Pt.2.**
AD-656-570 AGARDograph 103, Pt.2, 373-747, 1965.
N66-22286 This part deals with air inlets and nozzles, interference between propulsion system and airframe, specific propulsion installations, and VTOL propulsion. Abstracts of the individual papers are given in the succeeding items.

AG103/2/1 **An Investigation of Splitter Plates for Supersonic Twin Inlets.** J.B.PETERSON, JR.
AGARDograph 103, Pt.2, 373-409, 5 refs., 1965.
An experimental investigation was conducted to determine the ability of various splitter plates to isolate twin inlets aerodynamically such that in the event that one inlet is unstarted, the operation of the other inlet will not be affected. The effects of pylon height, inlet mass flow, and inlet yaw, on the performance of splitter plates were investigated. A pylon-mounted external-internal compression inlet model was used and the tests were made at Mach 2.5 and Reynolds number, based on cowl diameter, of 10.8×10^6.

AG103/2/2 **Boundary-Layer Interaction Effects in Intakes with Particular Reference to those Designed for Dual Subsonic and Supersonic Performance.** J.SEDDON.
AGARDograph 103, Pt.2, 411-444, 5 refs., 1965.
On the basis of a series of wind tunnel tests, a quantitative assessment is made of the loss of pressure recovery due to interaction between the boundary-layer and the pre-entry pressure gradient, including, when present, the normal shock. The analysis leads to a formula which is suggested for general application. Boundary-layer control to reduce or eliminate the interaction loss may take a special form when it is necessary not only to safeguard the supersonic performance but also to minimize the subsonic drag. Some brief discussion of this problem is given.

AG103/2/3 **Practical Possibilities for the Theoretical Study of Supersonic By-Pass Nozzles.** (In French). J.-M.HARDY.
AGARDograph 103, Pt.2, 445-478, 10 refs., 1965.
Following a brief review of the methods used in the design of by-pass nozzles (for both low and high secondary mass flows), a comparison is made with experimental results which shows the excellent agreement obtained when the fluid utilized for the primary and secondary flows is air at ambient temperature. In the case of a real air exhaust (γ and temperature variable), a critical survey of the theory shows that the effect of these factors is effectively taken into account in the case of high mass flows.

AG103/2/4 **Methods of Measuring Aerodynamic Efficiency and Thrust Vectors of Engine Exhaust Systems.** N.SCHOLZ.
AGARDograph 103, Pt.2, 479-501, 1965.
VTOL technology requires complex exhaust system configurations, the flow losses and thrust vectors of which are difficult to estimate. In most cases it is therefore necessary to determine the aerodynamic parameters of the system by testing models in cold air. The necessary analysis of the test results from which these parameters are obtained and three fundamental methods of test are discussed, namely, a thrust force measuring method, a stream tube method and a momentum method. This last method is discussed in some detail and its application is demonstrated by means of some test results.

AG103/2/5 **Propulsion System Integration in Wings.** J.LOCKWOOD TAYLOR.
AGARDograph 103, Pt.2, 503-511, 2 refs., 1965.
Concerns the effect on performance, and more especially on the induced vortex drag of the aircraft wing and on the lift/drag ratio of the aircraft as a whole, of a duct or jet engine nacelle at the wing tip. Theoretical and experimental evidence is given of performance improvement at subsonic speeds, and it appears that this improvement may be achieved at supersonic speeds also.

AG103/2/6 **A Fully Integrated Propulsion System for a Supersonic Transport Aircraft.** J.E.TALBOT, B.FURNESS.
AGARDograph 103, Pt.2, 513-538, 2 refs., 1965.
The separate development of intake and nozzle for a supersonic powerplant may lead to components which are, individually, very efficient, but not when integrated into a powerplant. This paper illustrates the problem and indicates that flexibility can be achieved by suitable development and choice of components. For the purposes of illustration the problem is treated in terms of quasi-static effects of changes in ambient temperature on performance.

AG103/2/7 **Jet VTOL Power Plant Experience During Flight Test of X-14A VTOL Research Vehicle.** L.STEWART ROLLS.
AGARDograph 103, Pt.2, 539-557, 8 refs., 1965.
Ames Research Center has used a deflected-jet VTOL research vehicle (the X-14A) extensively to investigate the handling qualities requirements for VTOL aircraft. Some power plant problems encountered were thrust loss due to hot gas ingestion, compressor damage due to the ingestion of ground erosion debris, negative ground effect or "suckdown", and the demands on the engines for high thrust as well as bleed air supply for the reaction controls.

AG103/2/8 **Jet Lift Intakes.** W.F.WILES.
AGARDograph 103, Pt.2, 559-586, 1965.
Gives a summary and a brief history of the problems which have arisen. Scoop type intakes were first selected and have been used on several aircraft. Simpler intakes were then developed, for example those with a cascade of vanes in front of the first engine. Work is still proceeding in this field on various engine configurations, the main objective being to reduce the installed volume of the engine, in particular that required for the intake.

AG103/2/9 **Techniques for the Simulation of Jet-Lift Engines in Wind-Tunnel Models of V/STOL Aircraft.** I.U.SACERDOTE.
AGARDograph 103, Pt.2, 587-617, 9 refs., 1965.
A technique has been developed, at FIAT Aviation Division, based on the application of compressed air ejectors. The compressed air is ducted to the model through a system of tubes floating on compressed air bearings, to minimise the force and/or moments induced on the model. The basic assumptions on which this particular technique is based, the calibration tests performed, and the data-reduction methods are illustrated, together with a summary of wind-tunnel results.

AG103/2/10 **Aerodynamic Interference Effects with Jet Lift Schemes on V/STOL Aircraft at Forward Speeds.** J.WILLIAMS, M.N.WOOD.
AGARDograph 103, Pt.2, 619-651, 18 refs., 1965.
The nature and magnitude of aerodynamic interference effects which can arise with jet and fan lift schemes for V/STOL aircraft are considered, particularly as regards possible adverse flows induced around the airframe by the jet (or fan) efflux during aircraft transition to and from purely wing-borne flight. The discussion is based mainly on aerodynamic research at RAE and concentrates on the understanding and analysis of major features, rather than on optimization of specific aircraft layouts.

AG103/2/11 **Lift-Fan V/STOL Propulsion and Airframe Integration.** H.E.DICKARD.
AGARDograph 103, Pt.2, 653-688, 7 refs., 1965.
With reference to the XV-5A V/STOL research aircraft, the paper shows potential improvements in lift-fan concepts with the advanced propulsion knowledge available today. The XV-5A is powered by two General Electric J.58 turbojet engines which provide forward propulsion and power to the 62.5 in. diameter lift fans in each wing. The paper concludes by presenting a spectrum of tactical lift-fan aircraft configurations with speed capability up to Mach 2.0.

AG103/2/12 **NASA Research on the Aerodynamics of Jet VTOL Engine Installations.** R.E.KUHN, M.O.McKINNEY, Jr.
AGARDograph 103, Pt.2, 689-713, 15 refs., 1965.
Only some of the more interesting results of NASA studies in the following areas are included: (i) exhaust nozzle losses; (ii) base losses in hovering out of ground effect; (iii) jet free stream induced lift loss and moment in transition in and out of ground effect; (iv) jet free stream interference effects on reaction control effectiveness; (v) losses in inlet pressure.

AG103/2/13 **Experimental Studies of VTOL Fan-in-Wing Inlets.** U.W.SCHAUB.
AGARDograph 103, Pt.2, 715-747, 5 refs., 1965.
The inflow problems associated with inlets, whose axes are perpendicular to the plane of the wing, have been studied in detail statically and at forward speed. Emphasis is placed on the distribution of velocity, total pressure loss, swirl and inflow-to-axis angles in the inlet as a function of inflow ratio and wing angle of incidence. These inlet annulus distributions feature, in general, a quasi-two-dimensional appearance with the inflow velocities being highest in the leading annulus sector.

AG104
AD-674-169
N68-29502 **High Frequency Radio Communications.** F.LIED, K.W.ERIKSEN, B.LANDMARK, B.MACHLUM, E.V.THRANE.
AGARDograph 104, 130 pp., 1967.
The aim of this book is to assist the practical Communication Officer and Engineer in radio communication, particularly when working in polar regions. Chapters are devoted to: propagation of radio waves via the ionosphere; prediction of ionospheric conditions; communication problems in the polar regions; prediction and reduction of polar communication difficulties. An appendix treats the Earth's magnetic field and its time variations.

AG105
AD-640-818
N66-39955 **Space Navigation, Guidance and Control.** J.E.MILLER (Editor).
AGARDograph 105, 373 pp., 1966.
An overall picture is given of the basic requirements, design philosophy, and equipment for the guidance and control of the "Apollo" Moon-landing vehicle. The information, which was written by senior design staff at the Instrument Laboratory of MIT, provides a guide to the methods used for interplanetary journeys, rendezvous and soft landings. These papers were originally presented at AGARD Lecture Series XVII in June 1965. Abstracts of the various parts included in this issue are given in the succeeding items.

AG105/1 **Guidance – Basic Principles.** C.S.DRAPER, W.WRIGLEY.
AGARDograph 105, 1-60, 25 refs., 1966.
Contains the following: problems of guidance; geometrical aspects of guidance and control; functional requirements of systems and their components for control and guidance; state of technology of components for control; navigation and guidance systems; gyroscopic units for realization of guidance system reference coordinates; basic principles of gyro unit applications; specific force receivers; and inertial systems.

AG105/2 **The Navigation, Guidance and Control of a Manned Lunar Landing.** D.G.HOAG.
AGARDograph 105, 61-146, 1966.
The background and the problem of guidance, navigation and control tasks in the "Apollo" mission; instrumentation in "Apollo"; operation modes of "Apollo" command module Block I; spacecraft safety considerations of guidance, navigation and control.

AG105/3 **Explicit and Unified Methods of Spacecraft Guidance.** R.H.BATTIN.
AGARDograph 105, 147-188, 13 refs., 1966.
The two fundamental tasks of a guidance system are to maintain accurate knowledge of spacecraft position and velocity, and to provide steering commands for required changes of course. Here, a review is given of current techniques for solving the guidance problem emphasizing those methods which are consistent with the explicit and unified philosophy of design.

AG105/4 **Inertial Measuring Units and Pulse Torquing.** J.E.MILLER.
AGARDograph 105, 189-230, 3 refs., 1966.
Covers in detail the mechanization of the inertial sensor equipment of the "Apollo" guidance and control system, under the headings: "Apollo" inertial measurement units; pulsed integrating pendulous accelerometer (PIPA); coupling data unit (CDU).

AG105/5 **Optical Measurements and Navigation Phenomena.** D.A.KOSO.
AGARDograph 105, 231-262, 5 refs., 1966.
On-board measurements are considered which can be used to determine the orbit of a satellite. The subjects covered are navigation in orbit, midcourse navigation, and the "Apollo" optical unit. The latter consists of a sextant, an automatic star tracker and photometer, and a scanning telescope. The scanning telescope is used for known landmark bearing measurements, and the other two instruments are used in the orbital part of the mission.

AG105/6 **Guidance Computer Design.** A.HOPKINS.
AGARDograph 105, 263-325, 13 refs., 1966.
Provides a background and specific techniques in the mechanization of the on-board digital computers. Application to the "Apollo" mission illustrates several problems of interest such as the methods for providing reasonable and straightforward astronaut data input and readout.

AG105/7 **Space Vehicle Control Systems.** W.E.VANDER VELDE.
AGARDograph 105, 327-370, 7 refs., 1966.
Concerns the specific problems and solution of vehicle attitude control under conditions both of rocket-powered flight and the free-fall coast conditions. The "Apollo" mission provides a diversity of examples of this area of technology in the control schemes of the command and service module, the lunar landing vehicle, and the Earth entry configuration.

AG106 **Some Effects of Raised Intrapulmonary Pressure in Man.** J.ERNSTING.
AD-647-419 AGARDograph 106, 343 pp., 289 refs., 1966.
N67-18403 Positive pressure breathing with oxygen is a means whereby an acceptable arterial oxygen tension may be maintained at altitudes in excess of 40,000 ft. The nature of the disturbances induced by raising the intrapulmonary pressure by between 30 and 140 mm Hg forms the subject of this monograph. Chapters are denoted to: experimental methods; limitations of various techniques of delivering gas under pressure to the respiratory tract; the mechanics of respiration during pressure breathing and the effects of chest and trunk counterpressure; pulmonary gas, exchange in pressure breathing; the cardiovascular effects of high pressure breathing; general summary and conclusions.

AG107 **Problems of Vision in Low Level Flight.** (In English and French.) A.MERCIER, G.PERDRIEL,
AD-661-164 T.C.D.WHITESIDE.
N68-13496 AGARDograph 107, 77 pp., 26 refs., 1967.
The problem areas considered fall into four main categories: (i) the external environment; (ii) man's response to his environment; (iii) human engineering considerations as a result of man's limitations; (iv) selection and training for the task of low-level flying.

AG108 **Combustibles, Lubrifiants et Fluides Auxiliaires pour Aviation Supersonique et Hypersonique.**
AD-709-166 G.J.SOUILLARD, J.DUCARME, TH. DE MENTEN DE HORNE.
N70-39638 AGARDograph 108, June 1970.
Rappel des problèmes relatifs aux combustibles, lubrifiants et fluides de transmission hydraulique utilisés dans l'aviation, posés par les exigences sévères du vol à grande vitesse (supersonique). Les réacteurs à performances élevées nécessaires au vol supersonique impliquent l'utilisation de combustibles convenablement choisis et traités, qui doivent en outre pouvoir servir de moyen de refroidissement de la machine ou du véhicule soumis à l'échauffement cinétique, d'introduction des combustibles liquides cryogéniques, tels que l'hydrogène ou le méthane, pose des problèmes particuliers, mais implique également des caractéristiques qui présentent un grand intérêt pour les avions supersoniques et hypersoniques. De plus, des produits très réactifs, tels que plusieurs composés de bore ou d'aluminium, peuvent servir d'initiateurs ou de stabilisateurs de combustion dans les écoulements à très grande vitesse. L'accroissement des performances des turboréacteurs conduit à l'augmentation de la température des gaz, limitée par la résistance thermique des matériaux utilisés, et l'élévation des rapports de pression des compresseurs, entraînant une augmentation globale de la température de la machine, rend plus difficile la lubrification des roulements de manière correcte. Les fluides hydrauliques sont souvent soumis à des contraintes thermiques sévères.

AG109 **Supersonic Wind Tunnel Wall Corrections.** H.C.GARNER (Editor).
AD-657-092 AGARDograph 109, 465 pp., 1966.
N67-34612 This is one of a series of publications sponsored by the NATO-AGARD Fluid Dynamics Panel. It is presented in seven chapters in which the theoretical background is reviewed, and modern developments in the formulation, calculation and application of interference corrections are discussed. Abstracts of the individual chapters are given in the subsequent items.

AG109/1 **Status of Interference Effects.** H.C.GARNER.
AGARDograph 109, pp. 1-20, 57 refs., 1966.
A general review is given of recent literature and also of the other chapters in this AGARDograph dealing with the types of interference on wings, bluff bodies and high lift systems, and the effects occurring in closed-, open-, and ventilated-tunnels. Recommendations are made for future research.

AG109/2 **Lift Interference on Two-Dimensional Wings.** H.C.GARNER.
AGARDograph 109, pp. 21-74, 37 refs., 1966.
After an introduction to the subject, wings of zero thickness and those of finite thickness are considered when tested in closed tunnels. Problems of interference on aerofoils with hinged flaps are treated either by means of linearized equations or by a nonlinear theory for incompressible flow. The boundary conditions, two-dimensional tests and spillage behind the model are considered for open-jet tunnels. Finally the viscous effects and experimental approaches to the problem of two-dimensional wall corrections, and the conclusions that may be drawn are discussed.

AG109/3 **Lift Interference on Three-Dimensional Wings.** H.C.GARNER.
AGARDograph 109, pp. 75-217, 80 refs., 1966.
This is a theoretical consideration of, small wings in closed and open tunnels, the general theory of lift interference, evaluation of interference parameters, numerical interference corrections, special configurations such as slender wings and wing-body-tail configurations, and experimental aspects of high lift and open and closed tunnels. Attention is drawn to the section which serves as an index to the more important equations, tables and figures.

AG109/4 **Interference Effects in Unsteady Experiments.** W.E.A.ACUM.
AGARDograph 109, pp. 219-278, 52 refs., 1966.
Concerns the calculation of wings performing oscillations sinusoidal in time. Two-dimensional wings are treated for compressible and incompressible flow, and a general theory is given for three-dimensional wings and applied for closed tunnels. Transonic flow problems are treated for ventilated tunnels having perforated or slotted walls. While the main part of the paper is concerned with the foregoing some information is also given on steadily rotating models such as propellers and slowly rolling wings. Applications to common experimental situations are included.

AG109/5 **Blockage Effects in Closed or Open Tunnels.** E.W.E.ROGERS.
AGARDograph 109, pp. 279-340, 70 refs., 1966.
The interference effect associated with the fact that the model and its wake occupy a certain volume within the finite tunnel stream is described and analyzed. Situations considered are blockage factors in closed and open tunnels. Also considered are the estimation of blockage from wall measurements, blockage corrections at very high subsonic speeds in closed tunnels, and the use of blockage factors in correcting measured quantities. The principle blockage formulae is summarized.

AG109/6 **Wall Interference in Tunnels with Ventilated Walls.** E.W.E.ROGERS.
AGARDograph 109, pp. 341-429, 73 refs., 1966.
Two- and three-dimensional blockage and lift interference are considered for tunnels with longitudinal slots and those with perforated walls. The ways in which blockage and lift interference may be used to correct the measured quantities are discussed together with application of these correction factors.

AG109/7 **Bluff Bodies and High-Lift Systems.** E.C.MASKELL.
AGARDograph 109, pp. 431-465, 29 refs., 1966.
Considers the blockage effects on bluff bodies; lifting wings with separated flow including stalled wings, wings with hinged or split flaps, and slender wings with leading edge vortices; V/STOL configurations including lifting rotors, jet flaps in closed tunnels, and the more general V/STOL configurations which must be expected to require representation by mathematical models incorporating more than one wake or slipstream.

AG110
AD-665-234
N68-17574

Electroencephalography in Aerospace Medicine. P.M. van WULFFTEN PALTHE (Editor).
AGARDograph 110, 193 pp., 1967.
The increasing use and importance of electroencephalography in aerospace medicine prompted the AGARD Aerospace Medical Panel to sponsor the compilation of this AGARDograph. Twelve papers are presented in four sections headed: generalities; electroencephalography of large populations of functionaries and aspirants in civil and military organisations; screening and selection; some special problems. Abstracts of the individual papers are given in the succeeding items.

AG110/1

The Use of the Electroencephalogram (EEG) in Aviation Medicine. P.J.O'CONNOR.
AGARDograph 110, 1-12, 1967.
It is suggested that the correct use of the EEG in aviation medicine is to make a routine recording on all aviation candidates when they join the Service and to repeat the record whenever there are symptoms which suggest disturbance of brain function. Three major reasons justifying this routine tracing procedure are put forward. The various types of disturbances of consciousness which are met with in aviation medicine are described.

AG110/2

The Use and Abuse of the EEG in Aircrew Selection. J.W.SCOTT.
AGARDograph 110, 13-23, 14 refs., 1967.
The main uses of the EEG in evaluating aircrew are discussed; these include the screening of all men accepted for training as pilots; monitoring cerebral insufficiency produced by various physiological stresses; clinical assessment of pilots being returned to duty following illnesses and injuries involving the nervous system.

AG110/3

The Use and Abuse of Electroencephalography in Clinical Medicine. W.B.MATTHEWS.
AGARDograph 110, 25-32, 2 refs., 1967.
Abuses in the use of EEG are first discussed. Questions commonly asked of the EEG and the extent to which they can be answered are then considered. These questions include: is the patient an epileptic, why has the patient had epileptic fits; what type of fit is the patient having; is the patient's epilepsy improving; is the patient suitable for temporal lobectomy; is there an intracranial space-occupying lesion; is the patient insane?

AG110/4

Meaning and Value of Electroencephalography in Aeronautical Medicine. C.BLANC, E.LAFONTAINE, R.LAPLANE.
AGARDograph 110, 33-61, 25 refs., 1967.
The principal results are described of ten years experience covering 8,000 electroencephalographic recordings made on subjects belonging to the Air France Cabin Staff. The criteria of the conventional EEG tracings were analysed by the use of a longitudinal classification distinguishing the "evolutive tracings" and the "stationary tracings". Certain electrical patterns observed on recruitment tracings, seem to have an anticipatory value, a predictive significance necessitating an exploration of the personality by a psychiatric examination.

AG110/5

Principles and Methods of Application of Electroencephalography in Aviation Medicine. C.BLANC, E.LAFONTAINE, R.LAPLANE.
AGARDograph 110, 63-73, 5 refs., 1967.
10,000 EEG recordings, arranged in evolutive studies were made in Air France laboratories during the last ten years (8,000 tracings in the cabin-staff group, 950 in the pilot group, 1,050 in the ground-staff group). The subclinical EEG disturbances frequently observed in this population appear to be correlated with psychological, psychiatric or psychophysiological factors in a great number of the longitudinal observations; they do not seem to be linked to potential epilepsies, as had been initially supposed.

AG110/6

Electroencephalographic Examination in the Context of the Assessment of Aptitude of Flying Personnel. (In French). A.J.M.RABOUTET, G.SOUSSEN.
AGARDograph 110, 75-91, 8 refs., 1967.
Over 6,700 EEGs have been carried out at the Paris Medical Examination Centre for Flying Personnel in the last 15 years. It is stressed that the EEG complements the normal medical examination procedures. The tracings obtained can be broken down into three groups: (i) usual tracings, 80%; (ii) borderline tracings, 17.5%; (iii) abnormal tracings, 2.5%: posterior theta-delta rhythms and "spike-wave" complex. Difficulties associated with group (ii) are discussed at some length.

AG110/7 **Flicker as a Helicopter Pilot Problem: Use of Photic Simulation and EEG as Screening Techniques.** L.C.JOHNSON.
AGARDograph 110, 93-109, 25 refs., 1967.
The goals of the study reported were: (i) to determine the incidence of flicker vertigo or flicker problems during actual flight operations, and (ii) to determine if any helicopter pilots in an operating squadron would reveal undue sensitivity to light as revealed by marked EEG changes or unusual subjective sensations during exposure to photic stimulation in the laboratory. A subsidiary goal was to obtain baseline resting EEG's on pilots. The methods used are described, and the results obtained are presented and discussed.

AG110/8 **The Influence of Flicker on the Level of Consciousness.** G.J.PUISTER.
AGARDograph 110, 111-121, 1 ref., 1967.
A lowering of the level of consciousness caused by flicker, as found elsewhere on the strength of subjective symptoms, could not be proved, using the Bourdon-Wiersma Stipple Test as an objective research method in a small population of young healthy subjects. The influence of hyperventilation in sensitive subjects of a comparable group could be measured objectively with the stipple test and shown in a concomitant electroencephalogram as related to fluctuations in the level of consciousness. However, an identical EEG pattern can have a different meaning.

AG110/9 **The Electroencephalogram in the Selection of Flying Personnel.** G.J.PUISTER.
AGARDograph 110, 123-133, 2 refs., 1967.
The interpretation of the different characteristics of the EEG's of experienced civil pilots, flight engineers and trainee pilots, is discussed with special reference to the alpha activity. For flight engineers, psychological analyses of the personality structure seem to indicate a correlation between the predominance of a polyrhythmic EEG and outstanding technical ability, whereas for the selection of future pilots, a polyrhythmic EEG is an unfavourable sign.

AG110/10 **Electroencephalographic Changes in Human Subjects during Blackout Produced by Positive Acceleration.** R.D.SQUIRES, R.E.JENSEN, W.C.SIPPLE, J.J.GORDON.
AGARDograph 110, 135-152, 12 refs., 1967.
A study is reported in which a series of subjects undergoing positive acceleration centrifuge runs, at a level sufficient to lower head blood pressure to a point where visual grey and blackout conditions would occur. The object was to evaluate the use of the EEG information on these subjects as an index of their level of consciousness, their depth of visual blackout and their performance capabilities under acceleration.

AG110/11 **Electroencephalography and Fluctuations in the Level of Consciousness.** P.M. van WULFFTEN PALTHE.
AGARDograph 110, 153-190, 12 refs., 1967.
Basic investigations of short duration (3 hours) were carried out at the Aero-Medical Centre at Soesterberg on 48 subjects of different ages and different occupations. Extreme conditions of isolation, obscurity, and silence were combined with a restriction on mobility and a complete absence of contact with other people. In addition to the EEG, the eye movements, the electrocardiogram and respiration were recorded throughout the test. The significance of the results obtained is discussed. Research carried out in connection with flight incidents is also reported.

AG110/12 **Electroencephalographs of Aviators in Relation to Aircraft Accidents and Attrition from Flight Training.** H.W.ADES.
AGARDograph 110, 191-193, 1967.
As the full text of this paper was not available at the time of going to press, a one-page summary only is presented, first in English and then in French. It is reported that baseline EEG's have been taken on more than 7,500 student naval aviators over a period of five years. So far, 352 of these aviators have been involved in 578 aircraft accidents and a much larger number eliminated from flight training for reasons which fall into eight major and several minor categories. Comparison of EEG's among these groups reveals several correlations which appear to be related to cerebral physiology.

AG111 **Thermal Problems in Aerospace Medicine.** J.D.HARDY (Editor).
AD-851-744 AGARDograph 111, 254 pp., many refs., 1968.
N69-25051 This volume presents the proceedings of two conferences of AGARD Aerospace Medical Panel held in Lisbon (1964) and Furstenfeldbruck (1965). The papers are divided into three sections "Intense Heat and Thermal Radiation" and "Effects of Laser and Microwave Radiation" and "Exposure of Humans to Hot and Cold Water". It contains 18 papers and a subject and author index. The papers are dealt with individually in the following abstracts.

AG111/1/1 **Cardiovascular Effects of Brief Intense Thermal Pulses in Man.** R.H.MURRAY.
AGARDograph 111, Chapter 1-1, pp. 3-12, 7 refs., 1968.
Six clothed human subjects were exposed to brief, intense heat stresses, wall temperatures rising 28°C/min. to peaks of 150°C or 205°C with subsequent passive cooling for a total time of twenty minutes. Measurements of heat rate etc. indicated severe strain of cardiovascular compensatory mechanisms and it is suggested that these stresses approached human tolerance limits.

AG111/1/2 **Skin Temperature Changes caused by Intense Diffuse Thermal Radiation.** W.C.KAUFMAN.
AGARDograph 111, Chapter 1-2, pp. 13-20, 15 refs., 1968.
Describes experiments on pilots to simulate exposure to the heat pulse from an atomic or nuclear weapon in which they were subjected to a simulated 1 megaton pulse with total energy of 2.5 cal/sq.cm. Although this energy was somewhat lower than that which was later proved to be the limit of the subjects performance it was still sufficient to sear the flight gloves and to cause dark-coloured objects to smoke. Aircrew members are partly protected by the windshield and helmetvisor which themselves may be damaged by thermal radiation.

AG111/1/3 **Effects on the Organism of Extreme Increase in Radiant Temperature.** (In French). J.COLIN, Y.HOUDAS.
AGARDograph 111, Chapter 1-3, pp. 21-30, 17 refs., 1968.
Weight changes and temperatures were recorded on human nude subjects during an extreme variation of the ambient temperature. Results show the sweating in subjects not adapted to hot climates, takes place after a certain delay, and the role of the central thermoreceptors seems preponderant in this release mechanism. Subjects already adapted to heat, sweating is almost immediate, and the role of the cutaneous thermoreceptors appear to be the most important, the central thermoreceptors intervening in a solely complementary manner. The different experimental modes used, a radiant temperature rise alone or an increase of both convective and radiant temperatures, do not appear to affect the response sequences.

AG111/1/4 **Skin and Subcutaneous Temperature Changes during Exposure to Intense Thermal Radiation.** J.A.J.STOLWIJK, J.D.HARDY.
AGARDograph 111, Chapter 1-4, pp. 31-45, 12 refs., 1968.
Several volunteers were subjected to intense thermal radiation by means of a timed shutter in front of 8 quartz lamps. The apparatus used and the instrumentation is described in detail and the results of filtering the source are described. By filtering out the green, blue and yellow portions of the visible spectrum and the infrared radiation longer than 1.8μ, a marked degree of protection can be obtained.

AG111/1/5 **Thermal Radiation.** C.R.UNDERWOOD, E.J.WARD, O.G.EDHOLM.
AGARDograph 111, Chapter 1-5, pp. 47-55, 11 refs., 1968.
Describes experiments on the heat exchange of man out-of-doors in the desert of Aden. In addition to total radiant exchange, the proportion of the surface area of man exposed to direct solar radiation has been investigated, for the shortwave energy from the sun has effects on the skin apart from heating.

AG111/1/6 **Thermal Radiation in the Investigation of Cutaneous Vasomotor and Sudomotor Control.** D.McK.KERSLAKE.
AGARDograph 111, Chapter 1-6, pp. 57-69, 34 refs., 1968.
Thermal radiation has proved to be a particularly useful form of stimulus for studying the effects of thermal stimulation of one skin region on the blood flow and sweat production of another. The properties of radiant stimulus greatly facilitated proof of the existence of the reflex mechanisms and investigation of their significance in body temperature regulation.

AG111/1/7 **Experimental Study of Heat Exchange Coefficients by Convection.** (In French). J.COLIN, Y.HOUDAS.
AGARDograph 111, Chapter 1-7, pp. 71-87, 18 refs., 1968.
An attempt was made to verify experimentally the coefficients of convective heat exchange previously proposed by different authors. The measurements of heat exchanges of subjects placed in a climatic coffer permitted the value of exchanges by convection to be measured, either directly by artifically suppressing the exchanges by radiation, or by keeping account of these exchanges after experimental determination of the effective radiation surface. Measurements were made of the quantity of heat lost by evaporation, metabolic heat production, and the skin temperatures of the subjects. Experiments were carried out with wall temperatures equal to the least cutaneous temperature, equal to the air temperature and a wind of 1.2m/sec., and equal to the air temperature and winds of 0.5, 0.3 and 0.2m/sec. Negative heat convection was investigated in further experiments where the air temperature was inferior to the least skin temperature. The results are compared to previous studies; the formula which responds best to the experimental data is given.

AG111/1/8 **Thermal Protection Principles.** A.M.STOLL, M.A.CHIANTA.
AGARDograph 111, Chapter 1-8, pp. 89-103, 11 refs., 1968.
This chapter is concerned with protection against intense thermal exposures productive of burns as distinguished from protection against head loss or gain due to long term environmental heat exchange. It is concluded that the basic protection is the prevention of tissue temperatures above 44°C. In convective heating limitation of heat transfer by air spaces between the protective material and the skin is an effective method. In conduction the situation is similar when the material is not limited to a single, solid layer. With a single solid layer, heat transfer can only by increasing the thickness of the insulating layer. In high intensity radiation control of the optical properties of the exposed material is required so that transmittance is reduced as far as possible.

AG111/1/9 **Responses of Man to Thermal Transients.** J.D.HARDY, J.A.J.STOLWIJK.
AGARDograph 111, Chapter 1-9, pp. 105-127, 40 refs., 1968.
Describes experiments in which young men in shorts, were exposed to a series of temperatures between the neutral level of 28°C and 48°C while maintaining low air movement and keeping the relative humidity below the level which would affect evaporative heat loss. The experimental method and instrumentation are described. Readings were obtained of ambient temperatures and relative humidity both in the rooms and the expiratory air, rectal, tympanic and skin temperatures, oxygen depletion in the expiratory air and rate of weight loss.

AG111/2/1 **Some Biological Effects of Laser Radiation.** W.T.HAMM, R.C.WILLIAMS, W.J.GEERAETS, H.A.MUELLER, R.S.RUFFIN, F.H.SCHMIDT, A.M.CLARKE.
AGARDograph 111, Chapter 2-1, pp. 131-148, 28 refs., 1968.
This paper is confined primarily to the biological effects of laser radiation on the mammalian retina but the results should be application to other organs and tissues. Instrumentation is fully described.

AG111/2/2 **Cutaneous Receptor Response to Microwave Irradiation.** E.HENDLER.
AGARDograph 111, Chapter 2-2, pp. 149-161, 16 refs., 1968.
The most obvious effect produced when microwaves are directed into an absorbing substance is the conversion of electromagnetic energy into heat. The absorption of microwave energy is directly dependent upon the electrical properties of the absorbing medium and these change as the frequency changes. The forehead was selected for a study of warmth sensation and the instrumentation and results are given in detail. A water filled skin simulant was used to determine how much of the incident energy is absorbed by the tissues.

AG111/2/3 **Some Effects of Acute and Chronic Microwave Irradiation of Mice.** A.S.HYDE, J.J.FRIEDMAN.
AGARDograph 111, Chapter 2-3, pp. 163-175, 5 refs., 1968.
This report relates exposures of different parameters of 3 and 10cm microwave radiation and the effects of such acute, reputed-acute, and chronic irradiation, upon body weight and peripheral blood hemograms of mice. Repeated acute thermogenic exposures to high dose 3cm microwaves caused severe weight loss, low doses however caused a gain in weight. The rationale of the present maximum safe exposure level of 0.01 watt/sq.cm is briefly discussed.

AG111/2/4 **Visceral Lesions Observed in Mice and Rats Exposed to Microwaves.** (In French). L.MIRO, R.LOUBIERE, A.PFISTER.
AGARDograph 111, Chapter 2-4, pp. 177-183, 1968.
An attempt was made to modulate the microwave emission so that the thermogenic effect would not raise the central temperatures of the animals more than 1°C, so that long exposure periods were possible. Using emission by pulsed modulation with a wavelength of 10cm, three groups of six animals were exposed for 19, 300 and 450 hours. Autopsies showed no effects either on looks behaviour or organs of the animals.

AG111/2/5 **Retinal Burn.** H.G.WAGNER.
AGARDograph 111, Chapter 2-5, pp. 185-188, 8 refs., 1968.
A short paper describing the effects of retinal burns from the sun, a laser pulse or a thermonuclear event. Damage from the sun is unlikely to occur accidentally due to discomfort, lid closure or squint but can occur in a determined observer. Damage is caused by excessive temperature in the tissue cells and 45°C usually causes cell death. This may be given by a high energy yielding source such as a laser from 0.2 calories/sq.cm, but with relatively cooler sources, such as the sun, the figure may be ten times this value. The effect of a burn is greatest in the fovea. Small lesions there of 300-400mu diameter will reduce visual acuity from 20/20 Snellen to 20/400 while much larger lesions a degree or so outside the fovea might be unnoticed by the subject. Such lesions tend to persist.

AG111/3/1 **A Review of Current Concepts and Practices Used to Control Body Heat Loss During Water Immersion.** E.L.BECKMAN.
AGARDograph 111, Chapter 3-1, pp. 191-209, 18 refs., 1968.
Reviews present methods of immersion protection, describes heated suits and the power systems required. It is suggested that development in protective garments for personnel who may be immersed in cold water, will be toward incorporating the unicellular neoprene foamed wetsuit with a supplemental heating system.

AG111/3/2 **Effects on Man of Immersion in Cold Water.** (In French). Y.HOUDAS, J.COLIN.
AGARDograph 111, Chapter 3-2, pp. 211-216, 11 refs., 1968.
Studies were made to determine the tolerance times for immersion in cold water as a function of temperature and the influence of dress is investigated. Body temperatures were measured and body heat losses were calculated. The value of wearing a neoprene suit over a partial pressurization garment is discussed.

AG111/3/3 **Skin Temperature and Cutaneous Pain During Warm Water Immersion.** J.D.HARDY, J.A.J.STOLWIJK, H.T.HAMMEL, D.MURGATROYD.
AGARDograph 111, Chapter 3-3, pp. 217-229, 25 refs., 1968.
The tests described in this chapter were undertaken to examine previous contradictory findings on the adaption of pain at about 45°C. Tests with hot water were done on four volunteers and the results are presented in graphical form.

AG111/3/4 **Some Aspects of Personal Cooling in Inadequately Air Conditioned Cockpits.** J.M.CLIFFORD.
AGARDograph 111, Chapter 3-4, pp. 231-242, 3 refs., 1968.
Discusses the heat problems in present cockpit and methods of cooling. Comparison is made between several air ventilated suits and a water cooled undergarment and it is suggested that a personal cooling system using both air and water cooling will probably be the most advantageous.

AG112
AD-804-362
N67-13407 **Molecular Beams for Rarefied Gasdynamic Research.** J.B.FRENCH.
AGARDograph 112, 95 pp., 124 refs., 1966.
A survey of the current state-of-the-art of molecular beam technology as it applies to rarefied gasdynamics is presented, together with enough background material to illustrate the main requirements imposed on molecular beam systems in this application. A review of the reasons, methods, and directions of the developing technology is given.

AG113
AD-812-896
N67-23241 **Free-Flight Testing in High-Speed Wind Tunnels.** B.DAYMAN, Jr.
AGARDograph 113, 87 pp., 64 refs., 1966.
The adaptation of free-flight techniques to testing in a conventional wind tunnel was made operational recently at the Jet-Propulsion Laboratory, C.I.T. This AGARDograph describes the technique in sufficient detail for it to be applied to other facilities with the minimum amount of development. Examples and results of many applications are included in order to demonstrate the need for, and advantages of, using this free-flight technique.

AG114
AD-851-745
N69-25082 **Application of Microelectronics to Aerospace Equipment.** E.KEONJIAN, R.C.DAVY (Editors).
AGARDograph 114, AGARD Lecture Series 22, 405 pp., many refs., 1968.
This volume presents the papers of the 22nd AGARD Lecture Series of the same title arranged by the Avionics Panel of AGARD in 1966. It contains a subject, originator and author index. The 13 chapters deal with separate aspects of microminiaturisation and are dealt with individually in the following abstracts.

AG114/1 **Criteria for Avionics Systems Realization.** A.J.STANZIANO.
AGARDograph 114, Chapter 1, pp. 5-18, 1968.
This paper discusses the factors influencing military operational requirements, mainly from the point of view of a U.S. Navy officer. The parts played by the Preliminary Feasibility Determination, Systems Design and Integration are described and the effects of military effectiveness and cost are discussed. The importance of maintenance and component failure are emphasised and the need for "Reliability Engineering" stressed. Typical examples are used to show that with modern methods, equipment of greatly increased complexity can be constructed and used with reduced cost, size and maintenance.

AG114/2 **Technology and Economics of Microelectronics.** C.F.O'DONNELL.
AGARDograph 114, Chapter 2, pp. 19-44, 1968.
The paper discusses in detail the construction and cost of the Semiconductor Integrated Circuit (SIC), the thin film behind circuit (TFHC) and the metal oxide semiconductor field effect transistor circuit (MOS FET). Typical costs are given for commercial circuits already being sold and the factors which determine cost are discussed. Finally the author expresses the opinion that device developments promise a technical revolution in the electronics industry and that the price of survival will be the development of technical and economic competence in the management of electronic firms.

AG114/3 **Reliability Assessment of Microcircuits and Microelectronic Systems.** E.C.HALL.
AGARDograph 114, Chapter 3, pp. 45-92, 4 refs., 1968.
This chapter investigates the reliability of microcircuits components and microelectronics systems and give examples of typical failures. The investigation includes the short-term testing done by several firms and where data are available the comparison between short-term tests and operating history.

AG114/4 **Guidelines for Implementing System Requirements into Electrical Design.** W.T.RHOADES.
AGARDograph 114, Chapter 4, pp. 93-132, 5 refs., 1968.
After presenting criteria for circuit selection the tradeoffs between circuit and line propagation delays are presented and design methods are described. The design considerations for Ultra High speeds (over 200 McBit/rate) systems are discussed in detail.

AG114/5 **Guidelines and Implementation of System Requirements into Mechanical Designs for the Aerospace Environment.** J.S.STALLER.
AGARDograph 114, Chapter 5, pp. 133-211, 18 refs., 1968.
Deals primarily with data processing equipment. The various types of micropackaging now in use are discussed in detail with practical examples. It is concluded that in the future larger and longer sections of circuitry will be formed as single chips and that the major problems to be solved are lack of repeatability of use and yield of more complex functions.

AG114/6 **Failure Mechanisms in Microcircuits.** G.V.BROWNING.
AGARDograph 114, Chapter 6, pp. 213-244, 26 refs., 1968.
Examples of failure modes are presented together with results of failure mechanism studies aimed at their elimination. The need for improvement is emphasised and it is stated that radiation effects are generally a design type problem as is temperature, but that failure mechanism studies will be helpful, particularly for a gamma radiation environment.

AG114/7 **Electrical Design of a Low Cost High Maintainability General Purpose Computer with Optimum Power Speed Product.** W.T.ROADES.
AGARDograph 114, Chapter 7, pp. 245-277, 3 refs., 1968.
This chapter complements Chapter 4 by giving a specific example of how some of the theory presented there was used. The circuit selection, timing, module design, wiring rules, grounding, power distribution and clock distribution are discussed in detail.

AG114/8 **Field Experience with a Microelectronic Multimode Radar.** G.J.WIDLY.
AGARDograph 114, Chapter 8, pp. 279-295, 1 ref., 1968.
This chapter describes the design, development and flight testing of the Autonetics XR-45 radar, a lightweight multimode airborne system constructed of microelectronic building blocks. The built-in test equipment provides automatic failure warning and fault isolation. Details of the radar and the method of system design, together with the operational results are discussed.

AG114/9 **Case History of the Apollo Guidance Computer.** E.C.HALL.
AGARDograph 114, Chapter 9, pp. 297-316, 4 refs., 1968.
The computer discussed is a sub-system of the guidance and navigation system designed for the Apollo program. Two models are discussed: the first will be used in early Apollo missions, the second with increased capabilities is designed to meet the requirements of later missions. The construction techniques used are described in some detail.

AG114/10 **Three Airborne Microelectronic Equipments Under Development in the U.K.** C.FROMBERG.
AGARDograph 114, Chapter 10, pp. 317-334, 4 refs., 1968.
To encourage the use of microelectronics in aircraft, orders were placed for the redesign of standard operational units used in both civil and military roles. Thus the I.L.S. marker beacon receiver and the S.S.R. transporter (military I.F.F.) were both microminituarised using either integrated or thin film circuits. The design problems are discussed and the integrated circuit receiver is described in some detail.

AG114/11 **Microelectronics in the United Kingdom.** S.FORTE.
AGARDograph 114, Chapter 11, pp. 335-350, 1968.
It is stated that three purely British firms are seriously engaged in the manufacture and marketing of integrated circuits and despite few military orders, have invested heavily in new production facilities and research. Examples of the equipment produced by thin film and integrated circuit techniques are discussed.

AG114/12 **Microelectronic Applications and Trends in France.** (In French). J.BERTRAIS.
AGARDograph 114, Chapter 12, pp. 351-385, 1968.
Studies made in France in the field of microelectronics are summarized, including integrated circuit technology and thin magnetic film developments. Applications include a distress beacon and a small computer with integrated circuits and a thin magnetic film memory. A new logic family CMCTL (Current Mode Complementary Transistors Logic) is discussed as to its electrical and logical advantages. Metal oxide semiconductor circuits are also considered.

AG114/13 **Production, Development and Research in Integrated Circuits in Germany.** C.R.FRITZSCHE.
AGARDograph 114, Chapter 13, pp. 387-392, 3 refs., 1968.
Special applications are discussed and it is stated that production and development of integrated circuits in Germany is a little different from that in other countries as the market offers the main business in medium speed low cost and in high noise margin digital circuits as well as linear circuits for entertainment. Research however covers essentially the same areas as in other countries.

AG115 **Wind Effects on Launch Vehicles.** E.D.GEISSLER (Editor).
AD-705-460 AGARDograph 115, February 1970.
N70-29260 This monograph is a comprehensive survey, by members of the George C. Marshall Space Flight Centre, of the influence of our knowledge of wind effects on such aspects of launch vehicle design as aerodynamics, airframe structure, and guidance and control methods (introduced by data indicating the methods of statistical representation of principal wind phenomena). The results show the development of practical methods for use in all stages of design – the examples described are vehicles of the Saturn family, especially the Saturn V "moon rocket".

AG116 **Fundamental Aspects of Solid Propellant Rockets.** F.A.WILLIAMS, M.BARRERE, N.C.HUANG.
AD-701-545 AGARDograph 116, 12 Chapters, 791 pp., many refs., 1969.
N70-24426 This volume forms a complete textbook on solid propellant rockets. The earlier chapters deal with the uses of solid fuel motors, the theoretical basis and methods of control. These are followed by the experimental approach and the theory of such aspects as ignition and burning and mechanical loads. Finally the future of solid propellants is discussed.

AG117 **Behaviour of Supercritical Nozzles Under Three-Dimensional Oscillatory Conditions.** L.CROCCO,
AD-672-435 W.A.SIRIGNANO.
N68-28848 AGARDograph 117, 149 pp., 12 refs., 1967.
A linearized treatment of three-dimensional oscillatory flow in supercritical nozzles is presented. The variables describing the transverse dependencies of the flow properties are governed by well known differential equations, but the differential equations for the axial dependencies must be solved numerically. The nozzle admittance coefficients are related to the axial dependencies and their calculation is the most important part of this research effort. The calculations for conical nozzles are presented in tables and their use in typical problems is demonstrated.

AG118 **Fluid Control – Components and Systems.** S.Y.LEE (Editor).
AD-851-746 AGARDograph 118, AGARD Lecture Series 23, 357 pp., many refs., 1968.
N69-25033 This volume presents the papers given in Europe during the summer of 1966 at a series of lectures sponsored by the Guidance and Control Panel of AGARD. The papers, 10 in all, cover a wide field from fluid suspension and damping to the newer branches such as pneumatic servo systems, air cushion vehicles, fluid power amplifiers and bi-state switches. The papers are dealt with individually in the following abstracts.

AG118/1 **Fluid Suspension, Damping and Signal Pickoff Techniques with Applications to Rate and Acceleration Sensors.** H.H.RICHARDSON.
AGARDograph 118, Chapter 1, pp. 1-64, 21 refs., 1968.
For the measurement of mechanical variations such as acceleration and angular rate the use of fluids (particularly gases) offers many advantages. Methods of performing the vital functions of element suspension, damping and signal pickoff are described and illustrated by three types of sensors. The design of pressurised bearings, damping devices and read-out elements is discussed in some detail.

AG118/2 **A Differential Pulse – Length Modulated Pneumatic Servo Utilizing Floating Flapper Disc Switching Valves.** S.R.GOLDSTEIN, H.H.RICHARDSON.
AGARDograph 118, Chapter 2, pp. 65-92, 5 refs., 1968.
This chapter describes a novel approach to gas servo design in which a floating flapper disc is used for modulation and valving. System performance is discussed and a prototype system described.

AG118/3 **Design Optimization of a Multimode Hydraulic Vehicle Suspension System.** Y.T.LI.
AGARDograph 118, Chapter 3, pp. 93-130, 1968.
Discusses the characteristics and desirable functions of a vehicle suspension system. Fluid powered semi-active and active suspension are discussed and analogue simulation and experimental results are presented.

AG118/4 **Stability and Control of an Air Cushion High Speed Ground Vehicle.** F.L.GIRAUD.
AGARDograph 118, Chapter 4, pp. 131-162, 1968.
This chapter deals with the problems of suspension and guidance of a high speed guided vehicle. It is pointed out that new conditions arise in guiding a ground cushion vehicle along a track and offers a mathematical treatment.

AG118/5 **Pure Fluid Amplifying and Logic Elements.** S.Y.LEE.
AGARDograph 118, Chapter 5, pp. 163-209, 26 refs., 1968.
Qualitative and quantitative discussions of the working principles and characteristics of various fluid amplifying logic and conversion elements are presented. Important circuits and control systems particularly suitable for each type of element are presented and their future potential discussed.

AG118/6 **A Brief Survey of Fluidics in the U.K. and some Comments on Problems Encountered in Developing Fluidic Circuits.** K.FOSTER.
AGARDograph 118, Chapter 6, pp. 211-234, 13 refs., 1968.
Contains an overall survey of work on fluidics in U.K. including digital and proportional systems, large scale and small scale elements. Research on sequence and digital control systems for machine tool control is included. The larger part of this chapter is a discussion of digital elements and systems.

AG118/7 **Small Signal Analysis of Vortex Amplifiers.** L.B.TAPLIN.
AGARDograph 118, Chapter 7, pp. 235-295, 29 refs., 1968.
This paper delineates various types of vortex valves and amplifiers and describes their operation and use as single element amplifiers. An idealized mathematical model is used to describe quantitive effects of vortex parameter changes. A network approach to circuit analysis is presented and some representative circuits and experimental work are described.

AG118/8 **Fluidic Safety and Sequencing Systems.** R.J.REILLY.
AGARDograph 118, Chapter 8, pp. 297-310, 2 refs., 1968.
This chapter describes a variety of fluidic devices suitable for the sequencing and monitoring of machinery in dangerous areas. These include visual indicators sensors and output devices. They are described and some circuits which have been used for sequencing and compressors in the gas pipeline industry are discussed.

AG118/9 **Rate and Attitude Stabilization for Aircraft and Missiles.** R.J.REILLY.
AGARDograph 118, Chapter 9, pp. 311-338, 1968.
This chapter describes three fluidic control systems which have been flight tested on a Cessna 310, a McDonnel F-101, and a small test missile.

AG118/10 **Fluidic Gas Turbine Control.** R.J.REILLY.
AGARDograph 118, Chapter 10, pp. 339-349, 3 refs., 1968.
This chapter was adapted from "All Fluid Devices and their Applications to Gas Turbine Controls", Society of Automotive Engineers Paper No. 650504. A closed loop control designed and tested for a General Electric J-85 gas turbine is described. In particular a fluidic temperature sensor operating in the 2000°F range and two shaft speed sensing devices are described in detail.

AG119
AD-668-251
N68-19195 **Thermo-Molecular Pressure Effects in Tubes and at Orifices.** M.KINSLOW, G.D.ARNEY, Jr.
AGARDograph 119, 57 pp., 22 refs., 1967.
An investigation of the errors arising from thermal non-equilibrium in systems measuring gas pressures is presented. The errors are attributed to a phenomenon referred to as thermo-molecular pressure. This effect is investigated theoretically and experimentally at sensing orifices and in tubes. A thorough review of the literature is included. Results of heat transfer measurements in the transition flow regime between flat plates are presented as a basic for correlating the orifice data.

AG120
AD-701-115
N70-19902

Supersonic Turbo-Jet Propulsion Systems and Components. J.CHAUVIN (Editor).
AGARDograph 120, Lecture Series 25, 8 Chapters, 474 pp., many refs., 1969.
This volume records the lectures and discussions at the 25th Lecture Series held at Varenna, Italy in 1967 under the sponsorship of the Propulsion and Energetics Panel of AGARD. It deals with the problems of air breathing gas turbines and in particular with the design of supersonic compressors and turbines, supersonic burning and exhaust nozzles. Fluidic control of the turbine, future problems and the airframe are then discussed. Eight lectures are recorded and these are dealt with separately in the following abstracts.

AG120/1

Introduction to Lectures on Supersonic Turbomachinery. E.G.JOHNSON.
AGARDograph 120, Chapter 1, pp. 5-24. 19 refs., 1969.
Significant innovations and performance trends for supersonic turbomachinery are reviewed after a short historical survey.

AG120/2

Supersonic Inlets. R.HURD.
AGARDograph 120, Chapter 2, pp. 25-58, 10 refs., 1969.
The problems of the supersonic inlet are reviewed and the main parameters required to describe its performance are set down. The matching of the inlet to the engine and of its integration to the airframe are then discussed.

AG120/3

Supersonic Compressors. J.CHAUVIN, F.BREUGELMANS, A.JANIGRO.
AGARDograph 120, Chapter 3, pp. 59-178, 75 refs., 1969.
After a brief historical survey the recent progress in axial flow supersonic compressors is reviewed on the basis of cascade, motor and stage results. Some experimental results are presented and supersonic radial compressors are reviewed. Future developments and the areas for research are then discussed.

AG120/4

Supersonic Combustion Technology. A.FERRI.
AGARDograph 120, Chapter 4, pp. 179-240, 38 refs., 1969.
The performance of a supersonic burning ramjet, here called scramjet, is discussed and it is shown to be superior to a normal ramjet at hypersonic speeds. Problems related to practical development are reviewed and the difficulty of testing at Mach numbers above 10-12 is indicated. The combustion process is discussed in detail and a simple mathematical model representing the interaction between the combustion process and the flow field is offered.

AG120/5

Air-Cooling of Turbine Blades and Vanes. G.A.HALLS.
AGARDograph 120, Chapter 5, pp. 241-285, 6 refs., 1969.
The advantages of high entry temperatures are briefly reviewed to establish the case for blade cooling. The blade design problems and transient operation are then discussed.

AG120/6

Exhaust Nozzles. P.CARRIERE.
AGARDograph 120, Chapter 6, pp. 287-378, 23 refs., 1969.
The behaviour of a de Laval nozzle is examined and the parameters controlling flow rate are analyzed. The present methods of computing wall temperatures are presented and discussed. The problems of practical applications of nozzles are set down and finally some examples of non-classical nozzles are discussed in relation to that of de Laval.

AG120/7

A Survey of Fluidic Components and their Application to Gas Turbine Control. R.J.REILLY.
AGARDograph 120, Chapter 7, pp. 379-439, 15 refs., 1969.
This chapter deals with fluid control devices in relation to the control of gas turbines. It surveys various fluidic devices, discusses the significant design parameters of beam deflection amplifiers and shows how these have been used.

AG120/9

Interface Problems of High Speed Air-Breathing Airplane Engines. A.A.FEJER.
AGARDograph 120, Chapter 9, pp. 447-470, 24 refs., 1969.
Air-breathing engines for the propulsion of long range supersonic transports at speeds up to M = 4 are considered in relation to the airplane mission and the engine. A procedure is outlined for matching to give efficient operating conditions. Problems due to transient phenomena at the interface between engine components are indicated.

AG121
AD-669-227
N68-23768

Techniques for Measurements of Dynamic Stability Derivatives in Ground Test Facilities.
C.J.SCHUELER, L.K.WARD, A.E.HODAPP.
AGARDograph 121, 209 pp., 432 refs., 1967.
Techniques for measuring dynamic stability derivatives in wind tunnels are described with emphasis on balance system design, data reduction methods, instrumentation and typical balance systems. The use of gas bearings for dynamic stability and roll damping balances is treated and a three-degree-of-freedom balance system employing a spherical gas bearing is described.

AG122
AD-683-361
N69-18349

Selected Topics in Electrofluid Dynamic Energy Conversion. M.LAWSON, F.WATTENDORF (Editors).
AGARDograph 122, 264 pp., many references and bibliography, 1968.
This AGARDograph is based largely on presentation of EFD research or related research being conducted in each NATO nation represented at the Electrofluid Dynamic "Workshop" Conference which was held at the Aerospace Research Laboratories, Wright-Patterson Air Force Base, Ohio, 23-25 May 1966; subsequently, many of the papers were updated at an editorial conference held at AGARD, Paris, 30-31 October 1967, while others still later, were updated by correspondence. Electrofluid dynamic (EFD) energy conversion processes have only in recent years received renewed interests as an area of research. EFD processes are of particular interest for directly converting fluid dynamic energy into electrical energy without the use of moving parts. The 12 papers included in this volume are dealt with individually in the following abstracts. In addition a bibliography of 107 entries is included.

AG122/1

The Role of Electrofluid Dynamics in the Field of Direct Energy Conversion. H.P.von OHAIN.
AGARDograph 122, Paper 1, pp. 4-12, 1968.
An introductory paper. Although relatively unexplored among the many direct energy conversion processes, electrofluid dynamics (EFD) promises performance characteristics complementary to other processes in the overall energy conversion spectrum. The high potential, low current density electrical power of EFD devices is said to have several natural applications. It is suggested that virtually unlimited applications possibilities will open up with the development of compact, inexpensive power conditioning apparatus.

AG122/2

Electrofluid Dynamic Energy Conversion Processes Characteristics and Research Areas. M.O.LAWSON.
AGARDograph 122, Paper 2, pp. 14-32, 4 refs., 1968.
The paper discusses the major characteristics of EFD generators and points out that as they are quite different from other direct energy conversion generators they promise an important class complementary to other generators. Theoretical analysis is reviewed and it is said that experimental work gives some faith in the theoretically predicted trends and relationship. More exact analyses are said to be needed and experimental work is stated to be in an early state.

AG122/3/1

Effects of Electrode Geometry Similarity and Scaling Laws in EFD Energy Conversion Processes. Part I Fundamental Considerations. J.A.DECAIRE.
AGARDograph 122, Paper 3, Part I, pp. 34-62, 15 refs., 1968.
This paper reviews the fundamental physical and theoretical considerations of viscous EFD energy conversion processes and outlines the special two-fluid, two-loop cycles being considered. A detailed description of the experimental generator and associated unipolar charge generation process (a corona discharge) is included. Experimental data is presented in Part II.

AG122/3/2

Effects of Electrode Geometry Similarity and Scaling Laws in EFD Energy Conversion Processes. Part II Experimental Results. J.R.WIFALL.
AGARDograph 122, Paper 3, Part II, pp. 63-95, 1968.
The results of tests on the rig described in Part I are presented. The ion currents generated with a sharp needle electrode increases linearly with increasing primary air pressure level up to about 40 atmospheres. Charged aerosol currents produced by condensation of water vapour around ions vary linearly with the inlet total pressure levels up to about 30 atmospheres. Further tests will investigate the high pressure aerosol current production.

AG122/4

Working Media for Electrofluid Dynamic Generators. M.HAWES.
AGARDograph 122, Paper 4, pp. 96-123, 18 refs., 1968.
Desirable characteristics of electrofluid dynamic working media with regard to power generation are reviewed. The dimensionless numbers of interest for power density and stage efficiency are cited. Special mixtures of gases were investigated and the results are compared with those from high pressure air.

AG122/5

Some Analytical Treatments of EFD Processes. J.E.MINARDI.
AGARDograph 122, Paper 5, pp. 124-179, 8 refs., 1968.
An approximate, analytic solution to the charge cloud growth in an assymmetric electrofluid dynamic (EFD) generator is presented and a computer program is used to calculate the efficiency and power density over a wide range of parameters.

AG122/6

Some Remarks on EFD Energy Conversion. J.P.CONTZEN.
AGARDograph 122, Paper 6, pp. 180-185, 2 refs., 1968.
Some of the work carried out in Belgium in the field of fluid dynamics associated with electric or magnetic effects is reviewed. The paper also gives some suggestions on possible applications of the EFD energy conversion process.

AG122/7 **Design and Construction of a 3-MW Magnetogasdynamic Power Generation Facility at the University of Toronto Institute of Aerospace Studies.** S.J.TOWNSEND.
AGARDograph 122, Paper 7, pp. 188-202, 1968.
The design features of a 3-MW, blow-down plasma facility are described. The primary aim has been to construct a research facility having a large interaction channel to emphasise volume rather than surface effects. First runs are expected in the summer of 1968.

AG122/8 **Plasma Research in Denmark.** K.REFSLUND.
AGARDograph 122, Paper 8, p. 203, 1968.
A very short paper listing advanced plasma research in Denmark.

AG122/9 **Comments on Electrofluid Dynamics and Related Research in France.**
AGARDograph 122, Paper 9, pp. 206-209, 1968.
In France various laboratories are working on plasmadynamics but the research is more of the magnetofluid dynamic type. Although the field of electrofluid dynamics is little developed, its potentialities seem very promising in particular for space applications. Two French laboratories are working in the field of ion propulsion and this work is briefly described.

AG122/10 **The Electrofluid Dynamic Energy Converter with Spacecharge Neutralization.** E.KNOERNSCHILD, P.A.SCHOECK.
AGARDograph 122, Paper 10, pp. 210-232, 1968.
A device is described which, it is claimed, would eliminate the biggest disadvantage of the EFD converter, namely its operation at very high voltage. The proposal is to eliminate the space charge as in the Hall accelerator. After a short review of the various types of EFD energy converters the basic difference between the space charge limited and space charge neutralized operation is pointed out. Test results which prove that space charge neutralization is possible, are presented.

AG122/11 **Comments on Electrofluid Dynamics and Related Researches in Italy.** L.G.NAPOLITANO.
AGARDograph 122, Paper 11, pp. 234-243, 3 refs., 1968.
Although there is little research in electrofluid dynamics in Italy, there is growing interest. The paper discusses the field and describes the approach of general studies that he and his group are doing.

AG122/12 **Interest and Progress in Electrofluid Dynamics and Related Researches in England.** R.G.VOYSEY.
AGARDograph 122, Paper 12, pp. 244-252, 1968.
In the United Kingdom there has been a small sustained interest in electrofluid dynamics over a long period of time, but the main effort has been on plasma research and MHD. Activities in these fields are briefly reviewed.

AG123 **Space Power Systems. Parts I and II.**
Part I – AD-698-652 N70-16217
Part II – AD-698-653 N70-16222
AGARDograph 123, Parts I and II, 646 pp., many refs., 1969.
Records the papers given at Lecture Series 27 sponsored by the Propulsion and Energetics Panel and the Consultant and Exchange Programme of AGARD. It was held at the Universite Libre de Bruxelles, Belgium from 2 to 6 October 1967. The course surveys the power requirements for space vehicles, discusses the difficulties of environment and then deals in detail with power systems both those in use and projected. The chapters of the two volumes are abstracted individually in the following AG123/I/I – AG123/I/IV (Part I) and AG123/II/IVB to VII (Part II).

AG123/I/I **Power Requirements: Similitudes and Limitations in Trans-Conventional Propulsion Systems.** G.S.SZEGO.
AGARDograph 123, Part I, Section I, pp. 1-19, 17 refs., 1969.
Reviews the problems of propulsion and the methods now available. It is considered that more efficient fuels than those of the chemical systems now used are required and possibilities are discussed. Finally the optimization of Specific Impulse for space vehicles is discussed.

AG123/I/II **Space Power Systems.** G.S.SZEGO.
AGARDograph 123, Part I, Section II, pp. 23-89, 102 refs., 1969.
Power systems are divided into three subsystems, an energy source or collector, a conversion system and a waste heat rejection system. Each of these is discussed in detail. Meteorite damage is considered to be of importance and the available information on frequency and size is reviewed. Radioisotope and Nuclear power supplies are described as are Solar Energy Conversion systems and Fuel Cells. Finally systems are compared in considerable detail.

AG123/I/III Nuclear Space Power Systems. H.M.DIECKAMP.
AGARDograph 123, Part I, Section III, pp. 93-302, 98 refs., 1969.
This section is divided into three chapters numbered I-III titled "Nuclear Space Power Systems", "Reactor Space Power Systems" and "Radioisotope Space Power". It is stated that for significant electrical power loads, which are required for missions in excess of several days, only solar and nuclear systems can be considered. These are considered in detail and evidence given for an appropriate choice.

AG123/I/IVA Mechanical Heat Engines for Space Power Systems. E.B.ZWICK.
AGARDograph 123, Part I, Section IVA, pp. 305-348, 11 refs., 1969.
This lecture reviews the heat engine concepts which are of significance for space applications. These are reviewed from a thermodynamic point of view to establish the basic cycle characteristics and the relative significance of various factors such as temperature and component efficiency on cycle performance. A few of these cycles in terms of the problem of optimizing a power system for use with a space vehicle.

AG123/II/IVB Turbomachinery for Space Power. E.B.ZWICK.
AGARDograph 123, Part II, Section IVB, pp. 349-369, 8 refs., 1969.
The low specific machine performance has been greatly improved and in addition new optimized turbomachinery data has been attained. Design data is now displayed on plots of specific speed against specific diameter and the use of these plots is demonstrated by the design of a 20KN Bipheryl Rankine cycle power plant. It is stated that the recent advances in design of missile and space power applications have far reaching implications for all power systems design.

AG123/II/IVC Alternators for Space Power Applications. E.B.ZWICK.
AGARDograph 123, Part II, Section IVC, pp. 371-396, 20 refs., 1969.
Reviews the basic principle of alternators, describes many of the types used and discusses the innovations imposed by space requirements of a very high temperature corrosive environment and extremely high speeds of rotation. It is stated that the new machinery which has been developed shows considerable promise for future applications in both space and terrestrial use.

AG123/II/VA Technology of Thermoelectric and Thermionic Energy Conversion. N.S.RASOR.
AGARDograph 123, Part II, Section VA, pp. 397-414, 13 refs., 1969.
Discusses the use of both the semiconductor and thermionic energy converters both of which use an electron gas as a working fluid. The basic nature of this fluid is briefly reviewed together with the associated properties important in thermoelectricity. The two systems are then compared.

AG123/II/VB Engineering Aspects of Thermionic Energy Conversion. N.S.RASOR.
AGARDograph 123, Part II, Section VB, pp. 415-441, 33 refs., 1969.
Outlines the status of thermionic converter development from the point of view of the engineer. Special attention is paid to new approaches which have arisen from change of requirements especially when viewed on an international scale The present status, and the potential impact of research in progress is illustrated by specific examples of application.

AG123/II/VI Electrochemical Space Power Sources. E.M.COHN.
AGARDograph 123, Part II, Section VI, pp. 443-501, 36 refs., 1969.
After a general discussion of electrochemical energy storage and electricity generation in (aero) space the paper presents the thermodynamic and kinetic electrochemical basis for these devices, as well as criteria for selecting electrochemically active materials and estimating densities. The following sections then consider primary and secondary equipment either now being used or of potential usefulness. These also consider possible earth-bound applications.

AG123/II/VII Photovoltaic Devices and Systems. M.RODOT, H.DASPET.
AGARDograph 123, Part II, Section VII, pp. 503-602, 66 refs., 1969.
This lecture outlines the nature of the radiation emitted by the sun and discusses solar simulators for ground tests. Solar cells are listed and described and the methods used to link them in solar panels are discussed. New developments are discussed and finally it is concluded that while Silicon cells are of proved suitability CdS cells may well be competitive.

AG123/II/App. Optimization of Energy Storage for Solar Space Power. G.C.SZEGO, B.PAIEWONSKY.
AGARDograph 123, Part II, Appendix I, pp. 605-618, 1969.
Three different concepts are stated to represent methods of conversion of solar to electrical energy; photovoltaic, photoemission and thermal. A number of simplifying assumptions are made and a method of making optimization calculations is demonstrated. It is concluded that in typical cases electrical or combined electrical-thermal energy storage can provide solar thermal space power systems of least mass.

AG124 Nonequilibrium Effects in Supersonic-Nozzle Flows. J.HALL, C.E.TREANOR.
AD-684-951 AGARDograph 124, 112 pp., 513 refs., 1967.
N69-22574 Nonequilibrium effects in supersonic-nozzle flows are discussed with emphasis on recent research results. The scope is limited to homogeneous gasphase flows and to departures from thermochemical equilibrium arising from collisional relaxation of internal degrees of freedom and chemical reaction, including ionization. Translational-rotational equilibrium is assumed. The first half of the report reviews equilibrium properties of gases at high temperatures and the various nonequilibrium rate processes of interest. The last half discusses nonequilibrium effects occurring in nozzle flow expansions. Diatomic gases and air are emphasized; complex mixtures for propulsion applications are also discussed.

AG125 Subatmospheric Decompression Sickness in Man. D.I.FRYER.
N70-25974 AGARDograph 125, 343 pp., Approx. 600 refs., 1969.
This monograph is based on a thesis submitted by the author, a member of the Royal Air Force, for the degree of Doctor of Medicine. It deals comprehensively with decompression sickness. A historical survey includes a study of the "bends" of the tunnel and caisson workers and is extended up to the present stage of knowledge of space medicine. While as yet, the causes of decompression sickness are diverse and apparently illogical this monograph provides a fair indication of the type of person liable to suffer from the malady and considerable assistance in the diagnosis. Some data on treatment and a "layman's" guide to the symptoms and its emergency treatment is included. A short subject index is included.

AG126 The Aerodynamics of V/STOL Aircraft.
AD-688-921 AGARDograph 126, Lecture Series 32, 500 pp., many refs., 1968.
N69-29645 These 8 papers were presented at a Lecture Series jointly sponsored by AGARD and the von Kármán Institute, held at the Institute, Rhode-Saint-Genese, Belgium, 13-17 May 1968. This publication contains the lecture notes for an AGARD-VKI Lecture Series. The material presented includes the following main divisions: Introduction to V/STOL Aircraft Concepts and Categories; Pure and Compound Helicopters; Basic Aerodynamics of Convertible Rotor/Propeller Aircraft; Aerodynamics of Shrouded Propellers; Turbo-Jet/Turbo-Fan Aircraft; Boundary Layer and Circulation Control for STOL Aircraft; Techniques for the Aerodynamic Testing of V/STOL Models; Flight Testing and V/STOL Handling Requirements. The 8 papers included in this volume are dealt with individually in the following abstracts.

AG126/A Introduction to V/STOL Aircraft Concepts and Categories. P.POISSON-QUINTON
AGARDograph 126, Paper A, pp. 1-49, 20 refs., 1968.
A review paper describing the present portion of Vertical Take-Off and Landing (VTOL) and Short Take-Off and Landing (STOL) aircraft. Some of the new problems are listed and the requirements discussed.

AG126/B Pure and Compound Helicopters. P.F.YAGGY.
AGARDograph 126, Paper B, pp. 51-147, 46 refs., 1968.
Traces the early history of helicopters and describes the present position. The problems and the newer concepts such as circulation control blades, compound and stopped rotor helicopters are discussed.

AG126/C Basic Aerodynamics of Convertible Rotor/Propeller Aircraft. W.Z.STEPNIEWSKI.
AGARDograph 126, Paper C, pp. 149-236, 77 refs., 1968.
Consists of four chapters each with references and with notes on recommended reading. The chapters deal with basic concepts, hovering and vertical climb, problems of forward flight and finally operation in the STOL mode of the VTOL aircraft described.

AG126/D Aerodynamics of Shrouded Propellers. M.LAZAREFF.
AGARDograph 126, Paper D, pp. 237-289, 4 refs., 1968.
This paper deals with the shrouded propeller both as a propulsive and lifting device. In propulsive flight it will allow of forward subsonic flight higher than a free propeller and in lifting flight it promises a lower fuel consumption than a turbojet. The aerodynamics are outlined and attention is directed to one of the problems – the high pitching movement when the transition from hovering to level flight is made.

AG126/F Turbo-Jet/Turbo-Fan Aircraft. J.WILLIAMS.
AGARDograph 126, Paper E, pp. 291-347, 61 refs., 1968.
The paper consists mainly of an aerodynamic analysis of relevant jet and fan lift-engines schemes in which they are divided broadly in four main groups. Light weight lift-engines, vectored thrust jet engines large lifting fans and ducted fan-propeller units. The efflux conditions for lift, transition and cruise are considered in some detail. Finally an extensive list of references divided naturally is offered for further study.

AG126/F **Boundary Layer and Circulation Control for STOL Aircraft.** F.THOMAS.
AGARDograph 126, Paper F, pp. 249-382, 39 refs., 1968.
This lecture is intended to give a survey of the most important methods of increasing lift by boundary layer and circulation control. Experimental test methods, calculation procedures and practical applications for full scale aeroplanes are described, special attention being paid to boundary layer control by blowing.

AG126/G **Techniques for the Aerodynamic Testing of V/STOL Models.** W.J.G.TREBBLE.
AGARDograph 126, Paper G, pp. 381-428, 19 refs., 1968.
In this paper attention is mainly concentrated on techniques required for lifting-jet or lifting-fan research though some mention is also made of the problems encountered with propeller driven V/STOL concepts. The need for adequate ground simulation is also considered as well as the desirability of special tunnels for V/STOL and high-lift research. The discussion is mainly based on research in U.K. but parallel developments elsewhere in Europe and U.S.A. are mentioned.

AG126/H **Flight Testing and V/STOL Handling Requirements.** P.F.YAGGY.
AGARDograph 126, Paper H, pp. 429-500, 33 refs., 1968.
This paper emphasises and discusses the use of simulators to investigate the problem and requirements for control and stability in V/STOL aircraft. Tethered and full flight tests are considered and the need for artificial stability is discussed.

AG127 **Air and Space Borne Computers.** E.KEONJIAN (Editor).
AD-711-275 AGARDograph 127, April 1970.
N70-39489 This publication contains the proceedings of the 31st Lecture Series organized by the Avionics Panel, held June 1968, at Amsterdam, Farnborough and Bologna. Specialists from leading computer companies of Western Europe and U.S.A. report on current philosophies and achievements in aerospace computer technology.

AG128 **Inertial Component Testing: Philosophy and Methods.** W.G.DENHARD (Editor).
N71-13201 AGARDograph 128, 596 pp., July 1970.
This publication contains the papers presented during a Lecture Series sponsored by the Guidance and Control Panel, and the Consultant and Exchange Program of AGARD, on Inertial Component Testing – Philosophy and Methods, held in Paris, 24-26 June 1968.

Under this overall subject of testing gyros and accelerometers, it was desired to present information not only on how to test, but also why testing should be done, and some judgement of the effectiveness of testing. Such discussion has provoked from the speakers and from the audience an interpretation of the philosophy of testing. Testing may be done for the purpose of further improvement of the instruments, and some may be done only to final-inspect a deliverable and a reliable instrument.

Discussion took place on the differences between system and component viewpoint of testing, and also on the need for being able to examine components electrically after installation in a system. This led into a discussion of the more prevalent modes of failure of components.

The Introduction by C.S.Draper (MIT) and a Summary of the final discussions are included.

AG129 **The Performance of Chemical Propellants.** I.GLASSMAN, R.F.SAWYER.
AD-705-461 AGARDograph 129. 143 pp., 50 refs., 1969.
N70-28466 Too often, extensive calculation and development tests are made in order to evaluate the performance of chemical propellants. However, reasonable analysis of the fundamental factors which govern the performance can reduce the effort. This volume represents a complete text book on the performance of chemical propellants and includes the theory of combustion, chamber and nozzle effects for solid, liquid and other propellants.

AG130 **Measurement Techniques in Heat Transfer.** E.R.G.ECKERT.
AGARDograph 130, November 1970.
This AGARDograph covers the following:

I: Measurements of Temperature;
II: Measurements of Heat Flux;
III: Measurements of Transfer Properties;
IV: Measurements of Radiative Transfer:
V: Measurements at High Temperature;
VI: Measurements by Spectroscopy;
VII: Measurements in Cryogenics;
VIII: Errors in Temperature and Heat Flux Measurements;
IX: Analogies to Heat Transfer:
X: Optical Measurement Techniques.

AG131 **Short Course on Guidance and Control for Aerospace Vehicles.**
AD-688-334 AGARDograph 131, 8 Chapters, 205 pp., many refs., 1969.
N70-27300 This volume is part of the AGARD lecture series and the objective is to show the application of modern "control theory" to the generation of guidance laws for astronautical as well as atmospheric aerospace vehicles. Time domain analysis is stressed throughout although frequency domain considerations are used when discussing instrumentation response characteristics. Particular emphasis is placed on the use of digital computers in solving these highly nonlinear problems and techniques are demonstrated for implementing and mechanizing these solutions to airborne and astronautical vehicles. The eight chapters are dealt with individually in the following abstracts.

AG131/1 **Input-Output Analysis of Linear Systems.** F.M.BROWN.
AGARDograph 131, Chapter 1, pp. 1-25, 5 refs., 1969.
The purpose of this and the following chapter is to review the language of modern control theory as it applies to linear systems and to lay the groundwork for analyzing and defining relatively complex problems of the TPBV vintage into a form amenable to computer image. This chapter deals with the Input-Output analysis.

AG131/2 **State-Space Analysis of Linear Systems.** F.M.BROWN.
AGARDograph 131, Chapter 2, pp. 28-70, 15 refs., 1969.
Continues Chapter 1 in reviewing the language and deals with the State-Space analysis.

AG131/3 **Optimization Techniques.** D.O.NORRIS.
AGARDograph 131, Chapter 3, pp. 71-79, 4 refs., 1969.
This and the following chapter introduces optimization theory and provide formulae and algorithms to produce optional controliers for so-called fixed time TPBV problems. It is pointed out that transformations can be applied to free time optimization problems translating them to fixed time equivalent forms.

AG131/4 **Theory and Application of Gradient Techniques.** D.O.NORRIS.
AGARDograph 131, Chapter 4, pp. 81-97, 4 refs., 1969.
This chapter deals further with optimization – in this case, by gradient techniques.

AG131/5 **The KALMAN Filter.** D.O.NORRIS.
AGARDograph 131, Chapter 5, pp. 99-104, 1 ref., 1969.
Describes discrete estimation or KALMAN filtering theory. A necessary part of computing the guidance commands for any aerospace vehicle is the measurement and estimation of state variables. This is included in Chapter 8.

AG131/6 **Inertial Instrument Theory and Stable Platform.** R.W.JOHNSON.
AGARDograph 131, Chapter 6, pp. 105-138, 8 refs., 1969.
Discusses space kinematic relationships describing motion in both inertial and moving coordinate frames. The theory of inertial sensors is presented as well as their implementation into stable platforms operating both in inertially fixed and "local vertical" tracking modes.

AG131/7 **Trajectory Theory and Guidance Coefficients.** R.W.JOHNSON.
AGARDograph 131, Chapter 7, pp. 139-174, 5 refs., 1969.
Develops trajectory theory and perturbation analysis as applied to astronautical vehicles. The concept of influence coefficients is used to derive the multipliers of the errors generated by the guidance system. This leads to a procedure for the generation of guidance coefficients for nonlinear dynamic systems.

AG131/8 **Guidance and Control Philosophy for Astronautical and Aerodynamic Vehicles.** R.W.JOHNSON.
AGARDograph 131, Chapter 8, pp. 175-205, 14 refs., 1969.
Describes the typical guidance and control philosophy used in aerodynamic as well as astronautical vehicles. Various applications are mechanized for the guidance of both linear and nonlinear systems. Particular emphasis is placed on the generation of the closed loop feedback gain matrices when optional solutions are used.

AG132 **The Electron Beam Fluorescence Technique.** E.P.MUNTZ.
AD-692-860 AGARDograph 132, 112 pp., 296 refs., 1968.
N69-38031 The electron beam fluorescence technique's development and its application to studies of gas flows are discussed. Present understanding of the technique is reviewed. Areas are indicated where further work is most needed. The practical employment of the technique is described by presenting brief reviews of the approximately eighty papers that have been published on its development and applications.

AG133 **Effects of Gravity and Acceleration on the Lungs.** D.H.GLAISTER.
AGARDograph 133, November 1970.
This monograph reports on the latest results of research on the effects of acceleration on the lungs. Changes of physiological functions such as breathing patterns, lung volumes, airflow, pulmonary mechanics, gas exchanges, gas absorption, circulation and tissue reactions, are described in relation to the magnitude, direction and duration of accelerations.

AG134 **A Portfolio of Stability Characteristics of Incompressible Boundary Layers.** H.J.OBREMSKI,
AD-693-660 M.V.MORKOVIN, M.LANDAHL.
N69-37935 AGARDograph 134, 128 pp., 81 refs., 1969.
This publication is one of a series sponsored by the Fluid Dynamics Panel of AGARD. A collection of linear amplification and propagation rates (temporal and spatial) for two similar and non-similar families of boundary layers is presented in graphical and tabular form.
The utilization of the Portfolio information for estimating transition Reynolds numbers is discussed. Throughout, emphasis is placed on relating the idealization of the stability theory to physical processes in the boundary layer.

AG135 **Fluidic Controls Systems for Aerospace Propulsion.**
AD-694-111 AGARDograph 135, AGARD Lecture Series 35, 164 pp., many refs., 1969.
N69-39139 The material of this book has been assembled to support a Lecture Series to be presented by the authors in Brussels and Viareggio in September 1969 under the sponsorship of AGARD, an Agency of NATO. This Lecture Series is intended as a progress report on fluidics as applied to aerospace propulsion problems. After a minimal review of basic operating principles, a number of operating prototype sensors and control systems are described. Fluidic control systems for aerodynamic inlets, gas turbines, and rocket engines are treated. Some of these systems have functioned successfully at temperatures exceeding 3000° Kelvin. The eight papers of this volume are abstracted individually in the following entries.

AG135/1 **The Fundamentals of Fluidic Elements and Fluidic Information Handling.** G.NARDI.
AGARDograph 135, Paper 1, p. 1, 1969.
Not available for reproduction. An abstract is printed on P1. A survey of the present state-of-the-art in fluidics shows that the transition of the technique from the field of the researcher to that of the application engineer is in progress at the present time. The paper shows how fluidics have been applied in Italy in developing a modular system of wide application and versatility.

AG135/2 **Fluidic Pressure Ratio Sensing and Sub-System Controls for Aircraft Gas Turbines.**
AGARDograph 135, Paper 2, pp. 2-1 to 2-20, 1 ref., 1969.
Fluidic elements have been designed as control elements to operate direct from the high pressure air from the engine compressor so eliminating much peripheral equipment. Proportional and switching pressure ratio sensors, high pressure amplifiers and high pressure switches are described and test data is discussed. The application of the units to a gas turbine engine sub-system control is illustrated in use in compressor bleed valve, engine nozzle area and range thrust control.

AG135/3 **Fluidic Signal Processing Techniques for Aerospace Propulsion Control Systems.** W.A.BOOTHE.
AGARDograph 135, Paper 3, pp. 3-1 to 3-22, 15 refs., 1969.
Both proportional (DC) and carrier modulation (AC) fluidic techniques are said to have their own advantages in aerospace propulsion control systems and in many cases a combination is used. The basic concepts are reviewed and the application of a mixed AC and DC system to the J-79 jet engine is described.

AG135/4 **The Behaviour of Transmission Lines and Nozzles in Fluidic Networks.** H.M.SCHAEDEL.
AGARDograph 135, Paper 4, pp. 4-1 to 4-29, 5 refs., 1969.
In analogy to electrical communications engineering the equivalent circuit for a short length of uniform fluidic transmission line is derived. The wave propagation factor and the characteristic impedance are then calculated. As line terminations abrupt nozzles are investigated and other equivalent circuits are derived to represent the complete fluidic circuit.

AG135/5 **Fluidic Temperature Sensor Investigations for High Gas Temperatures.** G.WALLISER.
AGARDograph 135, Paper 5, pp. 5-1 to 5-13, 4 refs., 1969.
A general description of fluidic temperature sensing systems in use at the present time is given and is followed by a discussion of the requirements for a sensor for gas turbine intake temperature. The oscillating type of sensor is discussed and experimental results with modified feedback oscillators are described.

AG135/6 — Fuel Weakening System for Gun Firing, Starting Sequences, Capture of N/T. (In French). J.P.CHAMPAGNON.
AGARDograph 135, Paper 6, pp. 6-1 to 6-10, 1969.
This paper is in three parts describing the application of fluidics to protect the gas turbine during gun firing, to a starting sequence control system and to an N/T digital pick off. In the first when the guns are being fired, the system will reduce the fuel supplied to the engine, during a controlled amount of time, the system will be automatically overriden in certain ranges of rotational speed. The other two papers describe other applications of the rotation speed probe developed for the first.

AG135/7 — Fluidic Gas Turbine Engine Controls. E.G.JOHNSON.
AGARDograph 135, Paper 7, pp. 7-1 to 7-17, 1969.
The paper describes the progress since the basic principles of fluidics were first introduced ten years ago and states that pure fluidic systems for relatively simple applications are now nearing production status. This paper describes two such applications, a military gas turbine control, and an industrial gas turbine control.

AG135/8 — Fluidics in the Control of Advanced Ramjet Engines. B.A.OTSAP.
AGARDograph 135, Paper 8, pp. 8-1 to 8-25, 8 refs., 1969.
Covers the application of fluidics technology to typical ramjet control functions with emphasis on the utilization of fluidics to perform, as far as possible, all the ramjet control function.

AG136
AD-700-224
N70-21838 — Problems of Aircraft Behaviour at High Angles of Attack. G.J.HANCOCK.
AGARDograph 136, 110 pp., 370 refs., 1969.
Interpreting high angles of attack as those associated with stall and post-stall behaviour, the report reviews both aerodynamic and dynamic aspects. Dynamic considerations include stability and control response, and pre-stall and post-stall behaviour. Aerodynamic considerations range over a wide field covering two-dimensional stall characteristics, finite wing stall characteristics, including the effects of stall devices, downwash at high angles, aircraft configuration force and moment characteristics, and aerodynamic derivative characteristics. Unsteady effects, Mach number effects, and propeller slipstream effects are included.

AG137
Part I –
AD-698-779
N70-15405
Part II –
AD-698-780
N70-15406 — Tables of Inviscid Supersonic Flow about Circular Cones at Incidence $\gamma = 1.4$. D.J.JONES.
AGARDograph 137, Parts I and II, 1054 pp., 3 refs., 1969.
The two volumes, sponsored by the AGARD Fluid Dynamics Panel provide tabulated results for the inviscid flow field about several circular cones at incidence to a uniform supersonic stream ($\gamma = 1.4$). The three velocity components, pressure and density are given at points between the circular cone and the corresponding attached bow shock wave. Also some overall quantities such as normal and axial force coefficients are listed. Results are given for Mach numbers ranging from 1.5 to 20, for cone half angles from 5° to 40° and for successive values of relative incidence 0, 0.1, 0.2 . . . .

AG138 — Ballistic-Range Technology. T.N.CANNING, A.SEIFF, C.S.JAMES.
AGARDograph 138, 520 pp., August 1970.
A comprehensive treatment of the state-of-the-art of ballistic-range testing, written for graduates by members of the staffs of the Hypersonic Free-Flight Branch at NASA-Ames Research Center and the Aerophysics Division of the Defense Research Establishment of Canada. The capability and potential of ballistic ranges are not as widely appreciated as they deserve to be and the book aims to show the opportunities they afford for experimental research in ballistic-missile aerodynamics, to point out the problems involved, to guide the preliminary design of new ballistic ranges, to provide reference material to enable full exploitation of existing ranges, and to help in evaluating the applicability and accuracy of results.

Individual chapters deal with modern ranges and their uses, light-gas guns, model design and launching techniques, terminal ballistics, counterflow, measurement systems, aerodynamics of bodies from motion analysis, photographic techniques, optical radiation studies, microwave studies, point measurements in the wake and convective-heating measurements.

AG139
AD-704-306
N70-25876 — Theory and Applications of KALMAN Filtering. C.T.LEONDES (Editor).
AGARDograph 139, 540 pp., February 1970.
KALMAN filtering techniques are of particular importance to the fields of guidance and control, and this text book covers the subject in three principal parts. The first examines the theory of KALMAN filtering in depth and significant new results of fundamental importance are included. The second part deals with the general area of related topics, whilst the third is a comprehensive review of many of the important applications of KALMAN filtering.

AG140 Physiopathology and Pathology of Affections of the Spine in Aerospace Medicine.
N71-10175 R-P DELAHAYE, R PANNIER, H.SERIS, R.AUFFRET, R.CARRE, H.MANGIN, M-J TEYSSANDIER.
AGARDograph 140, 80 pp., August 1970.
This book brings together the present views of a specific group of experts on the aitiology, diagnosis and prognosis of spinal injuries where these are associated with aviation, either in rotary or in fixed wing aircraft, or in parachuting or gliding.

Emphasis is placed on methods of prophylaxis, in which, for example, are compared the opening shocks of static line parachuting, where two packing methods have been employed: the adoption of various sitting positions in a pilot's seat, particularly in regard to method of bracing immediately before ejection or before crash landing.

In regard to the selection of aircrew and of candidates for roles involving regular parachuting, e.g. minor spinal abnormalities, and of the value of keeping a radiographic record of the individual's spine for subsequent comparison, should he be involved in an accident resulting in spinal injury.

AG141 Propergols Hautement Energetiques. P.TAVERNIER, J.BOISSON, B.CRAMPEL.
N71-17841 AGARDograph 141, 338 pp., August 1970.
Cet ouvrage, d'une grande valeur, présente toutes les questions relatives aux ergols et aux combinaisons propergoliques. Il se divise en 6 chapitres couvrant les aspects suivants. I. Historique de l'autopropulsion; II. Notions de base sur les moteurs-fusées, certains phénomènes de combustion inséparables des écoulements en tuyère, et influence du choix de la combinaison propergolique sur la balistique extérieure de l'engin; III. Revue des ergols possibles avec leurs caractéristiques physiques, chimiques et thermodynamiques. Moyens de production et problèmes spéciaux (caractère hygroscopique, toxicité, hypergolicité, stabilité, stockage et manutention); IV. Procédés de préparation et propriétés énergétiques des combinaisons propergoliques pouvant être obtenues à partir des ergols combustibles et des oxydants étudiés dans III. Possibilités d'amélioration du potentiel énergétique; V. Problèmes soulevés par la combustion et la mise en oeuvre des propergols hautement énergétiques. Tableaux des caractéristiques des matériaux utilisables pour la chambre de combustion et la tuyère. Problème du mouvement de la chaleur dans les parois et importance du régime transitoire sur les performances. Données pratiques sur les charges thermiques rassemblées sous forme de tableaux. Influence du jet fortement ionisé sur la propagation des ondes hertziennes; VI. Conclusions: influence importante de la mission de l'engin sur le choix de la combinaison propergolique à utiliser. Quelques indications sur les voies de développements futurs.

AG142 Human Factors in the Ground Control of Aircraft. V.DAVID HOPKIN.
AD-706-550 AGARDograph 142, 174 pp. April 1970.
N70-28472 The contribution of human factors to the functioning of air traffic control and air defence systems
N70-30833 is reviewed. The performance and well-being of those who work in these systems are affected by numerous factors, including the design of systems and of tasks, the working environment, selection and training procedures, the demands placed upon the man, and conditions of service. Much existing evidence refers to one system only, and to tasks which are so specific to it that they never recur elsewhere in exactly the same form. Such evidence cannot be generalised without verification, and rests on empirical rather than theoretical assumptions. Probable future trends in the application of human factors to these systems are indicated.

AG143 A Non-Invasive Technique of Cardio-Pulmonary Assessment. D.M.DENISON.
AD-711-261 AGARDograph 143, 113 pp., August 1970.
N70-38531 The cardio-respiratory function is examined primarily in connection with a particular non-invasive
N70-38530 test of this function. It describes a theoretical explanation of factors influencing gas tension in mixed venous blood and their measurement together with the effects of various cardio-pulmonary stresses. There is also a review of the work done in this field during the past two years.

AG144 Engineering Analysis of Non-Newtonian Flows. D.C.BOGUE, J.L.WHITE.
AD-710-324 AGARDograph 144, 104 pp., July 1970.
N70-38497 This AGARDograph covers in an introduction the classification of Materials Behaviour and a survey of Non-Newtonian Effects.

One main chapter is devoted to fundamentals of Rheology, covering Rheological equations of state, Viscometry and Rheological properties of fluids.

The other chapter deals with engineering analysis containing hydro-dynamics of viscoelastic fluids, dimensionless groups and scale-up, laminar flow through tubes, some applications in polymer pressing and turbulent flow of Non-Newtonian fluids.

AG145 Wind Tunnel Pressure Measuring Techniques. D.S.BYNUM, R.L.BEDFORD, W.E.SMOTHERMAN.
N71-14988 AGARDograph 145, 87 pp., 109 refs., December 1970.
This AGARDograph covers two main chapters dealing with Techniques for Continuous Flow Facilities, and Techniques for Impulse Facilities.

AG146
N71-12673

The Numerical Solution of Partial Differential Equations Governing Convection. H.LOMAX, P.KUTLER, F.B.FULLER.
AGARDograph 146, 49 pp., October 1970.
The time-dependent Navier-Stokes equations are a mathematical model for fluid flows that contain two quite different physical phenomena. These phenomena are contained in the formula representing the conservation of momentum and are referred to as convection and dissipation. The optimum numerical reduction from differential to difference equations of the terms that model these two aspects of fluid flow can be quite different. This report is devoted to a simple but systematic study of the numerical methods best suited for the analysis of convection.

AG147
N71-12582

Nonreacting and Chemically Reacting Viscous Flows Over a Hyperboloid at Hypersonic Condition. C.H.LEWIS.
AGARDograph 147, 170 pp., September 1970.
Results of various numerical methods for calculating viscous flows for a specific set of conditions are presented and compared.

The body chosen for the numerical experiments was a 10 degree half-angle hyperboloid at two altitude-velocity conditions and one perfect gas condition.

Wall skin friction and heat transfer coefficients are computed, velocity, temperature, species, etc., profiles across the viscous layer at various locations along the body are provided.

Preliminary results of the contributions were presented and discussed at the AGARD Seminar on "Numerical Methods of Viscous Flows", Teddington, England, September 1967. (Reference AGARD Conference Proceedings 60, published May 1970.)

CONFERENCE PROCEEDINGS

CP1 **Advances in Tactical Rocket Propulsion.** Editor S.S.PENNER.
AD-853-347 AGARD Conference Proceedings No. 1, 490 pp., many refs., 1968.
N69-40176 The papers reported here were presented at an AGARD Colloquium sponsored by the Propulsion and Energetics Panel "Progress in Tactical Rocket Propulsion" held at La Jolla, California, April 22 and 23, 1965. The articles represent significant evaluations of the status of solid liquid and hybrid propellant rocket development. The papers are in three sections, 11 papers in all and each is followed by a record of the discussion. They are dealt with separately in the following abstracts numbered CP1/1/1 to CP1/1/7 (part 1), CP1/2/1 to CP1/2/3 (part 2) and CP1/3/1 (part 3).

CP1/1/1 **Processing and Manufacture of Composite Propellants.** J.F.TORMEY.
AGARD Conference Proceedings No. 1, Part 1, Chapter 1, pp.1-11, 1968.
The paper describes the unit processing treatment of the manufacture of solid propellant motors. Raw material preparation, mixing, casting and curing is described and the processes of homogenization, wetting and curing are discussed in more detail.

CP1/1/2 **Accidental Ignition in Propellant Processing.** H.M.SHUEY.
AGARD Conference Proceedings No. 1, Part 1, Chapter 2, pp.13-18, 1968.
Sources of ignition during solid propellant processing are discussed. The most serious ignition hazard is said to be during the mixing operation where the sources for ignition are greatest and the result of ignition catastrophic because of the state of subdivision of flammable material and its confinement

CP1/1/3 **Study of the Internal Ballistics of Solid Propellant Rockets.** (in French) J.BOISSON.
AGARD Conference Proceedings No. 1, Part 1, Chapter 3, pp 19-47, 1 ref., 1968.
This paper presents a mathematical method for determining analytically the rocket engine thrust and chamber pressure development curves from charge and engine geometry, the heat of explosion, the kinetics and other parameters affecting engine operation. It is shown that it is possible to compute empirical values for burning rate and erosion effects from experimental findings and finally the calculation procedure is illustrated by four practical examples.

CP1/1/4 **Analytical and Experimental Studies of the Steady Static Combustion Mechanism of Solid Propellants.** M.BARRERE, F.A.WILLIAMS.
AGARD Conference Proceedings No. 1, Part 1, Chapter 4, pp.49-130, 66 refs., 1968.
Present knowledge of the steady-state combustion mechanisms of solid propellants is reviewed. Attention is directed mainly to heterogeneous propellants and both theoretical and experimental work is discussed. A theoretical analysis of a model of homogeneous propellant combustion is outlined and avenues for future research are recommended.

CP1/1/5 **Review of the Combustion Instability Characteristics of Solid Propellants.** E.W.PRICE.
AGARD Conference Proceedings No. 1, Part 1, Chapter 5, pp.139-189, 59 refs., 1968.
Classes of instability behaviour are reviewed and related to theory and to aspects of the combustion process. Experimental methods for small scale testing of stability characteristics of propellants are described and typical results are presented.

CP1/1/6 **Ignition Problems in Solid – Propellant Rockets.** B.F.HAUL, R.L.LOVINE.
AGARD Conference Proceedings No. 1, Part 1, Chapter 6, pp.195-240, 26 refs., 1968.
Methods of analysis of solid rocket motor ignition and igniter performance are given. The complete process is followed through from the combustion of the igniter pyrotechnic to the build up to equilibrium motor operating pressure

CP1/1/7 **Advances in Solid-Fuel Propulsion Systems for Tactical Rockets.** C.B.HENDERSON, R.M.MILLER.
AGARD Conference Proceedings No. 1, Part 1, Chapter 7, pp.249-259, 5 refs. 1968.
The paper surveys three areas in which advances of solid propulsion have allowed the improved design of tactical rockets. Micro-wave attenuation, acceleration - combustion interaction and performance optimisation are discussed.

CP1/2/1 **Fundamental Problems of Injector Design.** D.T.HARRJE
AGARD Conference Proceedings No. 1, Part 2, Chapter 1, pp.267-286, 34 refs., 1968.
The paper discusses the design of injectors for liquid propellant rocket engines The characteristics of injectors are discussed in relation to high energy conversion, stable operation control of heat transfer and finally ease of manufacture Mechanical damping devices are treated briefly

CP1/2/2 **Survey of the Relationship between Theory and Experiment for Convective Heat Transfer from Rocket Combustion Gases.** D.R.BARTZ.
AGARD Conference Proceedings No. 1, Part 2, Chapter 2, pp.291-378, 79 refs., 1968.
The paper reviews the knowledge on the distribution of heat flux in a rocket engine and presents a mathematical model which however requires several assumptions of the condition of the boundary layer. Several experiments are described to obtain boundary layer conditions and sample distributions of heat flux in several rocket engines are presented. It is concluded that combustion effects are not yet fully known.

CP1/2/3 **Secondary Non Destructive Instability in Medium Size Liquid Fuel Rocket Engines.** R.J.FONTAINE, R.S.LEVINE, L.P.COMBS.
AGARD Conference Proceedings No. 1, Part 2, Chapter 3, pp.383-419, 50 refs., 1968.
This paper reviews some of the combustion instability types which can occur in tactical liquid rockets. Destructive acoustic model or "screaming" instabilities are excluded. Linearised mathematical models of feed-system – coupled combustion instability are summarised and discussed. A specific case of instability associated with a non-rigid injector is described and it is shown that a cure was possible by the method predicted from the model.

CP1/3/1 **Research on the Combustion Mechanism of Hybrid Rockets.** G.A.MARXMAN, C.E.WOOLDRIDGE.
AGARD Conference Proceedings No. 1, Part 3, Chapter 1, pp.421-455, 40 refs., 1968.
The paper is a detailed and extensive review of the present knowledge on the regression rate process which controls the operation of hybrid-propellant rockets. Investigations of the turbulent boundary layer, particularly recent work in relation to hybrid combustion, are described. Areas of investigation requiring further work are mentioned.

CP2
AD-660-197
N66-33726 **Collected Papers Presented at the Twenty-Second Meeting of the AGARD Aerospace Medical Panel.**
AGARD Conference Proceedings CP 2, 523 pp., 1965.
This volume contains 33 papers which were presented at the twenty-second meeting of the Aerospace Medical Panel, Fuerstenfeldbruck Air Base, Germany, 2nd to 6th September, 1965. The programme was divided into six technical sessions covering: thermal and vestibular problems, psycho-physiology, cardiovascular and respiratory problems, environment, acceleration and vibration. Abstracts of the individual papers are given in the succeeding items.

CP2/1 **Vestibular Problems in Rotating Spacecraft.** K.E.MONEY.
AGARD Conference Proceedings CP 2, 1-8, 15 refs., 1965.
It is proposed that from the point of view of vestibular physiology (i) zero g is acceptable for long-term manned space flights, and (ii) rotation rates of 3 to 5 r.p.m. are hazardous. Evidence in support of these proposals is presented, and its significance is discussed.

CP2/2 **The Effects of the Direction of a Linear Acceleration Vector on Post-Rotational Vestibular Responses in Man.** A.J.BENSON, M.A.BODIN.
AGARD Conference Proceedings CP 2, 9-22, 8 refs., 1965.
Examines the extent to which post-rotational vestibular responses are dependent on the direction of the prevailing linear acceleration vector. Gives particular attention to subjective after-sensations because these conflict with veridical cues and in flight may precipitate spatial disorientation. Discusses the implications of the experimental findings to problems of aerospace medicine.

CP2/3 **Motion Sickness During Flying Training.** T.G.DOBIE.
AGARD Conference Proceedings CP 2, 23-32, 1965.
Presents a preliminary report of an investigation designed to see if it is possible to assess an individual's susceptibility to motion sickness and to attempt to reduce the incidence of the condition by some form of ground vestibular exercise. Details are given of the cupulometry techniques used in the investigations, and of the experimental procedure adopted. The preliminary results indicate that prior selection does not hold out much hope as a means of avoiding the wastage of flying training time due to motion sickness.

CP2/4 **Thermal Protection Principles.** A.M.STOLL, M.A.CHIANTA.
AGARD Conference Proceedings CP 2, 33-48, 11 refs., 1965.
Concerns protection against intense thermal exposures productive of burns, as distinguished from protection against heat loss or gain due to long-term environmental heat exchange. The nature of the tissue injury sustained under various thermal conditions is discussed. Thermal protection methods for convective heating, conduction heating and radiant heating are then described.

CP2/5 **Coefficients of Convective Heat Exchange: Experimental Study.** (In French). J.COLIN, Y.HOUDAS
AGARD Conference Proceedings CP 2, 49-72, 19 refs., 1965.
The aerodynamic heating of supersonic aircraft has emphasized the problem of creating habitable temperatures in the cockpit. In calculating the heating/cooling required, a detailed knowledge of the heat exchange mechanisms of the human body is needed. Knowledge on convective heat exchange is limited, and great divergences exist among the coefficients formulated by different researchers. The authors describe their experimental approach to this problem and the determination of a coefficient based on the data obtained.

CP2/6 **Some Aspects of Personal Cooling in Inadequately Air Conditioned Cockpits.** J.M.CLIFFORD.
AGARD Conference Proceedings CP 2, 73-86, 1965.
The adverse effects of a high ambient temperature and thus a high body temperature on aircrew performance are first briefly considered. The control of man's microclimate by three different methods (use of warm dry air to produce cooling by evaporation of sweat, air-ventilated suits, water-cooled suits) is then discussed. Particular attention is given to the performance of the water-cooled suit developed by RAE.

CP2/7 **Psychophysiological and Human Engineering Considerations in the Instrumentation and Control of VTOL-Aircraft.** H.VON DIRINGSHOFEN, W.BURKHARDT
AGARD Conference Proceedings CP 2, 87-93, 1965.
The psychological and human engineering problems entailed in the modern tendency to relieve pilots of most of their functions within the typical control circuits of aircraft and weapon-systems control are discussed. These problems include: the tendency of pilots to reject automation, the reluctance of designers to incorporate complex control systems of suspect reliability, the training of pilots for intervention in cases of emergency.

CP2/8 **Serial Sampling of Parotid Fluid for 17-Hydroxycorticosteroid Levels as a Quantitative Estimate of Stress During Flight in High-Performance Jet Aircraft.** B.H.WARREN, I.L.SHANNON, S.D.LEVERETT, JR.
AGARD Conference Proceedings CP 2, 95-108, 22 refs., 1965.
A technique has been developed for the collection of parotid fluid during flight which is relatively simple. This technique was used to measure 17-hydroxycorticosteroid levels of parotid fluid under relatively non-stressful flying conditions. The results obtained are compared with 17-OHCS levels obtained during periods when the subjects were experiencing stresses of one type or another.

CP2/9 **Recovery Rates with Descent from Hypoxia-Induced Peripheral Visual Field Loss.** W.L.SMITH.
AGARD Conference Proceedings CP 2, 109-118, 4 refs., 1965.
Experimentation on the title subject was carried out on five male subjects, using the Bosch and Lomb FEREE-RAND Simplified Perimeter. The experimental method is described, sources of error are listed, and the data obtained are discussed. It was found that loss of peripheral vision is quickly recovered with rapid descent below 10,000 ft. Recommendations for further studies are made.

CP2/10 **Importance of Electroretinography in Evaluating the Night Vision of Flying Personnel.** (In French). A.MERCIER, G.PERDRIEL, J.CHEVALERAUD.
AGARD Conference Proceedings CP 2, 119-123, 4 refs., 1965.
The advantage of electroretinographic examination for determining night vision capacity is that it provides an objective procedure which demonstrates the action of the "62" (scotopic) wave. Other techniques used depend upon the accuracy of the answers of the subject. Electroretinography is also of diagnostic, prognostic and therapeutic value in cases of possible hemeralopia in an aviator.

CP2/11 **Regional Blood Flow Distribution in Profound Experimental Hypothermia: A Technique for Definition of Blood Flow Patterns in Critical Organs During High Acceleration Stress.** M.D.TURNER, H.L.STONE, S.D.LEVERETT, JR.
AGARD Conference Proceedings CP 2, 125-138, 1965.
In this experimental investigation adult mongrel dogs were anaesthetized with sodium pentobarbital. Platinum electrodes were implanted via a midline abdominal incision. Usually electrodes were placed in one renal cortex, one adrenal gland, the pancreas, and the wall of the ileum. Control blood flow values were obtained at body temperatures of 37 to 30 deg. C. Pulse pressures and heart rates were continuously monitored and electrocardiograms and hematocrits were usually obtained. These measurements were then repeated at intervals as the animal's body was cooled. Data obtained are presented and discussed. The hydrogen gas technique for local blood flow determination was used in the study of blood flow distribution during accelerative stress. An example of the experimental technique used is described.

CP2/12 **The Distribution of Pulmonary Blood Flow in Human Subjects During Zero-G.** H.L.STONE, B.H.WARREN, H.WAGNER, JR.
AGARD Conference Proceedings CP 2, 139-148, 5 refs., 1965.
Macroaggregated human serum albumin (MAA) labelled with I^{131} was used to determine pulmonary blood flow distribution during the short periods of weightlessness produced by parabolic flight. A shift in blood flow towards the apical regions of the lungs was observed; however, this shift was not as great as that found in the supine position in another group of subjects.

CP2/13 **Recent Observations on Respiratory Physiology During Transverse Accelerations.** (In French). C.JACQUEMIN, P.VARENE, J.DEMANGE, J.TIMBAL.
AGARD Conference Proceedings CP 2, 149-177, 114 refs., 1965.
Transverse accelerations (+ Gx) determine a restrictive respiratory syndrome without the participation of an overall obstructive syndrome, as has been confirmed by measurement of respiratory resistance by the interrupter technique. Hypotheses relating to the nature of the restrictive syndrome are justified by the observation of descending alveolar plateaux on the CO_2 spectrograph traces, similar to those described in the course of the unilateral occlusion of a pulmonary artery.

CP2/14 **Complex Reaction Times at a Simulated Cabin Altitude of 8,000 Feet.** F.LEDWITH, D.M.DENISON.
AGARD Conference Proceedings CP 2, 179-197, 11 refs., 1965.
It has been generally assumed that there is unimpaired psychomotor performance at altitudes lower than 9,000 ft and for this reason most pressurized aircraft are pressurized to maintain cabin pressures at a ceiling cabin altitude of about 8,000 feet. This report describes an experiment to see if this assumption of unimpaired performance is justified. The experimental details are given in an appendix. The task chosen was designed to measure subjects' ability to assimilate visually-presented information on orientation with respect to some external reference and use it in relation to their "own body" frame of reference. The significance of the method of testing and of the results obtained is discussed. It is concluded that the ability to learn a task, involving spatial transformations of the stimulus materials appears to be impaired by exposure to a cabin altitude of 8,000 ft.

CP2/15 **Absorptional Atelectasis Breathing 100 Per Cent Oxygen at Simulated Altitude: Prevention Using Inert Gas.** T.TURAIDS.
AGARD Conference Proceedings CP 2, 199-208, 24 refs., 1965.
In the experiments reported, subjects were exposed for 72 hours at altitude and for 24 hours at sea level, in atmospheres of practically 100% oxygen at partial pressures of 258 mm Hg, 380 mm Hg or at sea level. Vital capacity measurements were made before, during and after each test. Chest X-rays were taken if there was a suspicion that atelectasis was present. Pulmonary function tests were carried out after completion of the tests. Airway resistance was measured and airway conductance was plotted against lung volume. The results are presented and discussed. Some subjects developed atelectasis, and in one subject this was prevented by the addition of 5% nitrogen.

CP2/16 **Comparison of Cardiovascular Reactions Originated by Difficult Helicopter Flight Patterns and Physical Workload.** E.A.LAUSCHNER, H.W.KIRCHHOFF.
AGARD Conference Proceedings CP 2, 209-222, 6 refs., 1965.
The object of this paper is to compare the results of laboratory functional testing of cardio-vascular and respiratory reactions and efficiency at the Institute of Aviation Medicine of the German Air Force with the values obtained by telemetric monitoring under difficult flying conditions as reported by Hoffmann, and to investigate the relationships between the results of the two methods.

CP2/17 **Engineered Atmospheres for Future Aerospace Operations.** A.G.SWAN.
AGARD Conference Proceedings CP 2, 223-232, 10 refs., 1965.
Reviews the progress of research at the laboratories of the USAF Aerospace Medical Division on the title subject. Aspects covered include. atmospheric composition and pressure, rapid decompression, oxygen toxicity, and dysbarism.

CP2/18 **Behaviour of Arterial Oxygen Saturation and of Pulmonary Ventilation in Dogs Subjected to + G_x Acceleration.** E.BUSNENGO, A.DAGIANTI, F.ROSSANIGO, P.ROTA.
AGARD Conference Proceedings CP 2, 233-243, 20 refs., 1965.
The modifications of the arterial oxygen saturation and of the pulmonary ventilation were studied in five dogs of normal size, anaesthetized under morphine and chloralose, when subject to transverse accelerations. The duration of the tests was varied from one to five minutes, accelerations ranged from one to eight g. The results are presented and discussed.

CP2/19 **Medico-Physiological Difficulties of the Pilot in Various VTOL Flight Operations.** R.AUFFRET, H.SERIS.
AGARD Conference Proceedings CP 2, 245-257, 1965.
To achieve high speeds coupled with zero landing and take-off speeds VTOL aircraft are powered by jet engines and are mechanically complex. This causes certain medico-physiological difficulties in VTOL flight patterns. The problems of piloting, exhaust gas pollution, vibrations, and low altitude bail-out are discussed. It is indicated that adequate solutions to these different problems can be hoped for.

CP2/20 **Aerospace Toxicology Research.** A.A.THOMAS.
AGARD Conference Proceedings CP 2, 259-278, 12 refs., 1965.
To highlight the research effort in this field a brief discussion is given of the three major research areas. The first concerns the handling of high energy storable propellants and parameters which form a basis for recommended tolerance criteria are discussed. Secondly atmospheric pollution by propellant and motor test operations requires laboratory and on-site mobile laboratory investigations. Finally, the most important area is that of toxicology in space cabins which requires a drastic new approach for its study.

CP2/21 **A Survey of an RAF Decompression Test at 28,000 Feet.** D.I.FRYER.
AGARD Conference Proceedings CP 2, 279-293, 4 refs., 1965.
An analysis of tests for aircrew whose duties involved high altitude flying is discussed. The exposure chosen was two hours at a simulated altitude of 28,000 ft. The tests were repeated once to make selection more stringent. The reasons for failing the test and a possible basis for not giving a man the test is included in the discussion.

CP2/22 **Design Requirements for Life Support Helmets.** R.A.BOSEE.
AGARD Conference Proceedings CP 2, 295-305, 3 refs., 1965.
In 1963 the US Navy sponsored a symposium to define the specifications of an integrated life support helmet. This paper considers some of these specifications in terms of the development efforts which have started since the symposium and progress achieved to-date.

CP2/23 **The Effects of Vibration on Human Performance.** C.S.HARRIS, R.W.SHOENBERGER.
AGARD Conference Proceedings CP 2, 307-326, 40 refs., 1965.
A brief review of the literature on the subject is followed by a description of investigations using sinusoidal vibration and sinusoidal versus random vibration. The method of testing is described and the results discussed. Future tests of longer duration will be made, and the importance of frequency in random vibration is to be examined.

CP2/24 **The Infrasonic Noise Environment in Aerospace Operations.** E.GUILD.
AGARD Conference Proceedings CP 2, 327-342, 8 refs., 1965.
Infrasound describes noise below 20 c/s in frequency. The paper begins by discussing the importance of the low-frequency sound spectrum, particularly now that more powerful engines and rockets have been developed. Information on human responses to very low-frequency noise is required and a long-term programme to explore the problems has begun at the Aerospace Medical Research Laboratories (AMRL). Observations made in operational conditions and studies conducted in the laboratory form the main content of the paper.

CP2/25 **Measurement of Low Frequency Vibrations on Heavy Helicopters and their Transmission to the Pilot.** H.SERIS, R.AUFFRET.
AGARD Conference Proceedings CP 2, 343-354, 24 refs., 1965.
A brief analysis of helicopter vibration records at the seat level and on the pilot (sternum and cranium) The low-frequency vibrations which cause the most difficulties (air sickness, fatigue, lumbalgia, etc) are said to be the most difficult to damp.

CP2 26 **The Dynamic Simulation of Turbulence Penetration.** L HITCHCOCK, JR., R.M.CHAMBERS.
AGARD Conference Proceedings CP 2, 355-394, 8 refs., 1965.
The facts that have emerged from crashes and other incidents of jet transports which have encountered atmospheric turbulence show that further research on pilot response to turbulence is needed. This paper is primarily directed to the problems of (i) providing the pilot and crew with essential information, and procedures to allow optimum control of the aircraft through atmospheric turbulence, and (ii) providing transport pilots with adequate training for this form of flying.

CP2 27 **Biological Parameters of Impact.** W K.BROWN, R.F.CHANDLER.
AGARD Conference Proceedings CP 2, 395-407, 24 refs., 1965.
A brief article discussing mechanical characteristics and response of body to impact, biological response to impact, and impact studies at Holloman Air Force Base. Some of the problems in establishing useful tolerance criteria to abrupt acceleration are presented

CP2/28 **Physiological Endpoints in Acceleration Research.** K.R.COBURN.
AGARD Conference Proceedings CP 2, 409-428, 13 refs., 1965.
Endpoint is defined as a predetermined occasion for terminating any given centrifuge run. Performance decrement usually occurs before a physiological endpoint is reached, thus eliminating the need for any decision as to whether or not to terminate the experiment in the face of deteriorating physiological state. Some suggestions are made regarding centrifuge requirements such as arm length, position of seat, dimensions of car, etc. Location of the subject's body is important and suggestions are made regarding the measurements of the subject.

CP2/29 **Acceleration Training for Astronauts and Test Personnel.** R.M.CHAMBERS, L.HITCHCOCK, JR.
AGARD Conference Proceedings CP 2, 429-468, 23 refs., 1965.
One of the most useful developments in physiological conditioning and training of astronauts for space flight has been the simulation by using human centrifuges. This report summarizes early developments of this technology and outlines the specific training programmes in which the techniques were developed.

CP2/30 **A Miniaturized 7-Channel Telemetry System for Medical Research.** A.R.MARKO.
AGARD Conference Proceedings CP 2, 469-476, 4 refs., 1965.
Development work on pulsed modulated miniature telemetry systems resulted in the design of this seven channel transmitting unit for physiological research, but it is not considered the final solution. It has high stability and a low power consumption, and its weight is 290 grains complete with battery for 30 hours continuous operation. The circuit design of the multiplexer lends itself to future microminiaturization using already-developed microelectronic building blocks.

CP2/31 **Multistation Monitoring during Rapid Decompression.** T.G.DOBIE.
AGARD Conference Proceedings CP 2, 477-485, 1965.
Concerns the physiological monitoring, applied to the training of aircrew in the use of certain partial pressure assemblies, at the RAF Aeromedical Training Centre. The scheme of remote multistation monitoring is nearing completion, the results in terms of training success have proved encouraging.

CP2/32 **Vision Research Facility at Aerospace Medical Research Department.** G.T.CHISUM, J.B.LYONS, J.H.HILL.
AGARD Conference Proceedings CP 2, 487-498, 6 refs., 1965.
Description and main design features are given of equipment which has binocular and monocular optical systems controlled by an automatic digital computer, and data recording system. Accessory apparatus consists of instruments which are used to calibrate and monitor stimuli and to make electrophysiological measurements on experimental observers. Much of the equipment has been developed for problems on "flashblindness", but it may be utilized for other problems concerning vision.

CP2/33 **The Centrifuge Method of Dynamic Flight Simulation.** R.J.CROSBIE.
AGARD Conference Proceedings CP 2, 499-523, 8 refs., 1965.
A summarized description of the evolution of the Aerospace Medical Research Department's centrifuge is followed by the capabilities of the modernized centrifuge, the various considerations and requirements to meet these capabilities, and the optimum potential of the centrifuge technique in solving problems associated with space vehicles and high performance aircraft.

CP3 **Propagation Factors in Space Communications.** W.T.BLACKBAND (Editor).
AD-674-170 AGARD Conference Proceedings CP 3, 569 pp., 1967.
N68-29083 The Ionospheric Research Committee of the Avionics Panel of AGARD/NATO held its tenth annual symposium meeting in Rome from 21st to 25th September, 1965. The theme was "Propagation factors in space communications". This volume presents the full text of those papers which have not been printed elsewhere, and also an account of the informal discussion which followed the papers. Abstracts of the individual papers are given in the succeeding items.

CP3/1 **A Survey of Tropospheric, Ionospheric, and Extra-Terrestrial Effects on Radio Propagation between the Earth and Space Vehicles.** G.H.MILLMAN.
AGARD Conference Proceedings CP 3, 3-55 46 refs., 1967.
The following are treated tropospheric refraction, ionospheric refraction experimental measurements of refraction, tropospheric time delay, ionospheric time delay, Doppler effects, scintillation effects, attenuation, ionospheric polarization rotation, ionospheric dispersion effects, cosmic noise Discussion

CP3/2 **The Effect of the Interplanetary Medium on S-Band Telecommunications.** M EASTERLING, R GOLDSTEIN.
AGARD Conference Proceedings CP 3, 59-72, 4 refs., 1967
The effect of the interplanetary medium has been investigated by sending radio waves through it and then analyzing the echoes reflected from the planets. The techniques used and the results obtained at S-band over a considerable area of the plane of the ecliptic are described.

CP3/3 **Atmospheric and Interplanetary Refraction Effects on High Precision Planetary Radar Measurements.** D.O.MUHLEMAN, P.REICHLEY.
AGARD Conference Proceedings CP 3, p.73, 1967.
A one-page summary only of this paper is given. Extensive programmes of radar observations of Venus, Mercury, Mars and the Moon have been carried out. This paper described the mathematical details of the eight figure computations of refraction corrections to range and range rate utilizing ray-tracing techniques. Future radar experiments using Venus or Mercury involving propagation at S-band through the solar were described. Consideration of the general relativistic effect on propagation very near the edge of the sun and experimental plans to detect the effect were included Discussion.

CP3/4 **A Summary of Preliminary Results of the MARINER IV Radio-Occulation Experiment.** A.M.KLIORE, D.L.CAIN, G.S.LEVY, V.R.ESHLEMAN, G.FJELDBO, F.D.DRAKE.
AGARD Conference Proceedings CP 3, 75-81, 10 refs., 1967.
The "Mariner IV occulation experiment" has provided very precise data relating to characteristics of the atmosphere and ionosphere of Mars. This paper presents a summary of the results obtained and a consideration of their significance. The paper is of a preliminary nature as much data analysis remains to be done. Discussion.

CP3/5 **Ionospheric Refraction of High-Frequency Radio Waves Propagating Between the Earth and Orbiting Satellites.** R.G.MALIPHANT.
AGARD Conference Proceedings CP 3, 85-103, 10 refs., 1967.
An equation is derived for the angular deviation of radio waves that penetrate through the earth's ionosphere. From this equation, a simple graphical method is produced for calculating the path of the ray emerging from the ionosphere. The method is used to determine the angle of arrival, at the earth's surface, of radio waves emanating from the "Topsi" satellite (S-48) at the times of loss of the signal at a monitoring ground station. A comparison of the theoretical cut-off angles (neglecting absorption), and the experimental limits thus determined, shows the extent to which absorption limits the ground coverage of the satellite. Discussion.

CP3/6 **Study of the Amplitude of the Electromagnetic Field of a Satellite at the Horizon of the Ground Station.** (In French and English). J.F.AUREJAC, J.PAPET-LEPINE.
AGARD Conference Proceedings CP 3, 105-131, 551-560, 1967.
Scintillations are observed in the radio signals received from satellites in the 20 to 60 Mc/s frequency band because of ionospheric irregularities. A statistical survey is made of recorded scintillations. For this survey they are divided into four classes producing changes of periods greater or less than 1 c/s and amplitudes greater or less than 25% of the received signal. It is shown that for any one station the scintillations were not uniformly distributed in azimuth and that the distributions for each class differed. Discussion

CP3/7 **Ionospheric Resonance Phenomena at VHF and HF, and Their Effects on Space Telecommunications.** I.PAGHIS.
AGARD Conference Proceedings CP 3, 133-159, 40 refs., 1967.
During the past three years a considerable amount of data relating to ionospheric plasma resonances has been collected by the "Alouette I" earth satellite. The purpose of this paper is to describe these satellite observations, and to discuss the probable effects of ionospheric resonances on space telecommunications systems, operating above the height of the F-layer maximum. Discussion.

CP3/8 **Irregularities and Plasma Resonances Observed by the Fixed Frequency Topside Sounder Satellite.** W.CALVERT, T.E. Van ZANDT.
AGARD Conference Proceedings CP 3, p.161, 1967.
A one-page summary only of this paper is presented. The fixed frequency topside sounder "Explorer 20" satellite (S-48) sounds on each of six frequencies between 1.50 and 7.22 Mc/s every 105 m/s, as the satellite moves about 800 m. This sounding pattern has proved useful for the study of field-aligned irregularities and plasma resonances on the topside of the ionosphere It is the nature of these irregularities that provides the main theme of this paper, the plasma resonances are also considered.

CP3/9 **Electron Content Measurements with a Stationary Satellite.** F.HARNISCHMACHER.
AGARD Conference Proceedings CP 3, 163-173, 1967.
After the launch of the "Early Bird" on 6th June 1965, attempts were made to monitor the beacon signal on 136.980 Mc/s. As "Early Bird" is stationary with respect to the earth, it is thus possible with this satellite to determine the total electron content in the direction 225° azimuth and 26° elevation from Freiburg continuously, day and night. Knowing from ground soundings the behaviour of the inner layers of the ionosphere, it is possible to discover short- and long-time changes even in the outer regions of the ionosphere. The results derived from the observations of Faraday rotations are presented and interpreted. Discussion

CP3/10 **Using Ionospheric Prediction Charts to Tentatively Forecast VLF Signal Intensity in Satellite Communications.** H.J.ALBRECHT.
AGARD Conference Proceedings CP 3, 175-179, 14 refs., 1967.
The purpose of this paper is to indicate some steps towards forecasting the VLF signal intensity at satellite positions above the lower edge of the so-called D-layer which is supposed to be the lowest effective ionized region. The objective is a general prediction procedure yielding an approximate signal level at any possible position in the upper atmosphere, using the prediction methods employed for ordinary world-wide communications in the high-frequency range.

CP3/11 **Large-Scale Irregularities and Horizontal Gradient of the Ionosphere from Active Satellites Transmissions Measurements.** M ANASTASSIADES, D.MATSOUKAS.
AGARD Conference Proceedings CP 3, 181-193, 6 refs., 1967.
A spaced receiver technique is used between the tracking centres of Athens and the Island of Crete, some 320 km apart, in order to investigate large irregularities and variations in the electron content at mid-latitudes. Amplitude recordings of signals from the satellites S-66 and DE-C were used for this purpose and the horizontal gradients of the electron content were determined. The derivation of the results and their significance are discussed.

CP3/12 **Diffraction of Random Waves in a Homogeneous Anisotropic Medium.** K.C.YEH.
AGARD Conference Proceedings CP 3, 195-202, 5 refs., 1967.
Such random waves are produced, for example, by reflection from a rough surface (e.g. the Moon) or by transmitting through the ionosphere containing irregularities. Due to anisotropy, both depolarization effects and the modification of the spectral density functions of the wave by the medium may occur. Both effects may be important in certain ionospheric applications. In the forward scatter approximation, it has been found that the sum of spectra of orthogonally polarized waves is uninfluenced by the medium.

CP3/13 **Topside Spread-F and Satellite Radio Scintillations.** J.L.JESPERSEN.
AGARD Conference Proceedings CP 3, 203-207, 11 refs., 1967.
The relation between scintillations and Spread-F detected by the topside sounder satellite, "Alouette I", near College, Alaska, is studied. The scintillations are correlated with small-scale irregularities in the vicinity of the satellite. This supports the view that high-latitude irregularities extend from near h max to as high as 1,000 km. Discussion.

CP3/14 **Polarization Variation of Satellite-Emitted Radio Signals.** H.SOICHER, G VOGT, P.R.APENDT, W.H.FISCHER, J.GRAU.
AGARD Conference Proceedings CP 3, 209-224, 14 refs., 1967
A system has been developed and tested that delivers reliable and precise data for second-by-second Faraday-rotation measurements of satellite beacon signals The precision of the data, when restricted to difference values and to a centre interval, is better than ±1%.

CP3/15 **Effects of Ionospheric Irregularities on Space Data Acquisition in the Auroral Zone.** E.J.FREMOUW
AGARD Conference Proceedings CP 3, 225-239, 12 refs., 1967.
Some scattering effects of ionospheric irregularities on tracking and data acquisition from trans-auroral-zone satellites are discussed. Particular attention is paid to severe scattering associated with active auroral displays. Signal strength fluctuations in excess of 20 dB have been recorded at 136 Mc/s by NASA's Gilmore Creek data acquisition facility near Fairbanks. The scintillations are often caused by distinct patches or arcs of irregular ionospheric structure, which the College all-sky camera shows to be associated with visible auroral forms

CP3/16 **Auroral Zone Radio Star Scintillation Measurements and Interpretations.** J.M.LANSINGER
AGARD Conference Proceedings CP 3, 241-260, 21 refs., 1967
This paper describes some preliminary results of continuous phase and amplitude radio-star scintillation measurements obtained from a lobe-sweep system operating at 68 Mc/s. The measurements were taken near College, Alaska, using an east-west interferometer with approximately a 50 wavelength spacing. The results presented cover scintillation measurements using the source Cygnus A in November 1964 and the source Cassiopeia A.

CP3/17 **Effects on Non-Inverse-Frequency-Squared Absorption Events.** S.M.BENNETT, G.F.ROURKE
AGARD Conference Proceedings CP 3, 261-272, 20 refs., 1967.
Attenuation computations utilizing theoretical D-region electron density profiles during solar proton events (PCA) have been extended through the VHF band. The generalized Sen-Wyller magnetoionic absorption equation for the quasi-longitudinal case is employed throughout, and the collision frequency is taken to correspond to summer in the polar cap region. Non inverse-squared frequency dependence exists throughout the frequency range considered (3 to 300 Mc/s) and the significance of the departure depends on the steady-state coefficient and spectral form chosen. Discussion.

CP3/18 **Ionospheric Effects of Solar X-ray Enhancements.** T.B.JONES.
AGARD Conference Proceedings CP 3, 275-286, 13 refs., 1967.
Measurements of the solar X-ray spectrum during a number of solar flares have been used to evaluate the changes produced by these events in the D-region electron density profile. By combining these profiles with estimates of the total electron content changes, deduced from observations of sudden frequency deviations (SFD), some indication can be obtained of the ionization changes above the D-region. Discussion.

CP3/19 **Radio-Wave Propagation Through Re-entry Plasma Sheaths.** M.P.BACHYNSKI.
AGARD Conference Proceedings CP 3, 287-308, 10 refs., 1967.
Laboratory studies are reported on the use of magnetic fields to alter the plasma characteristics in order to achieve communication during re-entry using an appropriate magnetoionic mode In the geometrical arrangement, the applied static magnetic field is aligned along the direction of propagation. The experimental results are compared with theory, and the implications of the conclusions are considered.

CP3/20 **Electro-Magnetic Wave Propagation Through an Ionized Gas Layer as an Optimal Process.** M.Z.v.KRZYWOBLOCKI.
AGARD Conference Proceedings CP 3, 309-325, 9 refs., 1967.
The mathematical formalism of the problem of an electromagnetic wave propagation through an ionized gas layer is presented as an optimal process with the use of continuous functions of several independent variables and partial differential systems

CP3/21 **Methods of Improving Radio-Wave Propagation Through the Plasma Sheath.** R.RAWHOUSER.
AGARD Conference Proceedings CP 3, 327-336, 17 refs., 1967.
A number of processes for getting electromagnetic waves through the plasma sheath are discussed. These include. signal frequency selection, aerodynamic shaping, static magnetic field, aerodynamic "gas spike", chemical additives, electron beam-plasma wave interaction; frequency mixing in the plasma. Discussion

CP3/22 **Surface Wave Propagation along a Dielectric Rod Immersed in an Unmagnetized Plasma and Its Application to Measuring Electron Density.** P.N.ROBSON, R.D.STEWART.
AGARD Conference Proceedings CP 3, 337-349, 10 refs., 1967.
A microwave surface-wave probe which enables the electron density profile in an unmagnetized gaseous plasma to be measured is described. The technique is used to measure the phase-change coefficient of an electromagnetic surface wave supported by a fused quartz rod which is inserted into the body of the plasma. Typical theoretical dispersion characteristics for the plasma-clad rod are presented and corrections for the Debye sheath forming at the surface of the rod are considered Discussion.

CP3/23 **Effects of the Plasma Sheath on Antenna Performance.** C.T.SWIFT, H.HODARA.
AGARD Conference Proceedings CP 3, 351-382, 16 refs., 1967.
The near fields of radiation from slot antennae on a fleet ground plane and on a cylindrical ground plane are investigated via a transfer function which algebraically relates the unknown aperture fields to those in free space. This transfer function is a matrix of computable numbers which are specified entirely by the plasma parameters regardless of whether the plasma is homogeneous or inhomogeneous. The admittance of long slots on cylinders and planes is computed. The results are compared, and the effects induced by the inhomogeneous plasma are noted. Discussion.

CP3/24 **Noise Production by Terrestrial Sources in the Near-Earth Space.** K.RAWER.
AGARD Conference Proceedings CP 3, 383-408, 1967.
This paper attempts to give a provisional answer to the question. how does the Earth look, if seen by radio waves from outside (i.e. in near space)? The answer is given in a broad way, mainly by indicating some equivalent temperature values, these are, of course, colour temperatures, and thus variable with temperature. The two major considerations, propagation problems and the radiated energy are treated. Discussion

CP3/25 **Absorption of Radio Waves in the Troposphere.** D.T.GJESSING.
AGARD Conference Proceedings CP 3, 411-421, 6 refs., 1967.
The physical processes giving rise to absorption of radio waves are first considered phenomenologically, the various types of molecular absorption spectra in gases being discussed. Having determined which atmospheric constituents are responsible for the absorption of radio waves, the various absorption processes are examined, particular attention is given to the absorbing effect on microwaves of the atmospheric gases and of liquid and solid particles in the troposphere.

CP3/26 **Tropospheric Refraction and Its Influence on the Coverage of Long-Range Radars.** D.T.GJESSING.
AGARD Conference Proceedings CP 3, 423-429, 3 refs., 1967.
An investigation of the frequency of occurrence and the effect on radar coverage of anomalous radar propagation (in a given area) is presented. The measured coverage diagram is compared with diagrams computed from a knowledge of the refractive index distribution in the troposphere. A method by which radio ducts can be predicted from synoptic weather data is discussed.

CP3/27 **Experimental Study of the Loss of Antenna Gain in Transhorizon Links** (In English and French).
L.BOITHIAS, J.BATTESTI.
AGARD Conference Proceedings CP 3, p.431, 1967.
As the full text of this paper has been published in Annales des Télécommunication, 19 (9-10), September–October, 1964, a short summary only is given here. The study reported was especially directed towards the establishment of microwave links, but the results are of general application. It appears that to a first approximation, the loss in gain is related to the gain of the antenna and that it depends but little upon the length of the path.

CP3/28 **The Influence of Wave-Front Coherence on the Radiation Parameters of Large-Size Antennas.**
C.COLAVITO.
AGARD Conference Proceedings CP 3, 433-444, 8 refs., 1967.
The calculation of the radiative parameters of antennae, when the received field is fluctuating in time and space, is treated. The theory of partially-coherent electromagnetic waves is employed to express these fluctuations by means of only one quantity, that is the complex "degree of coherence" which must be measured in the various points of the wave front. Formulae for the gain factor and for other antenna radiative parameters are derived. The application of the experimental and calculation procedure to large antennae used in satellite communication systems is illustrated.

CP3/29 **Laser Wave Propagation Through the Atmosphere.** H.HODARA.
AGARD Conference Proceedings CP 3, 445-474, 24 refs., 1967.
Communication with coherent light through the atmosphere brings out new system limitations besides those imposed by attenuation and scattering normally associated with incoherent waves, principal of these is the presence of random thermal turbulences. Here, the nature of such turbulences, their effects on communication systems, and the meaningful measurements that can be made are treated in considerable detail.

CP3/30 **Propagation Factors at 3.2 Millimeters.** L.A.HOFFMAN.
AGARD Conference Proceedings CP 3, 475-521, 23 refs., 1967.
Exploration of the millimeter wave spectrum for possible USAF systems applications has been conducted by Aerospace Corporation. All the measurement to-date have been taken at 3.2 mm at the "window" between the complex of absorption lines near 5 mm and the single absorption line near 2.5 mm. An account of this work is given. It is concluded that communications systems operating at 3.2 mm are feasible for short horizontal path lengths of the order of 50 km with only a minimum of required transmitting power (0.1 to 1 W). These systems can be small and rugged and will operate under most weather conditions, except perhaps those of moderate to heavy rainfall and extremes of humidity.

CP3/31 **Space Communications Propagation Studies at Lincoln Laboratory.** L.J.RICARDI.
AGARD Conference Proceedings CP 3, 523-528, 5 refs., 1967.
These space communications studies have included the investigation of the propagation characteristics of rainstorms and an attempt to establish a method of predicting the probable path loss due to their existence in a space-communication link. An experiment has been designed to increase the confidence in theoretical calculations and the understanding of the phenomena involved. A radar target with an accurately determined 1 square metre cross-section has been placed in a 1500 nautical mile circular orbit.

CP3/32 A Review of Refraction Effects on the Apparent Angle of Arrival of Signals. B.R.BEAN, R.E.McGAVIN.
AGARD Conference Proceedings CP 3, 529-546, 11 refs., 1967.
Radio signals passing through the atmosphere are refracted due to the changing structure of the radio refractive index, corrections can be made for errors in the angle of arrival. These corrections are most useful if they are based on standard or mean models of the radio refractive index such that surface values can be used as a predictor. A successful method of deriving such a model is found in ray tracing through a representative sample of refractive index profiles and relating refraction variables to surface values using least square techniques. An intensive study of the spectral behaviour of the radio refractive index near the ground emphasizes the dependence of the spectral distribution upon the basic mechanisms involved in the production of atmospheric turbulence

CP3/33 Closing Remarks (Propagation Factors in Space Communications). M ANASTASSIADES.
AGARD Conference Proceedings CP 3, p.547, 1967.
These closing remarks on the 10th Ionospheric Research Committee Meeting highlighted the new light thrown upon the nature of ionospheric irregularities by the use of topside sounders and other techniques as perhaps the most interesting feature of this symposium. Reference was also made to the papers on plasma sheaths and tropospheric propagation.

CP4/1 Separated Flows: Part 1.
AD-809-165 AGARD Conference Proceedings CP 4, Pt. 1, 478 pp., 1966.
N67-19281 The AGARD Specialists' Meeting on Separated Flows was held at Rhode-Saint-Genese, Belgium, from 10th to 13th May 1966. Pt. 1 of the Proceedings contains seven papers on laminar two-dimensional flows and eight papers on turbulent two-dimensional flows. Abstracts of these papers are given in the succeeding items.

CP4/1/1 Base Flow at Low Reynolds Numbers. (In French). H.VIVIAND, S.A.BERGER.
AGARD Conference Proceedings CP 4, Pt. 1, 1-29, 12 refs., 1966.
The title problem is studied by means of the Stokes approximation. Stokes equations are solved, for tv limensional and axisymmetric flows, in the half-space downstream of the base plane, for an arbitrarily given velocity field in this plane. Examples of two-dimensional base lows calculated by means of this solution, are presented, and the influence of various parameters, used to define the flow conditions in the base plane, is studied.

CP4/1/2 Theory of Laminar Separated Flows on Flared Surfaces including Supersonic Flow with Heating and Cooling. J.N.NIELSEN, L.L.LYNES, F.K.GOODWIN.
AGARD Conference Proceedings CP 4, Pt. 1, 31-68, 30 refs., 1966.
A method is developed, based on the Dorodnitsyn method of integral relations, to obtain solutions to the laminar boundary equations for separated flows induced on a plate by a ramp or on a cylinder by a conical flare. The analysis applies at any speed for a boundary layer under the influence of a specified pressure gradient for hot or cold walls, and to supersonic flow in which the pressure distribution is determined by free interaction between the boundary layer and the outer flow. The actual method of solution is by digital computer Systematic calculations have been made to study the effects of Mach number, Reynolds number, and heating and cooling on laminar separation and reattachment. Comparisons between theory and experiment for two-dimensional and axisymmetric flow as well as adiabatic and non-adiabatic flows show generally good agreement. Flow phenomena revealed by the calculations are presented.

CP4/1/3 Separation of Laminar Boundary-Layer Flow past a Concave Corner. M.HOLT.
AGARD Conference Proceedings CP 4, Pt. 1, 69-88, 3 refs., 1968.
Separation of a supersonic laminar boundary layer near a concave corner, due to a free interaction process, is investigated by the Method of Integral Relations. The shearing stress is represented as a two-parameter function of the stream-wise velocity component. Different representations are used in the attached and separated regions, but in both regions they are applied all the way to the wall. The solution of the attached flow equations runs smoothly into that of the separated layer equations. In a typical case, the solution gives a continuously decreasing wall shearing stress and a pressure distribution outside the boundary layer increasing up to and beyond the separation point.

CP4/1/4 Hypersonic Studies of Incipient Separa and Separated Flows. D A.NEEDHAM, J.L.STOLLERY.
AGARD Conference Proceedings CP 4, Pt. 1, 89-119, 13 refs., 1966.
Describes an experimental study of hypersonic flow separation performed in a gun tunnel

Separation of both laminar and transitional boundary layers resulting from interaction with either an incident oblique shock or a wedge compression corner are investigated from Mach 7.4 to 14.5 by schlieren photography and surface measurements of pressure and heat-transfer rate. The time required for the flow to reach a steady condition is shown to be a very small fraction of the typical 25 millisec test time available.

CP4/1/5 **Boundary-Layer Separation and Reattachment with and without Ablation.** D.M.KUEHN, D.J.MONSON.
AGARD Conference Proceedings CP 4, Pt. 1, 121-145, 7 refs., 1966.
Laminar boundary layer separation on ablating and non-ablating axisymmetric bodies was investigated at low Re and hypersonic Mach number. Two classes of models were studied. (i) cylinder-flare models, (ii) blunt-faced base-flow models. Various flare and base angles were tested in order to cover attached-flow and separated-flow conditions. Three ablation materials were used. The flows were studied with the aid of pressure distributions, surface oil accumulations and streaks, burn patterns, and photographs of the glow about models. The results obtained are presented and discussed. Evidence is presented of ablation-induced transition of the boundary layer near separation on one of the models.

CP4/1/6 **Theoretical and Experimental Studies of Separated Flows Induced by Shock-Wave – Boundary-Layer Interaction.** M.S.HOLDEN.
AGARD Conference Proceedings CP 4, Pt. 1, 147-180, 19 refs., 1966.
Describes a theoretical and experimental study of the shock-wave/laminar boundary layer interaction problem. The theoretical analysis describes the attached and separated interaction regions induced by the impingement of an oblique shock on the boundary layer, and by a forward-facing wedge on a flat plate. The experimental study was an exploratory investigation of the shock-wave/boundary layer interaction developed over a flat plate-wedge model.

CP4/1/7 **Numerical Calculation of Separated Flow Fields.** H.U.THOMMEN, R.J.MAGNUS.
AGARD Conference Proceedings CP 4 Pt 1, 181-205, 8 refs., 1966.
A numerical method for the integration of the Navier-Stokes equations for unsteady, compressible flow is discussed. The difference scheme proposed is a two-step Lax-Wendroff scheme, modified to take into account the effects of viscosity and heat conduction. The accuracy and stability of the different scheme are studied theoretically and numerically, using either the full Navier-Stokes equations or the simple Burgers equation. The application to separated flow fields is discussed and some observations on preliminary calculations are presented.

CP4/1/8 **Studies on Laminar and Turbulent Free Shear Layers with a Finite Initial Boundary Layer at Separation.** A.F.CHARWAT, J.DER, JR.
AGARD Conference Proceedings CP 4, Pt. 1, 207-240, 15 refs., 1966.
Initial results of a combined experimental and analytical (numerical) study of the development of a free shear layer originating from an attached boundary layer of finite thickness are described. Calculations for both symmetrical (incompressible) wakes behind an infinitely thin plate and for unsymmetrical (compressible) free shear layers in laminar flow for families of initial profiles are shown, the sensitivity to pressure gradients imposed on the shear layer is demonstrated. Partial experimental data showing the development of turbulent shear layers immediately downstream of separation are included.

CP4/1/9 **Contribution to the Experimental Study of the Isobaric Turbulent Mixing Layer of a Supersonic Flow.** (In French). M.SIRIEIX, J.L.SOLIGNAC.
AGARD Conference Proceedings CP 4, Pt. 1, 241-270, 20 refs., 1966.
Available theoretical results are reviewed, and an experimental investigation (carried out at Mach 3 and 4) is described. The evolution of the velocity, temperature and concentration curves is analyzed, particularly in the area of isobaric turbulent mixing dependent on the pre-existing boundary layer.

CP4/1/10 **Turbulent Supersonic Mixing and its Application to Reattachment Problems.** (In French) R.JACQUES, A.GAILLY
AGARD Conference Proceedings CP 4, Pt. 1, 271-301, 23 refs., 1966.
A new method of determining velocities, mass flows, temperatures and viscous stresses within a turbulent, compressible, isobaric mixing layer is established. It is applicable in the region where the velocity profile may be considered as similar, and when the flow is steady, isoenergetic and two-dimensional. The method may be extended to the case of an axisymmetric flow, and remain valid for laminar flow. The results thus obtained are used for the calculation of the base pressure or the reattachment angle, with or without injection by applying the Korst-Chapman criterion. In view of the disagreement between theoretical and experimental results, a new correlation method based on the experimental results of Carriere is proposed, it is valid for two-dimensional reattachment as well as conical reattachment.

CP4/1/11 **Turbulent Mixing in Supersonic Flow Past Slender Bodies with Large Blowing.** B.L.REEVES.
AGARD Conference Proceedings CP 4, Pt. 1, 303-324, 5 refs., 1966.
Supersonic flow past slender bodies with large blowing from the surface is investigated. If the flow in the blowing region is turbulent, the mean flow may be self-preserving and the equations of mean-motion for constant density flow behind the low shock-wave satisfied by conical forms of the turbulent and mean velocities. By introducing a scalar coefficient of eddy viscosity, solutions of the similarity equations are obtained in terms of a turbulent Peclet. The blowing region is shown to consist of three sub-regions. Quantitative results for the effect of large blowing on the flow about a flat plate and a slender cone are obtained.

CP4/1/12 **The Prediction of Separation and Reattachment Flow Characteristics for Two-Dimensional Supersonic and Hypersonic Turbulent Boundary Layers.** M.E.CHILDS, G.C.PAYNTER, E.REDEKER.
AGARD Conference Proceedings CP 4, Pt. 1, 325-352, 21 refs., 1966.
An analytical technique has been developed for predicting the location of separation and reattachment and the magnitude of the reattachment pressures and gradients in turbulent boundary-layer separation. The method is applicable to free-interaction separations caused by deflected control surfaces or shock impingement, and has been found to give results which agree well with Mach 3 to 8 experimental data. The solution is based on a control volume analysis of the separation bubble.

CP4/1/13 **Fundamentals of the Turbulent Reattachment of a Supersonic Jet.** (In French) M.SIRIEIX, J.MIRANDE, J.DELERY.
AGARD Conference Proceedings CP 4, Pt. 1, 353-391, 11 refs., 1966.
Basic data yielded by previous experiments on turbulent reattachment is surveyed, and a detailed analysis of the recompression field is presented. Various characteristics are brought out (the existence of critical points, and of a law of similarity in the evolution of wall pressures). An attempt has been made to acquire more precise knowledge of the reattachment structure, interferometry methods have made it possible to determine the evolution of the boundary layer thicknesses during reattachment.

CP4/1/14 **Two-Dimensional Turbulent Reattachment as a Boundary-Layer Problem.** J.E.GREEN.
AGARD Conference Proceedings CP 4, Pt. 1, 393-427, 12 refs., 1966
A conventional boundary-layer analysis is extended to treat the development of a steady turbulent wake downstream of a base. Using an iterative process, a solution is obtained in which the outer potential flow and the wake flow are compatible and mutually dependent. The wake calculation takes into account the reversed flow in the "dead-air" region, and the solution includes a description of the reattachment process. Attention is confined to steady, two-dimensional, incompressible base-flows.

CP4/1/15 **Heat and Mass Exchange in the Supersonic Base Region.** C.J.SCOTT, E.R.G.ECKERT.
AGARD Conference Proceedings CP 4, Pt. 1, 429-478, 19 refs., 1966.
The model for the base boundary layer selected for study in this report is a conventional stagnation-point boundary layer. This simplified theoretical flow model limits the applicability of the results to cases in which reattachment and recompression do not occur on the body. The near-wake case in which the flow reattaches to its image flow downstream of the body is analyzed. As the body is not in close proximity to the recompression region and its associated high pressure and high heat flux, the effect of the recompression process on the local and integrated heat transfer characteristics of the body is not direct, but only secondary through the mean base pressure.

CP4/2 **Separated Flows: Part 2.**
AD-809-166 AGARD Conference Proceedings CP 4, Pt. 2, 496 pp., 1966.
N67-19297 Part 2 of the Proceedings of the AGARD Specialists' Meeting on Separated Flows contains four papers on turbulent two-dimensional flows, four papers on three-dimensional flows and seven papers relating to practical problems. Abstracts of these papers are given in the succeeding items.

CP4/2/1 **Investigation into the Effect of Base Bleed on the Flow behind a Two-Dimensional Model with a Blunt Trailing Edge.** P.W.BEARMAN.
AGARD Conference Proceedings CP 4, Pt. 2, 479-507, 11 refs., 1966.
The effects of base bleed on the flow about a two-dimensional model with a blunt trailing edge were examined at Re 1.3×10^4 to 4.1×10^4 based on model base height. The ratio of total boundary-layer thickness at the trailing edge to model base height was approximately 0.4. Measurements were made of base pressure, vortex shedding frequency and the distance to vortex formation.

CP4/2/2 **A Study of the Oscillating Laminar Separated Flow Ahead of a Forward Facing Step Oscillating Transversely to a Hypersonic Free Stream.** R.A.EAST, P.R.WILKINSON.
AGARD Conference Proceedings CP 4, Pt. 2, 509-537, 8 refs., 1966.
An experimental and theoretical study of the title subject is reported. The experimental results show that the separated flow region does not behave in a quasi-steady manner and that appreciable phase differences exist between the movement of the separation point and that of the step. The experiments were performed in a hypersonic gun tunnel at Mach 8.4 to 12.5 and unit Re of 10^6 to 10^7 per ft. The theoretical work suggests certain parameters upon which the characteristics of this phenomenon depend; these are examined in the light of the experimental results.

CP4/2/3 **The Conditions of Separation and Vortex Formation Past Cylinders.** A.NAUMANN, M.MORSBACH, C.KRAMER.
AGARD Conference Proceedings CP 4, Pt. 2, 539-574, 13 refs., 1966.
Summarizes the results of experiments on flow pattern and flow-separation conditions past circular cylinders and through cylinder gratings. Deals with the interaction between local shock-waves and boundary layer separation in flow regimes at critical Mach number. Describes experiments on conditions of separation at super-critical Re in incompressible flow. The speeds at which the experiments were conducted range from low values of Mach numbers to high subsonic Mach numbers at which choking occurred.

CP4/2/4 **The Instability and the Formation of Vortices in a Free Boundary Layer.** A.MICHALKE, P.FREYMUTH.
AGARD Conference Proceedings CP 4, Pt. 2, 575-595, 29 refs., 1966.
The instability and the formation of vortices in free boundary layers are investigated for large Re, experimentally by means of the hot-wire technique and theoretically by means of the inviscid linearized stability theory of spatially growing disturbances.

CP4/2/5 **Three-Dimensional Effects in Shock-Separated Flow Regions Ahead of Lateral Control-Jets Issuing from Slot Nozzles of Finite Length.** F.MAURER.
AGARD Conference Proceedings CP 4, Pt. 2, 597-634, 27 refs., 1966.
The separated flow field ahead of side-jets expanding from slot nozzles of finite length into supersonic free jet wind tunnel flows is investigated by means of pressure distribution measurements, surface oil-flow pictures and schlieren pictures. The experimental evidence provides a basis for an analytical approach to the problem. The results of iterative flow-field calculations agree rather well with the experiments.

CP4/2/6 **Shock Wave-Laminar Boundary-Layer Interaction: Integral Analysis and Experimental Results.** A.MARTELLUCCI, F.W.LIPFERT.
AGARD Conference Proceedings CP 4, Pt. 2, 635-665, 17 refs., 1966.
The shock wave-boundary layer interaction problem is considered from two aspects: (i) an integral method for analyzing laminar flows; (ii) an experimental study of impinging shocks at Mach 5.4 under laminar and transitional conditions. The analysis considers the general case of a planar shock wave which is swept with respect to the flow external to the boundary layer.

CP4/2/7 **A Theoretical and Experimental Investigation of Secondary Jets in a Mach 6 Free Stream with Emphasis on the Structure of the Jet and Separation Ahead of the Jet.** J.R.STERRETT, J.B.BARBER.
AGARD Conference Proceedings CP 4, Pt. 2, 667-700, 19 refs., 1966.
The experimental phase of the programme reported consisted of an investigation of free jets exhausting against a flat plate, including interferograms taken with a laser grating interferometer, and an investigation conducted in a Mach 6 wind tunnel with secondary jets of various exit Mach numbers issuing perpendicularly from a flat plate. The theoretical investigation included the calculation of various free jet patterns by the use of the two-dimensional characteristic theory for various boundary conditions and the examination of various shock calculations for different shock patterns.

CP4/2/8 **Dynamics and Thermodynamics of Separated Flows.** H.H.KORST.
AGARD Conference Proceedings CP 4, Pt. 2, 701-746, 29 refs., 1966.
Finite velocities within wakes account for convective mechanisms controlling energy transfer to and across separated flow regions. Here, the wake flow problem is approached by formulating consecutive systems approaches for the "dissipative flow model" and the "heat transfer model" A critical evaluation of the present theory was effected partly from previously obtained experimental results and partly from specially initiated experiments which are reported.

CP4/2/9 **A Study of Axially Symmetrical Base Flow Behind Bodies of Revolution at Supersonic Speeds.** J.S.A.DE KRASINKI.
AGARD Conference Proceedings CP 4, Pt. 2, 747-778, 29 refs., 1966.
Detailed tests were made in the wake of axially cylindrical adiabatic models at Mach 1.48 and 2.55 covering the laminar, transitional and turbulent Reynolds number range. The tests included inverted flow measurements, and indicated that the separated flow field behind the base forms a system where the mixing processes in the throat, the final energy level of the dividing streamline, and the intensity of the returned mass flow are connected together organically. This point of view reconciles the contradictory tenets of the dividing streamline and Crocco-Lees theories without accepting details.

CP4/2/10 **Some Results of Investigations of Separation Bubbles.** A.D.YOUNG, H.P.HORTON.
AGARD Conference Proceedings CP 4, Pt. 2, 779-812, 6 refs., 1966.
Work carried out to-date at Queen Mary College on separation bubbles is briefly reviewed. Pt. 1 deals with two-dimensional bubbles as measured (i) on aerofoils and (ii) on a flat plate, with a suitable pressure distribution induced by a nearby auxiliary wing and also by a porous cylinder with circulation control provided by suction and a Thwaites flap. Pt. 2 deals with three-dimensional bubbles on a swept plate similarly induced by a swept porous cylinder with a Thwaites flap. The results of streamwise and cross-flow velocity measurements, as well as pressure measurements, are presented and compared with the two-dimensional results.

CP4/2/11 **The Structure and Behaviour of Laminar Separation Bubbles.** M.GASTER.
AGARD Conference Proceedings CP 4, Pt. 2, 813-854, 9 refs., 1966.
Laminar separation bubbles formed under a wide range of Re and pressure distributions were studied. Bubble structure depended on the value of Re of the separating bounding layer and a parameter based on the pressure rise over the region occupied by the bubble. Conditions for the bursting of "short" bubbles were determined by a unique relationship between these two parameters. Hot-wire measurements of both mean and fluctuating velocity in the separated region together with oscilloscope records of the fluctuations explain some of the flow mechanisms involved.

CP4/2/12 **The Separation of the Turbulent Boundary Layer as Influenced by Blowing, Suction, Moving Wall, and Propeller Slipstream.** K.GERSTEN.
AGARD Conference Proceedings CP 4, Pt. 2, 855-886, 6 refs., 1966.
A short report is presented of an experimental investigation of the effect of different means of boundary layer control (blowing, suction, rotational velocity, and propeller slipstream) on separation of the turbulent boundary layer.

CP4/2/13 **The Wake Pressure Behind Wedges as Influenced by Splitter Plates and Suction.** M.TANNER.
AGARD Conference Proceedings CP 4, Pt. 2, 887-909, 8 refs., 1966.
Investigations were made of the base pressure on isosceles wedges in two-dimensional incompressible flow; the measurements obtained related to the effect of splitter plates of various lengths and of suction through a long porous splitter plate. A theory of wake flow, based on these experimental results, has been established. The amount of incoming flow and of the outgoing flow of the closed wake bubble are shown to be the significant parameters. An equation was derived relating the base pressure and drag coefficient to the amount of outflow of the wake.

CP4/2/14 **Theoretical Analysis of Launch Vehicle Base Flow.** R.J.DIXON, R.H.PAGE.
AGARD Conference Proceedings CP 4, Pt. 2, 911-940, 17 refs., 1966.
An analytical model of the flow field at the base of a vehicle with propulsion nozzles has been developed. The model has been used to calculate the heat transfer at the base stagnation point. The pressure distribution and other flow field parameters are also determined for the base region. The theoretical analysis and a typical comparison with experimental data are presented.

CP4/2/15 **Wind Tunnel Experiments on Unsteady Cavity Flow at High Subsonic Speeds.** B.M.SPEE.
AGARD Conference Proceedings CP 4, Pt. 2, 941-974, 6 refs., 1966.
The investigation reported is part of an experimental programme on the interaction between sound waves and two-dimensional transonic flows. The purpose of the present experiments is to examine whether the sound field radiated by the cavity system would be suitable for such interaction studies. The tests were performed on a two-dimensional cavity system consisting of a rectangular gap connected with a resonance chamber. The flow speeds covered were Mach 0.4 to 0.85. The investigation involved schlieren and shadowgraph observations as well as measurements of the frequency and intensity of the radiated field.

CP4/3
AD-654-539
N67-30134

Discussions Following the Presentations of Papers at the AGARD Fluid Dynamics Specialists' Meeting on "Separated Flows". J.GINOUX, H.UEBELHACK (Editors).
AGARD Conference Proceedings CP 4, Supplement, 42 pp., 1966.
The proceedings of the AGARD sponsored meeting on Separated Flows were published in AGARD Conference Proceedings No. 4, with the exception of a paper by Dr. Weinbaum which was published separately as AGARD Report No. 526. This supplement contains the texts of the discussions which followed the presentation of the papers at the above meeting.

CP5
AD-804-361
N67-13061

Optoelectronic Components and Devices.
AGARD Conference Proceedings CP 5, 446 pp., 1965.
The texts of the twenty-three papers on the title subject which were presented at the Ninth Meeting of the AGARD Avionics Panel (held in Paris from 6th to 9th September, 1965) are reproduced in these Proceedings. Abstracts of the individual papers are given in the succeeding items.

CP5/1

Semiconductor Optoelectronic Devices. E.L.BONIN.
AGARD Conference Proceedings CP 5, 1-22, 1965.
In considering the use of a semiconductor non coherent photon-emitting diode in combination with a semiconductor photo-detector in a single miniature package, the following aspects are discussed: the state-of-art characteristics of emitting diodes, fabrication techniques for photon-coupled devices, limitations and problems to be overcome, and possible trends and future developments.

CP5/2

Lasers for Digital Devices. W.F.KOSONOCKY.
AGARD Conference Proceedings CP 5, 23-77, 44 refs., 1965.
Continuously pumped lasers are considered as components for digital circuits in which all of the processing signals are in the form of optical energy. The operation of the laser digital circuits is based on signal gain derived from a laser amplifier and non-linear (saturable) response of optical materials to laser signals. A laser inverter, a laser bistable oscillator and a laser monostable oscillator are examined as switching devices that could be implemented with GaAs lasers. The GaAs laser is further evaluated as a general purpose switching device, and experimental tests with this device are reported.

CP5/3

Optical Pusle Amplifiers with Active Saturable Absorption Switches. D.ROESS.
AGARD Conference Proceedings CP 5, 79-90, 6 refs., 1965.
Lasers are interesting as logical elements because of the extremely fast risetime of laser amplifiers. These very short times can be utilized in logical units only if all processes are performed by light signals in a light-light logic. A promising way to the realization of a light-light logic is founded on the effect of saturable absorption which was first used as a means for passive switching in giant-pulse lasers. Here, basic considerations relating to active switching are treated.

CP5/4

Coupling Problems between Transistor Logic and Electroluminescence-Photoconductor Logic. H.N.TOUSSAINT, W.SCHMIDT.
AGARD Conference Proceedings CP 5, 91-104, 2 refs., 1965.
Electroluminescence-photoconductor logic (EL-PC logic) qualifies for use at the output end of transistorized data processing systems. Difficulties arise however in the transition from transistor logic (T-logic) to EL-PC logic. The possible coupling circuits between T- and EL-PC logic are discussed and compared with respect to switching time and useful time.

CP5/5

A Possible Electron Image Information Store. A.D.BERG, R.W.SMITH.
AGARD Conference Proceedings CP 5, 105-112, 2 refs., 1965.
A comprehensive system of computer logic can be developed using the opto-electronic NOR gate proposed by Cooke-Yarborough et al. In this system logical interconnections are made by light signals using fibre optics. The logic elements can be stacked to form a two-dimensionsl array and the information passed through the computer as a picture made up of light and dark points. A store suitable for these information pictures is proposed which uses an NOR gate. From results obtained, it is shown that 100 pictures can be stored, the total capacity of the store is 4×10^5 bits.

CP5/6

An Image Storage Tube. A.E.HUSTON, J.BALDERSTON, D.A.PROCTER.
AGARD Conference Proceedings CP 5, 113-127, 5 refs., 1965.
A complete design for a two-stage storage tube, capable of storing vacuum ultra-violet image information and reproducing it as an electrical signal, is given, The expected performance l been calculated, and several of the component parts have been assembled and tested. The second stage, which is an image storage tube in its own right has been developed to a stage where a working model is now under test.

CP5/7 **Electro-Optic Crystals and Their Use for Light Modulation.** A.R.JOHNSTON.
AGARD Conference Proceedings CP 5, 129-164, 121 refs., 1965.
Aspects of the title subject treated include: introduction and applications; the piezo-optic contribution; the measurement technique; experimental results for $BaTiO_3$; review of properties of electro-optic crystals. An appendix gives a formal description of these electro-optic effects.

CP5/8 **Low Power, Wide Bandwidth Laser Modulators.** J.L.HOBART.
AGARD Conference Proceedings CP 5, 165-177, 6 refs., 1965.
Recent advances in electro-optic modulators now permit large modulation band-widths at low driving voltages. Present emphasis centres on three classes of devices: temperature-compensated transverse Pockel's effect type, multiple-cell type using the longitudinal Pockel's effect, and the room temperature paraelectric perovskites. The physical principles of each of these devices are reviewed and their present state of development summarized. Examples of the application of these devices to optoelectronic systems are given.

CP5/9 **Electro-Optical Image Synthesis and Communications by Holographic (Wavefront-Reconstruction) Methods.** G.W.STROKE.
AGARD Conference Proceedings CP 5, 179-202, 20 refs., 1965.
Three new areas of holography (wavefront-reconstruction imaging and applications) are presented: (i) Fourier-transform holography; (ii) Fourier-transform holography with extended sources; and (iii) holography with double-exposed (or multiple-exposed) holograms, both of which permit image "coding" and "decoding", the latter by successively adding intensities in a single hologram.

CP5/10 **Linearity of Optical Transformations with Coherent Light.** (In French). S.LOWENTHAL.
AGARD Conference Proceedings CP 5, 203-212, 11 refs., 1965.
Under coherent illumination an optical instrument always gives a linear object-image correspondence in complex amplitude; however, it is generally not invariant with translation, which may strongly affect its response. The conditions for achieving invariance with translation under coherent illumination, over a wide field, are determined and it is shown that these conditions are a prerequisite for optical data processing.

CP5/11 **Modulation of Coherent Optical Signals by Franz-Keldysh Effect Devices.** B.T.FRENCH.
AGARD Conference Proceedings CP 5, 213-235, 9 refs., 1965.
The Franz-Keldysh effect is currently being investigated as a basic mechanism for an optical transmission modulator because it offers a method for rapid control of the optical transmission of a device by the application of an electric field. Several planar devices have been designed and fabricated for use as light modulators and elements of optical function generators. Their design and subsequent evaluation as high speed optical intensity modulators is discussed with respect to transient response, passive and active damage to coherence, modulation range and optical and electrical efficiency. Projected methods of utilizing these devices to provide displays of some real continuous functions of one or two variables, are also described.

CP5/12 **Coherent Optical Signal Processors.** E.C.LAVIER.
AGARD Conference Proceedings CP 5, 237-249, 5 refs., 1965.
A coherent optical signal processor is an electro-optical device that makes use of coherent light sources and diffraction phenomena to perform certain linear operations on input signals. These operations may include: filtering, spectral analysis, and combinations of these to effect autocorrelation and cross-correlation. The way these operations are carried out is discussed. The constituent elements of the optical processor are itemized, and the effect of each of these elements on the processor performance is discussed. Possible applications of optical signal processors are indicated.

CP5/13 **Mosaic Electro-Optical Techniques.** G.STRULL.
AGARD Conference Proceedings CP 5, 251-273, 3 refs., 1965.
Three categories of mosaic electro-optical techniques are considered: the integrated conventional radiation sensor in mosaic form; the molecularized sensor, including its output circuitry, as an all-electrical readout system for sensing radiation; the mosaic system employing electro-optical techniques in the readout circuitry.

CP5/14 **Light Beam Scanning by Optical Signal Processing Techniques.** G.W.JULL.
AGARD Conference Proceedings CP 5, 275-294, 9 refs., 1965.
In the non-mechanical scanning method described, a linear, frequency-modulated, waveform applied to an ultrasonic light modulator is used to form a time-varying diffraction grating. Light diffracted through this grating is filtered and subsequently rediffracted by a second grating to form an image at an angle determined by the difference in frequency between the two gratings at the particular time. This method of forming a phased array at light wavelengths may have application for line-by-line sequential readout of spatially varying signals stored on photographic transparencies.

CP5/15 **Rapid Extraction of Periodic Signals Using Phosphorescent Memories.** (In French). J.N.AUBRUN.
AGARD Conference Proceedings CP 5, 295-304, 2 refs., 1965.
In detecting a periodic signal in the presence of background noise, one of the problems involved is the choice of a suitable memory element. Here, the use of a phosphorescent track as such a memory is described. The phosphorescent track comprises, in effect, a quasi-continuous assembly of filters which are comparable to the channels of a multi-channel sampler; it has, however, the advantages of linearity and of extracting high frequency signals. Such devices find application in electron or nuclear spectrometers.

CP5/16 **Unconventional Optics for Electronic Guidance Systems.** W.A.BOWEN, JR.
AGARD Conference Proceedings CP 5, 305-312, 1 ref., 1965.
The object of this paper was to stimulate interest in the potentialities of unconventional optical collectors and modulators in solving avionics guidance problems. It is shown that in the case of vehicles requiring an aerodynamic spike on the principle axis, optics in the form of an annular ring, with the resulting highly distorted image, may have certain advantages over conventional optical telescopes. Reference is made to well-known optical phenomena with simple illustrations of the physical principles involved.

CP5/17 **Application of an Image Intensifier to Radar Spectrum Analysis.** R.VOLES.
AGARD Conference Proceedings CP 5, 313-327, 1965.
In some coherent radars, it is required to derive the Doppler spectrum of the returns while preserving range resolution. It is proposed that this function may be performed by the use of an image intensifier. In this arrangement, the returns are painted as brightness modulation along the vertical diameter of a CRT having a phosphor decay time of the order of the interval between pulses. This line is projected onto the photocathode of an image intensifier in which a horizontal detection circuit is used to sweep the resultant image across the output phosphor which has a relatively long decay time. Alternatively the light output from a phosphor with a short decay time may be projected onto the signal plate of a camera. During the sweep the gain of the intensifier is varied sinusoidally at a rate dependent on the position of the pulse in the group under analysis. It is shown that the brightness distribution on the output phosphor or the charge distribution on the signal plate then represents the radar energy distributed in range vertically and Doppler horizontally.

CP5/18 **Optoelectronic Aircraft Altimeter.** J.E.HOPSON.
AGARD Conference Proceedings CP 5, 329-343, 18 refs., 1965.
The altimeter design considered is for use at altitudes of less than 50 ft with an accuracy of ± 6 in. at the time of touchdown. The basic optoelectronic components comprise an electron injection laser diode, an optical transmission medium, and a silicon photodetector. Height determination is based on the transit time for a light beam to travel from the laser to the ground and back to the photo detector.

CP5/19 **Electro-optical Processor for Phased Array Antennas.** M.ARM, L.B.LAMBERT, A.AIMETTE.
AGARD Conference Proceedings CP 5, 345-378, 17 refs., 1965.
Results are presented of a theoretical and experimental investigation of electro-optical processing of signals received by a planar array antenna. The signals are converted into proportional ultrasonic waves. The resulting Debye-Sears effect is utilized to modulate spatially laser light in the object plane of a coherent optical system. The spatial distribution of light intensity in the image plane is shown to be a replica of the far-field radiation pattern associated with the received signals.

CP5/20 **A More Flexible Optical Correlator Using Electro-Optical Doppler Replicas.** B.DI TANO.
AGARD Conference Proceedings CP 5, 379-401, 18 refs., 1965.
Presents the results of a theoretical investigation of optical signal processing techniques and describes a correlation technique for the processing of radar signals by means of electro-optical devices arranged in tandem. The electro-optical correlator described represents a modification to the correlators presently used in radars. The two-dimensional (range and Doppler) correlation scheme eliminates the film processing by utilizing a second light modulator. A modification in the ultrasonic light modulator configuration is accomplished which enables it to be used as an electro-optical Doppler replica.

CP5/21 **On the Application of Modern Optical Techniques to Radar Data Processing.** L.J.CUTRONA, E.N.LEITH, L.J.PORCELLO, W.E.VIVIAN.
AGARD Conference Proceedings CP 5, 403-418, 4 refs., 1965.
Coherent optical systems are used for the processing of data collected by side-looking synthetic-aperture radars. This type of radar, which is useful for fine-resolution terrain imagery, has the capability of providing along-track, or azimuth resolution, which is much finer than the azimuth dimension of the radiated beam itself; however, the attainment of this finer resolution requires extensive processing of the received radar signal. Coherent optical systems are well suited to such

processing and a simple optical system can readily convert the unintelligible raw data record into a high-quality radar map, an operation which would require considerable equipment if carried out electronically.

CP5/22 **Optimization of the Emitter and Receiving Components of a Transmission System Using a Non-Coherent Infra-Red Diode Emitter.** (In French). P.LECLERC, D.J.ROULSTON.
AGARD Conference Proceedings CP 5, 419-431, 3 refs., 1965.
Systems for the transmission of information using infra-red carriers present potential advantages in directionality and compactness. The reduced atmospheric absorption at about 9000 Å encourages the use of gallium arsenide emitters. The two most important parameters of systems using such devices relate to the useful power emitted and the sensitivity at reception, these two aspects are the subject of the analyses presented.

CP5/23 **Non-Coherent Optical Communication System.** D.E.WRIGHT.
AGARD Conference Proceedings CP 5, 433-446, 1965.
To demonstrate the usefulness of non-coherent light sources, two promising and recently developed non-coherent optical sources were selected and several experimental voice communication systems built around them. One source was a xenon-hydrogen discharge tube of unconfined arc design while the other was a high power gallium arsenide optical diode. Experiments carried out with these devices are described and the results obtained are presented and discussed.

CP6 **Aircraft Flight Instrumentation Integrated Data Systems.** D.BOSMAN (Editor).
AD-674-171 AGARD Conference Proceedings CP 6, 297 pp., 52 refs., 1967.
N68-29181 This volume contains the proceedings of the 10th Meeting of the Avionics Panel. The twenty papers provide a survey of the methods of data acquisition and their use in improving the design of aircraft by providing a check on vital flight functions and recording where a failure has led to disaster. The book is divided into three parts dealing with (i) requirements for an aircraft integrated data system, (ii) data acquisition and handling, and (iii) methods of protecting and transmitting the data. Abstracts of the individual papers are given in the subsequent items.

CP6/1 **A Survey of Operational Flight Recording in the United Kingdom.** M.E.BURT.
AGARD Conference Proceedings CP 6, 3-16, 1967.
Gives a broad survey of past, present and possible future activities in the UK in the field of recording data by means of automatic instruments during operational flights of civil and military aircraft. Emphasis is placed upon the reasons for doing the work, the value obtained from the results, and the scale of the effort involved. Recording and analysis techniques are also described. Recent developments of recording for airworthiness purposes, accident data recording, maintenance data recording and also recording for operational purposes are presented. Possible future developments are considered.

CP6/2 **Use of In-Flight Data Recording for the Air Forces of Central Europe.** M.A.BOUVET.
AGARD Conference Proceedings CP 6, 17-20, 1967.
Gives a short description of three exercises in order to outline the requirements for a mission performance recording system. The evaluation methods presently in use are briefly described and the problem areas, where a suitable recording system could be used to advantage, are discussed. Finally the basic requirements are given.

CP6/3 **Airline Requirements Regarding Total System Flexibility Aids.** H.C.VERMEULEN.
AGARD Conference Proceedings CP 6, 21-32, 1967.
Based on past experience with airborne recording, the point that "AIDS" still is in a metamorphosic state and that the selections of hardware should reflect this by built-in flexibility is stressed. It is in the nature of the AIDS-concept that the characteristics of an airline operation will demand AIDS to help solve ever-arising new problems and overcome new constraints faster. The author, directed by experimental results, points to specific areas where flexibility is important to long-term system effectiveness.

CP6/4 **A Recording System Designed for Airline Fleet Fitment, Primarily Intended to meet Ministry of Aviation Mandatory Requirements.** P.WALLER.
AGARD Conference Proceedings CP 6, 33-46, 1967.
The purpose is to trace the history of the introduction of a flight data recording system to meet Ministry of Aviation mandatory requirements for civil aircraft. A technical description of the airborne and ground equipment is given, with particular emphasis on the reason for adopting the various techniques and materials described, and on the validity of data so recorded. Application of the system, firstly as a tool for investigation into the economic benefits of recording for maintenance purposes, and secondly to maintenance recording itself, is described. Various experiments intended to assist with this investigation are outlined, and results given.

CP6/5 **Requirements for a Flight Data Acquisition System.** A.S.LUCKING.
AGARD Conference Proceedings CP 6, 47-57, 1967.
This chapter reports the experience of a major airline in the application of flight recording during rourine airline operations and discusses the problems that have arisen. Reference is made to various airborne recording techniques, the technical and administrative problems of data recovery, and the background to effective application. The possible reconciliation of mandatory accident and domestic data requirements is discussed and a process by which it is possible to arrive at a statement of the overall requirements for a flight data acquisition system is reported. Particular reference is made to the problems of time compres on within the data processing functions and the prospect of effective data application within the airline complex. An integrated system capable of meeting the requirement is described, and the significance of civil experience is suggested.

CP6/6 **Signal Conditioning in Airborne Recording Systems.** A.POOL.
AGARD Conference Proceedings CP 6, 65-75, 1967.
The function of conditioners in airborne recording and telemetry systems is discussed. It is shown that it is threefold: signal transformation, conservation of static accuracy and reduction of dynamic errors (filtering). These three functions are discussed separately.

CP6/7 **An Aircraft Integrated Data Recording System Using Magnetic Tape.** G.E.BENNETT, R.GILL.
AGARD Conference Proceedings CP 6, 77-96, 1967.
Describes the aircraft data recording and presentation system being developed at the RAE. The system is primarily aimed at meeting the requirements for flight data recording, during normal operations of civil and military aircraft, for airworthiness/accident purposes. A degree of versatility is provided which may extend the application of the system to other purposes of operational data recording, such as aircraft maintenance and operational efficiency. The system uses Pulse Code Modulation on magnetic tape, and its special features include an airborne tape transport and digital recording technique capable of an exceptionally high data packing density.

CP6/8 **In-Flight Data Acquisition by Means of Magnetic Recording and Data Preprocessing by Ground Equipment.** G.LANGER, A.CABALERY.
AGARD Conference Proceedings CP 6, 97-102, 1967.
The AID System described is developed jointly by the Applied Physics Laboratory of Sud-Aviation and the Magnetic Recording Department of the Compagnie des Compteurs. Its characteristics are in agreement with the requirements set forth by the Centre d' Essais en Vol. The paper outlines the features of the airborne equipment and the tape-to-tape converter (air-ground interface) of SEPAL (Système d' Enregistrement Pour Avions de Ligne).

CP6/9 **Operational Experience with an Airborne Magnetic Tape P.C.M. System.** C.LOWE.
AGARD Conference Proceedings CP 6, 103-114, 1967.
Brief descriptions of the two P.C.M. systems used for Belfast flight testing are given. Both systems have both high and low-level inputs, whilst the second system also has digital gates. An account of difficulties experienced with both the transducers and commutators, together with remedial action, is included. Details of calibration procedures found to be necessary for accurate data reduction through all systems, i.e. transducers, commutators and replay equipment, are given, followed by a comparative study of the advantages and disadvantages of the two systems.

CP6/10 **Integrated Data Systems for Engineering Flight Tests.** B.E.MAHON.
AGARD Conference Proceedings CP 6, 115-125, 1967.
Such a system has been developed by Boeing Co. during the past eleven years. The entire system is automatic, from measurement transducers through the airborne recording system and the ground data processing station, to the mathematical computer. The results are tabulated or plotted by machine. The system produces information based on measurements of many variables which undergo complex mathematical operations. With few exceptions, manual reading or calculations are not required at any stage of the data reduction process.

CP6/11 **Flight Load Recording for Aircraft Structural Integrity.** H.M.WELLS, JR.
AGARD Conference Proceedings CP 6, 127-140, 1967.
The requirements for a magnetic tape structural flight loads recorder and the development history are presented. A review of the system requirements for the magnetic tape recorder, the data processing facility and the structural analyses led to the recent development of a unique airborne recorder. This recorder incorporates an airborne solid-state computer to permit only significant data to be recorded and thus reduce the work of the ground processing system. A large-scale data processing system handling one million hours of data a year is described. Long range requirements for Vgh and multi-channel recording systems are presented.

CP6/12 **Monitoring Data from Jet Engines.** H.N.TAYLOR.
AGARD Conference Proceedings CP 6, 141-152, 1967.
Reviews United Air Lines' effort to determine the usefulness of monitoring data from jet engines; the present programme has been developed through several phases. No attempt is made to explore a complete AIDS concept, but some general principles of the "Flight Log Monitoring" programme now in use are applicable to the development of AIDS. The paper presents: (i) an outline of one airline's approach; (ii) some results obtained from hand recorded data; (iii) a short discussion of the influence of the programme on airline operation.

CP6/13 **Aircraft Engine Data Logging and Processing.** P ODOUL, J.SOLLIER.
AGARD Conference Proceedings CP 6, 153-165, 283-289, 1967.
With the development of fully electronic control systems it is becoming possible to consider linking the three operations of regulation, monitoring and maintenance of aircraft engines, by designing integrated airborne systems for logging and processing data essential to the regulation, safety and maintenance of the engine. Certain basic ideas are set down, followed by a description of some types of currently available equipment which can deal with one or another of the problems involved. Lastly a composite system which would be able to handle them all simultaneously is outlined. (The paper is given in full in both French and English).

CP6/14 **The Acquisition and Digestion of Aero-Engine Test Data During Flight Development.** V.A.FISHER.
AGARD Conference Proceedings CP 6, 167-178, 1967.
Gives an outline of the instrumentation techniques being used in the initial flight testing of the Olympus 593B engine in a Vulcan flying test bed (F.T.B.). The bulk of the test data are recorded by a digital data recorder on to magnetic tape. Improvement in accuracy and versatility is gained over conventional methods. A system of automatic reduction of the test data to extract the precise information required is used. Development of the present recording system to include on-line computing is proposed.

CP6/15 **Recorders in USA Civil Aircraft.** F.B.KEMERY.
AGARD Conference Proceedings CP 6, 185-194, 1967.
The Federal Aviation Agency has an interest in three types of airborne recording systems. They are flight data recorders, cockpit voice recorders, and maintenance recorders. Each of these types is treated separately before drawing conclusions with respect to airborne recording in general.

CP6/16 **The Design and Applications of Wire Recorders in Airborne Data Systems.** A.J.HELLIWELL.
AGARD Conference Proceedings CP 6, 195-204, 1967.
The purpose is to demonstrate the merits and limitations of these instruments and, by inference to current achievements and future developments, to show how their particular features can be incorporated to advantage in new aircraft data systems. The characteristics of wire as a recording medium for accident and normal data acquisition systems are discussed. The development of a suitable wire is described and the properties of the latest materials are given. The criteria of wire transport systems are expounded and a description is given of the effects of aircraft environmental conditions on such systems. Overall performance figures for typical recorders are given together with results of tests under laboratory, normal aircraft flight and simulated crash conditions.

CP6/17 **Accident Data Recorder for Military High Performance Aircraft.** D.J.MAUCHEL, J.E.HOWARD.
AGARD Conference Proceedings CP 6, 205-210, 1967.
A description is given of an accident data recording system employing an ejectable recorder capsule. The system was developed jointly by Redifon, Ltd, and RAE. A 1% accuracy is maintained during the severe environmental conditions encountered before a crash. The capsule, carrying a 15 min record, is explosively ejected when a sensor unit indicates that a crash is imminent. The capsule will withstand 600 deg.C for 20 minutes and 1000 g impact. Recovery aids include a parachute, flotation bag and dye marker. The novel error correction system employed is shown to maintain 1% accuracy during extensive climatic, vibration and aircraft evaluation trials.

CP6/18 **Ten Years of Crash Recovery Research.** H.T.STEVINSON.
AGARD Conference Proceedings CP 6, 211-247, 1967.
The conditions under which accident data tapes and their containers tear loose from an aircraft structure and hurtle deep into the earth or smash on hard surfaces are examined. An aerodynamic method of avoiding much of this trouble has been developed over the past ten years in Canada. Its fundamentals are briefly outlined. The accident data tape is kept separate from the maintenance tape, and also kept very light. It can then be installed in a light aerofoil along with a distress beacon at the rear of an aircraft. On early detection of a crash the aerofoil is deployed and flies away with its pay-load and rapidly slows down for a landing.

CP6/19 **The Secondary Radar System as a Means for Transmission of Digital Data from Aircraft to Ground Station.** H.WEIKERT.
AGARD Conference Proceedings CP 6, 249-257, 1967.
A description is given of the Secondary Radar System as it is in use nowadays. The possibilities of using it as a means of more elaborate information transfer between an Air Traffic Control Centre and aircraft are discussed. The sources of interference and the desirability of data protection are treated as well as the maximum data transfer and the probability of the transponder being triggered.

CP6/20 **Communications and Data Handling for Aircraft Trials.** D.W.EMMETT, M.J.POPAY.
AGARD Conference Proceedings CP 6, 259-273, 1967.
A comprehensive flight data handling system is in use for performance analysis of automatic flight control systems. For immediate study the data are displayed on an ultra-violet galvanometer recorder. A digital computer is used to give an edited and calibrated display of selected quantities on a digital to analogue plotter and also to calculate from the time amplitude relationship between input and output the transfer function of the system elements. A statistical investigation of the variation and correlation of quantities is performed by a computer and the results printed out by teleprinter. The current work is aimed at extending the application of these established techniques to computer based analysis and presentation of maintenance and reliability data.

CP7 **Helicopter Developments.**
AD-805-752 AGARD Conference Proceedings CP 7, 567 pp., 1966.
N67-15181 These proceedings comprise the texts of 29 unclassified papers presented at a classified technical meeting held in the NATO Building, Paris from 10th to 14th January, 1966. Abstracts of the individual papers are given in the succeeding items.

CP7/1 **Limitation on the Speed of Pure Helicopters by Problems Arising from Stresses.** (In French). F.LIARD.
AGARD Conference Proceedings CP 7, pp.1-28, 1966.
The speed of helicopters is limited essentially by the increased level of vibration that occurs with increased velocity. Here, the following aspects of this subject are treated: generalities on the origin and development of the exciting forces; production of vibratory forces; problems posed and methods of implementation, transmission of vibratory forces; resonance of structures and mechanisms; improvement of the strength of the most highly stressed components.

CP7/2 **Improvements in Efficiency of Rotors Designed to Provide both Lift and Thrust.** J.PFLEIDERER.
AGARD Conference Proceedings CP 7, pp.29-56, 1966.
A survey of German contributions to research on advanced helicopter systems is presented. It consists of three topics dealing with improvements in efficiency of rotors designed to provide both lift and thrust, and in addition gives some information on compound and stoppable rotor systems.

CP7/3 **Some Contributions to the Problems of High Speed Rotorcraft.** G.KANNAMÜLLER.
AGARD Conference Proceedings CP 7, pp.57-75, 1966
A short survey is given of results and current work at Dornier to increase economically the speed of rotorcraft. Included are some problems imposed by rotors operating at high advance ratios, a comparison of different devices for additional thrust, and a concept for propulsion, yaw control and rotor torque compensation. Two compound helicopter projects, a consequence of these results, are illustrated.

CP7/4 **The Promise of Compounding.** J.M.DRESS, R.R.LYNN.
AGARD Conference Proceedings CP 7, pp.77-111, 31 refs., 1966.
Reviews existing rotorcraft technology; defines some of the major problem areas associated with the concepts; discusses possible improvements which can now be foreseen; and, assuming realistic state-of-the-art advancements, establishes what can be expected to be achieved by the mid-1970's. The approach taken is to establish the probable characteristics of future rotorcraft, then to judge their relative potential with the pure helicopter as the basis of comparison. Essentially, no degradation of the favourable low-speed characteristics of today's helicopter is accepted for the future machines. For this study, turbine-powered, gear-driven, single-rotor machines are used.

CP7/5 **The Promise of Compounding.** A.B.CONNOR.
AGARD Conference Proceedings CP 7, pp.113-126, 7 refs., 1966.
Experience with research compound helicopters indicates that compounding promises high performance, flexibility, and basically good handling qualities. Speeds in the 300-knot range, lift/drag ratios in the range of 7.5 and quiet rotor operation are all within the realm of reality and can be attained with the present state-of-the-art. It appears that the only difficulty in achieving this almost ideal V/STOL aircraft is the execution of the concept.

CP7/6 **Prepared Comments on the Papers by J.M.Drees and A.B.Connor.** G.S.HISLOP.
AGARD Conference Proceedings CP 7, pp.129-131, 1966.
Presents brief comments on the previous two papers. Some of the assumptions made by Drees and Lynn are questioned; the present author also disagrees with their estimate of the weight increase for compounding.

CP7/7 **The Compound Helicopter.** D.M.DAVIES, G.S.HISLOP.
AGARD Conference Proceedings CP 7, pp.133-140, 1966.
The reasons for the revival of interest in the compound helicopter are first outlined. Some of the characteristics of this type of aircraft are then discussed. Problem areas in future development efforts are also examined.

CP7/8 **Range-Endurance-Payload Factors and Their Relative Importance Depending on Mission.**
E.S.CARTER, Jr., J.R.OLSON.
AGARD Conference Proceedings CP 7, pp.141-175, 2 refs., 1966.
In this range-payload capability evaluation of rotary wing aircraft, the following are examined: mission effectiveness criteria, current capabilities, effect of mission requirements, design factors, design efficiency factors.

CP7/9 **A Note on Helicopter Configurations for Increased Range, Speed and Endurance.**
E.F KATZENBERGER.
AGARD Conference Proceedings CP 7, pp.177-189, 1 ref., 1966.
The three configurations which are considered from the point of view of their potential for increased range, speed and endurance are (i) the compound helicopter, (ii) the tilt-rotor helicopter; and (iii) the stowed rotor helicopter.

CP7/10 **An Analysis of Low-Disc-Loading VTOL Aircraft Types.** R.L.LICHTEN.
AGARD Conference Proceedings CP 7, pp.191-209, 1966.
A comparative design study was made of the more promising low-disc-loading VTOL concepts which combine the VTOL capability of the helicopter with the high speed and efficient cruise of the airplane. The VTOL concepts examined were: slowed-rotor compound; stopped rotor; stowed rotor; tilt-prop rotor; tilt wing; trail rotor. These aircraft were designed for high-speed, low-altitude transport missions requiring a pay load of at least 3,000 lb.

CP7/11 **Stopped/Folded Rotor Vehicles.** R.M.CARLSON.
AGARD Conference Proceedings CP 7, pp.211-223, 5 refs., 1966.
A report of research at Lockheed on such vehicles is given. Studies have been concerned primarily with high-speed, low disc loading applications. An experimental programme on the feasibility of stopping and starting a rotor in forward flight was initiated. Results obtained are reported as is an experimental evaluation of design criteria and the aerodynamic performance of stopped/folded rotor configurations. Brief details are also given of the application of this configuration to the short-haul transport requirement by McDonnell Aircraft Corp.

CP7/12 **Remarks on High Speed and Payload Capability of Rotary-Wing Aircraft.** W.Z.STEPNIEWSKI.
AGARD Conference Proceedings CP 7, pp.225-252, 8 refs., 1966.
High speed aspects of various rotary wing configurations (compound helicopter, stopped/folded rotor, folded and retracted rotor, etc.) are first discussed. Relative payload/time-on-station and relative payload/range characteristics are then examined. Finally, a brief consideration of the suitability of different configurations for various missions is presented.

CP7/13 **Heavy Lift Helicopter with Jet Flaps.** (In French). R.DORAND.
AGARD Conference Proceedings CP 7, pp.253-280, 4 refs., 1966
The general characteristics of rotors incorporating jet flaps, and the control characteristics of helicopters incorporating such rotors are first discussed. An evaluation of a proposed multi-purpose heavy-lift helicopter with such a rotor system is then presented. Finally, reduction of the rate of vibration and the maintenance costs are considered.

CP7/14 **The Turbogyre 330.** (In French). R.MOUILLE.
AGARD Conference Proceedings CP 7, pp.281-293, 1966
The "Turbogyre 330" aircraft, which is a combined helicopter-autogyro, has been designed by Sud-Aviation to meet the specifications issued by different NATO nations for a tactical utility VTOL aircraft. Its major design feature is the use of gas generated by two podded jet engines mounted on either side of the fuselage with a view to ensuring actuation of a turbine, coaxial with the rotor and driving this rotor by means of an epicyclic gear, or propulsion by reaction combined with a turbo-fan type thrust booster. A full description and performance details of the "Turbogyre 330" are given.

CP7/15 **Sud-Aviation Project for a Combined Turbo-Rotor.** (In French).
AGARD Conference Proceedings CP 7, pp.299-315, 1966.
This project is for a "Turbo-Rotor" aircraft capable of meeting interservice requirements and offering qualities of simplicity, ease of maintenance, and safety. The simplicity of design stems from the elimination of all mechanical transmission components. Gases ejected from two Rolls-Royce RB189 jet engines are used to drive the rotor during take-off, landing and slow flying; at other times the rotor is autorotative. For high-speed flight, propulsion is by two GE T-64 turbo-props or two jet engines (Lycoming PLF IB2 or BS309).

CP7/16 **Advanced Configurations Proposed for High Speed and/or Range-Endurance-Payload Considerations: Contributions to the Round Table Discussion.** L.KINGSTON, C.FISCHER.
AGARD Conference Proceedings CP 7, pp.317-325, 1966.
The remarks by Kingston relate to high speed performance (the pure helicopter with optimum geometry rotor, compound helicopter, new systems of blade motion control) and payload-range-endurance. Fischer's comments concern the limitations of the pure helicopter, projects under development and the convertible helicopter.

CP7/17 **Large Rotors with Mechanical Drive.** R.B.LIGHTFOOT.
AGARD Conference Proceedings CP 7, pp.327-348, 1966.
Gives design details of heavy lift helicopters (HLH) with special reference to the proposed Sikorsky 20 ton payload crane. Aspects covered include: general arrangement, rotor system, rotor head, blades, main gear box, dynamic system, vibration, fuselage, growth trends, economics, configuration selection.

CP7/18 **The Problems of Rotor Drive and the Feasibility of Using Very Large Rotors with Tip Jet-Drives.** U.HÜTTER.
AGARD Conference Proceedings CP 7, pp.349-386, 16 refs., 1966.
Reviews recent research and development work on tip jet drives for helicopters carried out in the Federal Republic of Germany. To a certain extent, the theoretical studies and the results of experimental investigations concentrated attention on the question whether "mixed cycle" or "hot cycle" would be more effective when using very large rotors with tip jet drives.

CP7/19 **Factors Governing the Design of Tip Jet Engines.** G.L.WILDE, P.A.TAYLOR.
AGARD Conference Proceedings CP 7, pp.387-400, 4 refs., 1966.
General requirements of the tip jet engine (engine size, specific fuel consumption, noise, environmental factors); considerations affecting the design of a tip jet engine of 150 lb thrust (general, engine design data, engine cycle and aerodynamic layout, engine bearings, fatigue problems, noise, installation); engine problems requiring further investigation; general conclusions.

CP7/20 **Alternatives to Large Single Lifting Rotors.** C.W.ELLIS.
AGARD Conference Proceedings CP 7, pp.401-422, 1966.
A review is presented of heavy lift helicopter systems based on the use both of single helicopters and of two or more helicopters operating together (multilift). For the single helicopter case, the effect of the number of lifting rotors on rotor drive system, and fuselage weights is reviewed. For the multilift case, at the same level of mission availability, multilift offers a significantly reduced system weight empty for a payload mix as high as 60% at sixty-ton-payload and 40% at twenty-ton-payload, when compared to separate twenty- and sixty-ton-payload aircraft capable of doing the same task.

CP7/21 **Advanced Flight Control Concepts for VTOL Aircraft.** R.B.TRUEBLOOD.
AGARD Conference Proceedings CP 7, pp.423-439, 1 ref., 1966.
The results of a systems oriented approach to obtaining desirable handling qualities in VTOL aircraft are discussed. Major emphasis is on the hovering and low-speed flight regimes. The effects of such factors as control task, external conditions and aircraft characteristics on the flight control responses necessary to provide precision flight are considered. The desirability of ground-referenced stabilization for the translational motions of the aircraft is discussed along with the system concepts necessary for a practical implementation.

CP7/22 **All-Weather Approach and Landing for Helicopters.** D.F.FANCE, H.B.JOHNSON.
AGARD Conference Proceedings CP 7, pp.441-451, 1966.
Summarizes work carried out at R.A.E. into the problems of aircraft handling during approach, and the development of a guidance equipment suitable for use by VTOL aircraft. Aspects treated include: operational requirements; aircraft performance limitations; piloting and approach aids; terminal navigation; future development of pilot aids; radio guidance environment; approach aid techniques.

CP7/23 **The Case for Inherent Stability of Helicopters.** J.P.REEDER, R.J.TAPSCOTT, J.F.GARREN, Jr.
AGARD Conference Proceedings CP 7, pp.453-472, 11 refs., 1966.
It is postulated that stability and/or control augmentation will be used for advanced, higher performance helicopters. Here, the following topics are discussed: the nature of the stability characteristics of concern; the trade-off in applying augmentation to achieve the desired flying qualities, and minimum requirements for inherent stability should the augmentation fail.

CP7/24 **Special Problems in Helicopter Handling Qualities as Influenced by Anti-Submarine Warfare Requirements.** J.R.WILLIFORD.
AGARD Conference Proceedings CP 7, pp.473-478, 1966.
The US Navy is currently employing the Sikorsky SH-3A for ASW; areas in which improvements in handling qualities are required for the ASW mission using this machine are listed. More generally applicable improvements related to the control and use of helicopters are then discussed.

CP7/25 **The Reliability and Maintainability of the Wessex HAS 1 Helicopter.** H.G.SPURR.
AGARD Conference Proceedings CP 7, pp.479-486, 1966.
The HAS 1 is a single-engined, single lifting rotor helicopter, developed from the Sikorsky S58. Its principal operational equipment for its ASW role includes: dunking sonar, Doppler radar and an autostabilization system. This paper presents information about the contribution of the different sub-systems and components of the HAS 1 to the total unreliability. A breakdown is given of operational reliability and scheduled and unscheduled maintenance

CP7/26 **Sikorsky Aircraft's Reliability and Maintainability Design Philosophies and Programs.** E.S.CARTER, Jr., E.F.STOLPER.
AGARD Conference Proceedings CP 7, pp.487-504, 2 refs., 1966.
At Sikorsky Aircraft the approach to reliability and maintainability is that the ultimate responsibility for all design attributes must rest with the detail designer. There are many ways in which staff support provides considerable assistance to the designer however. The implementation of this policy is discussed.

CP7/27 **Designing for Reliability Using the UH-1 M & R Field Program Data.** J.A GEAN.
AGARD Conference Proceedings CP 7, pp.505-531, 1966.
This paper is concerned with reliability of helicopters during the period from the delivery of the first batch of production machines until they have accumulated at least 2,000 flying hours. Throughout, reference is made to the Bell Helicopter Co UH-1 Maintainability and Reliability Program.

CP7/28 **A Study of the Effects of Simultaneous Development and Production Programs upon Measured Reliability.** R.B ARONSON.
AGARD Conference Proceedings CP 7, pp.533-541, 1966.
The urgent needs of the military services require that the time from drawing board to field assignment of aircraft be minimized. This requirement had certain effects upon the measured reliability of a Boeing-Vertol military helicopter presently in production. This report is intended to illustrate these effects upon the reliability of early aircraft.

CP7/29 **Vibration Control in Rotary-Winged Aircraft.** D.E.BRANDT.
AGARD Conference Proceedings CP 7, pp.543-567, 22 refs., 1966.
The current status in vibration control is discussed and presented from the technical and financial standpoints, each of six steps is illustrated by specific results. The necessary research and development programmes to improve vibration control technology are described, illustrated by preliminary results where applicable, and discussed from the standpoint of technical advantages, engineering compromises involved and the magnitude of research and development programmes needed for implementation.

CP8/1 **Fundamental Studies of Ions and Plasmas: Volume 1.** H.D.WILSTED (Editor).
AD-805-749 AGARD Conference Proceedings CP 8, 1, 384 pp., 1965.
N67-15221 A Specialists' Meeting on the same subject, sponsored by the AGARD Propulsion and Energetics Panel, was held in Pisa, Italy, from 6th to 10th September, 1965. The topics dealt with in the 26 papers presented concerned: production and reaction of ions in flames, plasma diagnostics and the interaction of electromagnetic radiation with plasmas and flames. Volume 1 contains eight papers on the first of these topics and four papers on plasma diagnostics. Abstracts of the individual papers are given in the succeeding items.

CP8/1/1 **Ionization in Hydrocarbon Flames.** H.F.CALCOTE
AGARD Conference Proceedings CP 8, 1, pp 1-42, 42 refs., 1965.
Experimental observations on ionization in hydrocarbon flames are summarized in the form of a series of factual statements, and the twelve most probable ionic flame reactions are derived from these statements. The reaction mechanisms involving ionic species are sufficiently well understood for the flame to be considered as a medium for measuring reaction rates involving ions.

CP8/1/2 **Proce·es of Ionization and Recombination of Metallic Additives in Flames.** T.M.SUGDEN.
AGARD Conference Proceedings CP 8, 1, 43-64, 40 refs., 1965.
Alkali metals and alkaline earth elements are important sources of flame ionization as they have markedly lower ionization potentials than other constituents of flame gases. Hypotheses relating to the mechanisms by which the alkali ions are formed are discussed, including the thermal ionization characteristics of the flame. Addition of a halogen may increase the electron concentration in a flame; it is concluded that a mechanism in which the halogen acts as a homogeneous catalyst is operative. Discussion.

CP8/1/3 **Fositive Ion Collection By Spherical Probes in High Pressure Flame Plasmas.** I.W.SALTER, B.E.L.TRAVERS.
AGARD Conference Proceedings CP 8, 1, 65-80, 4 refs., 1965.
The continuum theory of Su and Lam for positive ion collection on a spherical probe operating at high pressure was investigated for seeded hydrogen-oxygen-nitrogen flames at atmospheric pressure. The results obtained (some of which do not agree with the theory of Su and Lam) were applied to subatmospheric pressure acetylene-air flames to estimate ion densities in these flames; values obtained by the direct application of the theory of Su and Lam were several orders of magnitude too high.

CP8/1/4 **Surface Effects in Seeded Combustion Products.** D.L.TURCOTTE.
AGARD Conference Proceedings CP 8, 1, 81-122, 40 refs., 1965.
Current-voltage characteristics of a double probe were obtained in the combustion products of a seeded, atmospheric-pressure, alcohol-air flame. Sodium hydroxide, potassium hydroxide and caesium chloride were the seeding compounds. The appropriate continuum sheath theory is developed. The properties of the combustion products are calculated using the measured temperature. Partial dissociation of the seed molecules and electron attachment to the hydroxyl radical are considered. The dependence of the saturation currents on the electrode temperature is explained by thermal emission of electrons from the electrodes. Discussion.

CP8/1/5 **Contributions of Electrons to Ionization in Flame Gases.** A.VON ENGEL, J.R.COZENS.
AGARD Conference Proceedings CP 8, 1, 123-138, 22 refs., 1965.
A brief summary is given of recent work on the origin of ionization in flame gases. It is shown that, in certain flames, the electrons in the flame possess a mean energy which is significantly larger than that of the neutral unexcited gas. The degree of ionization is much greater than earlier theory predicts. The present authors have proposed that electron collisions with molecules are largely responsible for ionization. The way in which ionization occurs, in accordance with this hypothesis is explained, and experimental evidence which supports the electron collision picture is presented. Discussion.

CP8/1/6 **Chemi-Ionization in Gaseous Detonations.** J.R.KELLY, TAU-YI TOONG, CHEE-CHEN TUNG.
AGARD Conference Proceedings CP 8, 1, 139-159, 11 refs., 1965.
A constant-voltage d.c. probe was used to investigate electrical conductivity profiles in acetylene-oxygen and propane-oxygen detonations at sub-atmospheric initial pressures. A clear distinction was found between regions of dominant chemi-ionization and dominant thermal ionization. The rôle played by chemically produced electrons in the early development of thermal ionization, and the rates of decay of electron concentration behind the reaction zone are considered. Discussion.

CP8/1/7 **A Simple Electrostatic Probe for the Measurement of Ion Densities in Atmospheric Pressure Flames and its Application to a Study of Charge Exchange Reactions in Hydrocarbon Flame Gases.** R.G.SOUNDY, H.WILLIAMS.
AGARD Conference Proceedings CP 8, 1, 160-189, 23 refs., 1965.
A description is given of a simple probe technique for measuring accurately local ion density in flame gases with a high degree of spatial resolution; the method was developed along the lines suggested by the continuum theory of Su and Lam. Results obtained during application of the technique to a study of charge exchange reactions between natural flame ions and added metallic elements are also presented. Discussion.

CP8/1/8 **Observations on Negative Ions in Hydrocarbon Flames.** J.A.GREEN.
AGARD Conference Proceedings CP 8, 1, 191-214, 15 refs., 1965.
Spectrometer observations made on flames at atmospheric pressure are reported that extend the scope of earlier work on negative ions with respect to actual species and their dependence on position in the flame and on the amount of hydrocarbon present. The significance of the results obtained is then examined. Discussion.

CP8/1/9 **Physics of Synthetic Plasma Beams.** (In French). J.F.BONNAL, J.GIACOMINI, G.MAINFRAY, C.MANUS, J.MORELLEC, G.SPIESS.
AGARD Conference Proceedings CP 8, 1, 215-278, 13 refs., 1965.
Research work carried out in the Services de Physique Appliquée department of C.E.N.S. on

synthetic plasma sources and beams is described. The work relates to (i) the electron bombardment ion source, (ii) the ion beam (intensity and yields as functions of the parameters of the source), and (iii) ion beam neutralization by electron injection.

CP8/1/10 **Spectroscopic Measurements in Direct Energy Conversion Devices.** H.D.WILSTED, R.T.SCHNEIDER, W.WOERNER.
AGARD Conference Proceedings CP 8, 1, 270-324, 15 refs., 1965.
Re-examines and summarizes the results of various spectroscopic methods used by the Allison Division of General Motors to measure some of the properties of plasmas generated during direct-conversion device investigations. The spectroscopic methods relate to various line reversal techniques for determining plasma temperature. Discussion.

CP8/1/11 **Some R.F. and Spectroscopic Diagnostic Methods of a Helium Plasma in a Magnetic Field.** P.CALDIROLA, V.AGNELLO, N.BARASSI, U.FINZI, M.FONTANESI, E.SINDONI.
AGARD Conference Proceedings CP 8, 1, 325-352, 13 refs., 1965.
Diagnostic methods for a low-density plasma in the presence of a steady magnetic field are described. Plasma was produced in low-pressure helium by an r.f. field. Breakdown fields were measured for several values of the magnetic field and for some container shapes. Electron kinetic temperature was measured spectroscopically. Electron density was evaluated using a method based on admittance measurements. Electron density was also determined by excitation of characteristic resonances. Discussion.

CP8/1/12 **Plasma Energy Transfer to a Surface with and without Electric Current.** E.R.G.ECKERT, E.PFENDER.
AGARD Conference Proceedings CP 8, 1, 353-383, 26 refs., 1965.
Results of heat transfer studies from a hot, dense plasma to a solid surface are presented and discussed with emphasis on the importance of an electron current from the plasma to such a surface. Simple energy transfer models are proposed which appear to be helpful, at least, for a qualitative description of the observed energy transfer phenomena. Discussion.

CP8/2 **Fundamental Studies of Ions and Plasmas: Volume 2.** H.D.WILSTED (Editor).
AD-805-750 AGARD Conference Proceedings CP 8, 2, 345 pp., 1965.
N67-15234 In this second volume of the proceedings of the Specialists' Meeting on the title subject sponsored by the AGARD Propulsion and Energetics Panel, eight papers on plasma diagnostics are followed by six papers on the interaction of electro-magnetic radiation with plasmas and flames. Abstracts of the individual papers are given in the succeeding items.

CP8/2/1 **Diagnosis of a Plasma Beam Extracted from an Electron-Bombardment Ion Source.** W.A.CLAYDEN, C.V.HURDLE.
AGARD Conference Proceedings CP 8, 2, 389-418, 13 refs., 1965.
A plasma beam operating with argon as a working fluid has been built at R.A.R.D.E. (UK). This note describes the facility and the techniques used to calibrate the beam. The model scaling laws are stated and it appears that the facility can simulate a small vehicle moving through the upper ionosphere.

CP8/2/2 **Microwave Interferometer Measurements of The Electron Density Distribution Behind Shock Fronts and Discharge Plasmas.** W.MAKIOS.
AGARD Conference Proceedings CP 8, 2, 419-441, 7 refs., 1965.
Various investigators have shown that in electro-magnetically driven shock waves the luminous front is generated from parts of the discharge plasma, in front of which the shock front is propagating. In order to measure the electron density distribution behind the shock front, microwave transmission interferometric measurements have been made, with use of Lecher wires instead of horn antennae, a space resolution of about half a wavelength was obtained.

CP8/2/3 **On The Correlation of Experimental Data for Non-Equilibrium Seeded Plasma.** R.MONTI.
AGARD Conference Proceedings CP 8, 2, 443-471, 7 refs., 1965.
The available experimental data obtained for d.c. discharges through argon-potassium and argon-caesium plasmas are critically examined and compared with theoretical predictions obtained by using a previously proposed theory and by accounting for Joule heating effects on the plasma bulk temperature.

CP8/2/4 **Determination of Transport Properties of a Plasma from Arc Measurements.** G SCHMITZ, H.J.PATT.
AGARD Conference Proceedings CP 8, 2, 473-494, 15 refs., 1965.
Investigates the various possibilities of determining semi-experimentally the transport properties of a plasma as a function of temperature and pressure from the behaviour of electric arcs. Because there is a quasi-neutral thermal plasma in electric arcs, the basic equations of the single-fluid model of plasma physics are used for this problem. The procedures are applied to nitrogen and argon plasmas.

CP8/2/5 **Ionization Equation of Transparent Plasmas in Non-Equilibrium.** (In French). W.L.BOHN.
AGARD Conference Proceedings CP 8, 2, 495-515, 3 refs., 1965.
For optically thin non-equilibrium plasmas a generalized ionization equation is derived and discussed. With low electron densities, this equation becomes the corona formula, whereas with high electron densities it becomes the Isha equation relative to the electron temperature. Thereby, temperature and ionic charge play a major role. By means of this non-equilibrium equation the components of a helium plasma are investigated with regard to the metastable HeI 2^3S level. Furthermore, an estimate has been made of influence of the metastable level on the temperatures spectroscopically determined.

CP8/2/6 **Laser Interferometer Measurements of Rapid Electron Density Changes in a Plasma.** C.B.WHEELER, A.E.DANGOR.
AGARD Conference Proceedings CP 8, 2, 517-527, 1 ref., 1965.
A He-Ne laser was constructed and used with various specialized types of interferometer to measure plasma electron density. Results of density measurements using a modified Fabry-Perot system are presented as a function of time for a range of discharge parameters. At very high number densities the fringes disappeared. The disappearance has been shown to be due to refraction of the laser beam in the plasma due to radial electron density gradients.

CP8/2/7 **Plasma Diagnostics with Gaseous Lasers.** J.T.VERDEYEN, J.B.GERARDO.
AGARD Conference Proceedings CP 8, 2, 529-572, 25 refs., 1965.
Discusses the principles of the spherical laser interferometer and indicates the optimum geometry from the standpoint of sensitivity, time response, and spatial resolvability. Some experimental results for both pulsed afterglow plasmas and theta-pinch-produced plasmas are presented.

CP8/2/8 **Derivation of The Frequency Dependent Electrical Conductivity of Relativistic Plasmas.** M.BAUS, R.BALESCU.
AGARD Conference Proceedings CP 8, 2, 573-586, 5 refs., 1965.
The statistical electrodynamics of relativistic classical plasmas recently developed in the Prigogine school are used to derive a general framework for the study of material coefficients with spatial and frequency dispersion. Starting from the Liouville equation, the conductivity tensor corresponding to the first order response of the plasma to an arbitrary external electromagnetic field is computed. The Vlassov approximation of this tensor for an isotropic system is calculated.

CP8/2/9 **Electromagnetic Wave Propagation in a Weakly Ionized Plasma.** P.CALDIROLA, O.DE BARBIERI, C.MAROLI.
AGARD Conference Proceedings CP 8, 2, 587-618, 29 refs., 1965.
Starting from the Boltzmann equation for the electronic distribution function and using the multiple-time-scale method, recently introduced by Frieman and Sandi, it is possible to obtain a set of equations which describe the interaction processes between an electromagnetic field and a weakly ionized magneto-plasma. Using this technique the expressions of the electronic distribution function and of the complex dielectric permittivity tensor are explicitly calculated.

CP8/2/10 **Influence of Ionization Non-Equilibrium on Wave Propagation Through Plasma.** L.DE SOCIO, L.G.NAPOLITANO.
AGARD Conference Proceedings CP 8, 2, 619-641, 10 refs., 1965.
The propagation characteristics for plane magneto-fluid-dynamic waves of small amplitude are dealt with in media of finite electrical conductivity taking into account a finite ionization rate. The model describing the plasma is that for an inviscid mixture with variable ionization degree and negligible thermal conductivity, viscosity and diffusion effects. The general dispersion equation for any relative orientations of the external magnetic field B_0 and the wave vector λ is given. The influence and the relative importance of the chemical and electrical dissipation on the wave characteristics are discussed.

CP8/2/11 **Acceleration and Reflection of Plasma Beams by Mixed Structures: H.F. + Static Magnetism.** (In French). R.BARDET, T.CONSOLI, L.DUPAS, R.GELLER, J.LEROY, F.PARLANGE.
AGARD Conference Proceedings CP 8, 2, 643-658, 10 refs., 1965.
Reference is made to the basic principle and the mechanism of the production and reflection of plasma jets. Two types of accelerators are described, measurement methods used are discussed and experimental results are given. The apparatus described functions either with a steady HF field produced by an S band, 500 W d.c. generator, or with a dampened travelling wave HF field, with right circular polarization, produced by an X band, 300 W d.c. generator.

CP8/2/12 **Electron Cyclotron Plasma Thrustor for Orbit Corrective Missions.** H.W.HENDEL, T.J.FAITH, Jr.
AGARD Conference Proceedings CP 8, 2, 659-677, 8 refs., 1965.
An electron cyclotron resonance plasma thrustor at a microwave frequency of 2.45 Gc is described and discussed in relation to an orbit corrective mission for a 1500 lb synchronous satellite. A

laboratory model thrustor operating at a microwave input power level of 50 watts has achieved an electrical efficiency of 30% and a fuel utilization efficiency of 50%. The thrustor system weight for the mission considered is less than one tenth of the weight of the total satellite system.

CP8/2/13 **Microwave Powered Plasma Accelerators.** D.B.MILLER.
AGARD Conference Proceedings CP 8, 2, 679-698, 5 refs., 1965.
Steady state plasma accelerators powered by microwave frequency electric fields are shown to operate efficiently under high-power, steady-state conditions. Details of the experimental studies on a group of microwave-driven plasma accelerators are presented. R.F. probing indicated that under the most efficient conditions, the majority of the interaction occurs in a narrow region out beyond the accelerator exit.

CP8/2/14 **Electromagnetic Wave Interaction with Rocket Exhausts.** W.W.BALWANZ.
AGARD Conference Proceedings CP 8, 2, 699-729, 14 refs., 1965.
The nature of the interactions between electromagnetic waves and an exhaust plasma is established. The path through an underdense plasma may be determined by use of a ray-tracing technique, and the absorption along the path obtained by graphical integration. The path for the waves bent or ducted around an overdense plasma, passing near or through the transition region between the overdense and underdense regions and the underdense regions is not readily established. When the path can be established, the calculation of the signal loss is obtained by graphical integration.

CP9/1 **Gas Turbines.**
AD-815-805 AGARD Conference Proceedings CP 9, Pt. 1, 448 pp., 1966.
N67-29181 Problems of engine integration, with regard especially to VTOL aircraft, problems of by-pass engines, the turbo-ramjet engine in hypersonic aircraft, the problems of stability and control of jet engines with particular regard to VTOL aircraft, and test methods and material applicable to advanced jet engines were all the subject of papers and discussions: the engines foreseen for the near future were considered as well as those at present under development. The unclassified papers presented at the 27th Meeting of the Propulsion and Energetics Panel of AGARD in co-operation with the Structures and Materials Panel, Paris, France on April 4-7, 1966, are reproduced in this volume. Abstracts of the individual papers are given in the succeeding items.

CP9/1/1 **Aerodynamics of Airframe-Engine Integration of Advanced Supersonic Aircraft.** M.R.NICHOLS.
AGARD Conference Proceedings CP 9, Pt. 1, pp.1-44, 51 refs., 1966.
A review from the airframe viewpoint of some major aerodynamic problems involved in the design of the propulsion-system installations of advanced supersonic aircraft. Consideration is given to environmental factors such as flow fields, the airframe boundary layer, airframe-inlet and inlet-inlet shock interference, and jet-airframe interference. New aerodynamic tools available to the designer are discussed and are used along with experimental data to analyze the overall drag minimization problem of multiengine aircraft including consideration of the effects of location, size, shape, and orientation of the nacelles. Finally, detailed attention is given to the problem of optimizing the propulsion system itself from the standpoint of inlet and nozzle selection, flow distortion effects, handling of the various secondary airflows, and afterbody drag.

CP9/1/2 **Factors Determining Engine Installation Drag on Subsonic and Supersonic Long-Range Aircraft.** J.SEDDON.
AGARD Conference Proceedings CP 9, Pt. 1, pp.45-64, 3 refs., 1966.
Discusses three speed categories which are significant in relation to the future development of the gas turbine and the ramjet. They are: (i) high subsonic, (ii) moderate supersonic, and (iii) high supersonic and hypersonic (above Mach 3). The relative methods of reducing drag at these speeds are studied and recommendations are made.

CP9/1/3 **Full Integration of VTOL Power Plants in the Aircraft Fuselage.** H.HERTEL.
AGARD Conference Proceedings CP 9, Pt. 1, pp.65-96, 1966.
The advantages of the lifting power plant within the fuselage are outlined. The problem of this type of installation is that there is insufficient room in present-day cylindrical fuselages. The paper therefore pays considerable attention to the investigation of suitable fuselage shapes, concluding that the "shark" shape offers the greatest advantages. Details are then briefly given of underfloor lift-fan and turbojet installations and also retractable lift-fans.

CP9/1/4 **Problems and Possible Solutions Presented by the Fan of Large Bypass Engines.** G.L.WILDE.
AGARD Conference Proceedings CP 9, Pt. 1, pp.97-108, 1966.
Discusses the relationship between the fan and the gas generator as the design by-pass ratio is increased. Some of the basic aerodynamic design characteristics of the fan are presented, and it is shown how these can influence the fundamental layout of a high by-pass ratio engine. Several alternative proposals are compared.

CP9/1/5 **Ducted Fan Motors of High By-Pass Ratio for Short and Medium Range Programmes -- Adaptation to the Airframe.** (In French). L.BAUGER, C.BOURGAREL, J.CALMON.
AGARD Conference Proceedings CP 9, Pt. 1, pp.109-133, 1966.
It is assumed that the cruising flight is characterized by conditions where M = 0.8, Z = 30,000 ft (short and middle range programme). It is shown that the specific consumption varies very rapidly depending on the values of the following parameters: ratio of the required cruise thrust to the maximum thrust during the take-off phase (reduction of the aircraft cruise drag leads to selecting higher by-pass ratios, determining a total consumption gain due to the decrease of the required thrust and the improvement of the specific consumption), maximum turbine entry temperature during cruise (an increase of the turbine entry temperature makes it possible to select a higher by-pass ratio, resulting in a reduction of the specific consumption). As regards engine integration, it would seem that the nacelles arrangements, at the rear of the fuselage, is adequate for small or average weight aircraft, the nacelles being installed under the wings for the largest aircraft.

CP9/1/6 **Design Consideration of High Bypass Ratio Engines in Subsonic Aircraft.** J.WOTTON.
AGARD Conference Proceedings CP 9, Pt. 1, pp.135-148, 1966.
Discusses: choice of aircraft configuration (number and location of engines), examination of the basic characteristics of high bypass ratio, effect of bypass ratio upon engine pod size, comparison of front and aft fans, installation of chosen engine at rear and underwing, boundary layer ingestion and engine compatibility, drag reduction by integration, component efficiency compromise with high bypass ratio and effect upon noise, promise of improved overall characteristics in the contra-rotating Rostat engine, bypass ratio for long or short range.

CP9/1/7 **Critical Problems in the Application of Turbomachines, Turboramjets and Ramjets to High Speeds.** (In French). A.GOZLAN.
AGARD Conference Proceedings CP 9, Pt. 1, pp.149-176, 1966.
The fundamental characteristics and limitations of turbomachines and ramjets are presented to bring out the need for turboramjet combinations, taking the flight requirements into account. Various combinations of turbomachines and ramjets are depicted. Experience gained from the testing of such mixed propulsion modes is summarized and some of the connected critical problems are explained. The application of pure ramjets is considered and hypersonic problems are discussed.

CP9/1/8 **The Operation of a Combined Turboramjet.** (In French). J.CALMON, C.MENIOUX, J.SHARP.
AGARD Conference Proceedings CP 9, Pt. 1, pp.177-218, 1966.
A brief description of the turboramjet, together with the operation cycle and performance of the by-pass turbojet and of the ramjet is given. Particular attention is then paid to the transition period between the Mach numbers of 2.0 and 2.5; the design of the engine must cover this intermediate range. The initiation of the transition phase is determined by the characteristics of the turbojet, the result is a definition of the ramjet engine geometry which itself determines the end of the transition phase.

CP9/1/9 **The Turboramjet as the Propulsion System for Space Travel Vehicles.** (In French). H.G.MUNZBERG.
AGARD Conference Proceedings CP 9, Pt. 1, pp.219-238, 1966.
Consideration of the performance of air-breathing engines in the supersonic-hypersonic field should include the type of propulsion systems at present operating in this speed range, e.g. chemical rockets. When designing a turboramjet for a given flight programme, account should be taken of the specific consumption, the unit thrust, the drag of the cowled engine and its weight. The design of a turboramjet as a complete propulsion system is discussed and compared with the chemical rocket for use in spacecraft missions.

CP9/1/10 **Review of Requirements for an Engine Used for VTOL Application.** M.CROY.
AGARD Conference Proceedings CP 9, Pt. 1, pp.239-246, 1966.
The evaluation of a jet engine with respect to its use for stabilizing VTOL aircraft has been a difficult problem. This has been mostly due to an incomplete picture of the requirements that need to be fulfilled. However, over the past years experience has been gained in which these requirements have slowly crystallized. This paper reviews these requirements and describes a method for arriving at concrete engine specifications for a given control/stabilization system.

CP9/1/11 **Considerations for Control of Tomorrow's Family of Engines.** A.A.STEFACZA.
AGARD Conference Proceedings CP 9, Pt. 1, pp.247-262, 1966.
Identifies the parameters which must be sensed and the ranges of dynamic and steady state performance which are required to control the engine under development. These are compared with the requirements for currently operating engines. A hypothetical modern engine which encompasses the control problems of lift, lift-cruise, and cruise applications is used as a study model. The "user's problem" is explored from the standpoint of engine and control malfunction detection, component replacement prediction, comparative reliability, and the maintainability – at both the squadron and overhaul levels.

CP9/1/12 **Stability of a Loop Control for Speed and Temperature of a Jet Engine with Variable Nozzle.** (In French). A.STIEGLITZ.
AGARD Conference Proceedings CP 9, Pt. 1, pp.263-274, 1966.
In engine partial load conditions, the variable nozzle makes it possible to select the speed and temperature value to obtain the best cruise fuel consumption, and provides the optimum acceleration and surge protection during transient ratings. The control system of this single-spool straight flow engine operates similarly for dry operation and reheat. The means used to obtain stable operation of this control with three superimposed loops having a mutual dependence on each other are described, together with response time and control accuracy achieved.

CP9/1/13 **Simulator Rig for Control of a Twin-Spool By-Pass Jet Engine with Re-Heat.** (In French). A.RAVAGLI.
AGARD Conference Proceedings CP 9, Pt. 1, pp.275-288, 1966.
This rig, designed by SNECMA, makes it possible to study the dynamic operation of a full-scale fuel control system associated with an anologue computer reproducing transient operating conditions of the engine. Controls are fed with oil or fuel by pumps driven at a constant mean speed, and pick-offs measure the fuel flow and the position of a nozzle simulator jack. These parameters are fed into the computer, which formulates the control parameters as a function of certain selected values typical of flight conditions simulated. The rig makes it possible to study the dynamic operation around a steady operating position if magnitude of variation of various parameters is sufficiently low to maintain the linearization assumptions. A second development step, being pursued, will extend the capacity of this rig to the study of large power setting variations (acceleration – deceleration).

CP9/1/14 **General Review of the New Mechanical Problems Set by Gas Turbines of Advanced Design.** (In French). J.DEVRIESE.
AGARD Conference Proceedings CP 9, Pt. 1, pp.289-308, 1966.
The trends towards high by-pass ratio gas turbines have presented both aerodynamic and mechanical problems. The main effort from the aerodynamic point of view is the reduction in size of compressors and fans. Metallurgical improvements are also necessary. Other problems are lubrication, thermal expansion of rotor and stator, thin structural stiffness, and cooling.

CP9/1/15 **Cyclic Testing for Life Prediction.** D.McLEAN.
AGARD Conference Proceedings CP 9, Pt. 1, pp.309-325, 1966.
It is pointed out that refined analytical stress analysis methods are not sufficiently accurate to ensure minimum weight components with the desired strength and life. This deficiency can be made good by cyclic testing on rigs where the components are subjected to conditions they will experience on the engine. Failures are corrected by changes in design until the optimum component has been reached. Details of testing shafts, casings and discs are included.

CP9/1/16 **Analysis and Testing of Air Cooled Turbine Rotor and Stator Blades.** H.E.HELMS, C.W.EMMERSON.
AGARD Conference Proceedings CP 9, Pt. 1, pp.327-354, 5 refs., 1966.
Advancing turbine engine technology requires air cooled turbines. Cooling mechanisms applied must be exploited in a practical manner to obtain meximum cooling effectiveness. Cooled turbine stator and rotor blade design requires rigorous analysis supplemented by verifying experimental data. Problem definition, analysis techniques, material application, cascade and engine testing, and correlation of data are presented for air cooled turbine. Convection, impingement, film, transpiration and combined cooling mechanisms are reviewed.

CP9/1/17 **Liquid Cooling of Gas-Turbine Blades with Forced Convection.** H.MAY.
AGARD Conference Proceedings CP 9, Pt. 1, pp.355-367, 16 refs., 1966.
Using an organic coolant, experiments were carried out on a cascade at rest for various pressure ratios, coolant flows, coolant temperatures and various cooling-hole arrangements at gas temperatures up to 1200 deg.C (for a short time 1300 deg.C). The temperature decrease within the blade was found to be 500 to 600 deg.C at a gas temperature of 1200 deg.C and a coolant temperature of 200 deg.C. The measured temperature-distribution agrees satisfactorily with analytical results. Only at the leading-edge stagnation point is there a greater difference between calculated and experimental temperatures. For some examples, the influences of the heat, conducted by the coolant, on the efficiency and the specific power of a gas turbine are shown.

CP9/1/18 **Investigations of the Temperature Distribution and Heat Transfer in Gas Turbine Blades.** W.H.DETTMERING.
AGARD Conference Proceedings CP 9, Pt. 1, pp.369-380, 1966.
Two experimental methods were used in investigations on gas turbine blades to determine temperature distribution and heat transfer. Measurements performed on a rotating turbine wheel in operation were supplemented by means of an electrical analogy. A description is given of the experimental gas turbine built for the purpose and of the electrical analogy test stand used. Some of the results obtained are presented, with illustrations, and discussed.

CP9/1/19 **Fabrication Techniques for Turbine Components.** L.P.JAHNKE.
AGARD Conference Proceedings CP 9, Pt. 1, pp.381-412, 5 refs., 1966.
The primary motivations behind the recent evolution of fabrication methods for gas turbine components are described. Examples of the newer and more effective techniques used for direct part consolidation, joining, metal removal and forming are reviewed, showing the equipment required and the hardware which results. Conclusions are drawn about the future trends and the major opportunities which remain to be exploited.

CP9/1/20 **Rolling Bearings and Lubricants for High-Temperature Applications, Particularly in Turbine Engines.** F.COLANZI.
AGARD Conference Proceedings CP 9, Pt. 1, pp.413-434, 1966.
RIV's experience in the field of aircraft turbine-engine bearings is briefly summarized. Tests carried out with high-temperature lubricants are reported, together with technical data on the manufacture and lubrication of aircraft turbine-engine bearings.

CP9/1/21 **Materials Developed for Turbomachine Compressors.** (In French). R.BRUNETAUD.
AGARD Conference Proceedings CP 9, Pt. 1, pp.435-448, 1966.
Outlines the working conditions of compressor blades and casings to highlight the physical requirements of the materials needed to make these components. Light alloys, steels, nickel-base alloys and titanium alloys are discussed. Beryllium and composite structures, in particular with a boron or graphite fibre base, could produce weight savings and solve the brittleness problem.

CP10 **The Fluid Dynamic Aspects of Ballistics.**
AD-805-753 AGARD Conference Proceedings CP 10, 464 pp., 1966.
N67-15361 Contains a collection of the papers presented at the AGARD Specialists' Meeting on "The Fluid Dynamic Aspects of Ballistics". The purpose of the meeting was to review and discuss interior, intermediate and exterior ballistics, to present a good cross-section of the current state-of-the-art, and to provide guidance for future research and development. The papers emphasize the areas: internal ballistics, intermediate ballistics, liquid filled shell, projectile shape, trajectories, stability, base pressure, bomb ballistics, and ballistic measurements. Held in Mulhouse, France, 5-8 September 1966, under the sponsorship of the AGARD Fluid Dynamics Panel. Abstracts of the individual papers are given in the succeeding items.

CP10/1 **Fluid Dynamics Aspects of the Internal Ballistics of Guns.** J.B.GOODE, D.E.WEALD.
AGARD Conference Proceedings CP 10, pp.1-12, 6 refs., 1966.
There are two main fluid dynamics aspects of the internal ballistics of guns. These are the longitudinal flow of the propellant gases in the bore, and the pressure and shock waves which may occur. The longitudinal flow is characterised by a pressure gradient for long associated with the name of Lagrange. Discrepancies between experiment and theory are probably due to the obstruction of the propellant grains to the gas flow. The localised nature of ignition tends to set up pressure waves which can be amplified by passing over burning propellant, and which may develop into shock waves. Other aspects are the gas flow of the barrel after the ejection of the projectile, heat transfer from the gases to the barrel, and recoilless guns.

CP10/2 **Fluid Dynamics of Bulk-Loaded Liquid Propellant Guns.** R.H.COMER.
AGARD Conference Proceedings CP 10, pp.13-36, 17 refs., 1966.
The extant theoretical and experimental work on the instabilities occurring at the interface between two fluids when subjected to acceleration or velocity fields (the so-called Taylor and Helmholtz instabilities) as they pertain to the problem of the interior ballistics of liquid propellant guns, has been reviewed. The relation of these instabilities to the problem of the penetration and break-up of the liquid charge by the cavities produced by the primer and combustion gases is discussed and related to the observed results derived from numerous carefully controlled firings in well-instrumented guns. It is shown that it is possible to account for the observations and derived results in a semi-quantitative way. Finally, an idealized model of the functioning of a liquid propellant gun is presented.

CP10/3 **Determination of the Motion of a Projectile Within the Bore of a 20 mm Gun.** (In French).
G.KRAUTH, H.LUKANOW, G.SCHULTZE, K.ZIMMERMANN.
AGARD Conference Proceedings CP 10, pp.37-47, 4 refs., 1966.
The motion is analyzed with a Doppler effect radar, micro-waves of two different wave-lengths (Q and X bands) being used. The location in time and space of such measurements is checked by means of flash radiography. The motion of the projectile can be calculated owing to simultaneous gas pressure measurements. Integration is carried out according to the conventional internal ballistics method (Piobert's second coefficient, constant = ½ and constant resistance). Results obtained through the Doppler method are compared with those calculated on the basis of the gas pressure variation curve. The correlation between these two types of results is sufficiently satisfactory from the practical standpoint.

CP10/4 **Interior Ballistics Calculation Systems for Light Gas Guns and Conventional Guns.** J.R.B.MURPHY, L.K.BADHWAR, G.A.LAVOIE.
AGARD Conference Proceedings CP 10, pp.49-78, 20 refs., 1966.
Numerical integration methods have been applied by the authors to calculate the fluid dynamics of two stage light gas guns and solid propellant conventional guns. A description of this work and a brief review of other calculation systems is given. The systems developed by the authors use an Eulerian frame of reference, which overcomes sources of error in Lagrangian methods. Stationary and moving propellant charge are considered in the case of the conventional gun and results are compared with very high performance firings. Comments are made regarding possible improvements to and limitations of numerical methods.

CP10/5 **Model Experiments on Muzzle Brakes.** F.SMITH.
AGARD Conference Proceedings CP 10, pp.79-98, 8 refs., 1966.
Describes model experiments made using steady flow. A 7.62 mm rifle was used to substantiate the use of steady flow techniques. Considers in detail a theoretical model for the flow around muzzle brake surfaces, using the available information on free jets. This model fits the experimental results well and could be used to extend the numerous model test results.

CP10/6 **Viscous Corrections to Stewartson's Stability Criterion.** E.H.WEDEMEYER.
AGARD Conference Proceedings CP 10, pp.99-116, 5 refs., 1966.
Stewartson's theory on the stability of a spinning top containing liquid has been successful in predicting instabilities of spin-stabilized, liquid-filled shells. However, discrepancies between theoretical and experimental ranges of instability have been observed. According to Stewartson, the spinning top is unstable whenever its frequency of nutation (or precession) falls within a certain bandwidth about any of the natural frequencies of the liquid. Experimentally it was found that the bandwidth for instability was considerably larger and the central frequency shifted relative to theoretical values. Stewartson's theory was re-examined, taking into account viscous terms in the dynamic equations for the liquid. The modified theory explains both the broadening of the bandwidth and the frequency shift due to viscosity. Comparison with experiments shows excellent agreement.

CP10/7 **On the Shape Design of Projectiles.** P.M.ZANDBERGEN.
AGARD Conference Proceedings CP 10, pp.117-146, 20 refs., 1966.
A discussion is given of the theoretical aspects of a number of factors influencing the design of projectiles. These include the Magnus effect, base drag, the determination of normal forces and the minimization of wave drag. The last two are considered in more detail because they are more dependent on the shape of the projectile. For the minimum wave drag shapes, remarkable results have been obtained, consisting of whole families of low wave drag shapes.

CP10/8 **Mathematical Models of the Trajectory of a Shell.** (In French). P.GODFRIND.
AGARD Conference Proceedings CP 10, pp.147-165, 1966.
Until now, experts in ballistics have used a so-called mathematical model which is simplified to a great extent. The trajectory of the shell can be calculated by means of such a model if one considers only the resistance of the air parallel to the velocity of the centre of gravity of the shell, and gravity. A few years ago, force and moment measurements were very inaccurate; therefore, it was not desirable to introduce in the equations small forces which were poorly known. But nowadays the measurements are much more accurate. Therefore, the question arises: "Should the mathematical model be changed?"

CP10/9 **Perturbation Effects on Rockets.** H.MOLITZ.
AGARD Conference Proceedings CP 10, pp.167-180, 1 ref., 1966.
The accuracy of unguided rockets is influenced by several errors such as incorrect thrust alignment, imbalances, and cross-wind. Considerations of the simultaneous effects of the principal errors give the optimum values for stability and rate of spin. The principal source of error in the case of lateral dispersion is the effect of a cross-wind. Using the extended Didion equation it is shown that several methods can be applied to reduce appreciably the effect of the wind, e.g., to ensure that the first phase in the flight of the rocket will be unstable. The definition of the so-called ballistic wind is no longer valid in all cases.

CP10/10 **The Influence of Aerodynamic Parameters on the Dispersion of Unguided Rockets Due to Gusts.** N.TREINIES, E.H.HIRSCHEL.
AGARD Conference Proceedings CP 10, pp.181-210, 6 refs., 1966.
The powered part of the flight path of an unguided rocket influenced by a variable cross wind and thrust malalignment is calculated on a digital computer. The magnitude of the deviation caused by distinct disturbances depends on the aerodynamic data of the missile. The optimum yaw oscillation distance decreases with increasing frequency of the cross wind.

CP10/11 **Review of Base Drag.** R.SEDNEY.
AGARD Conference Proceedings CP 10, pp.211-240, 48 refs., 1966.
A review of the present state of knowledge of axisymmetric base drag is given. With application to ballistics in mind, it is especially concerned with supersonic flight and turbulent boundary layers. Correlations of base pressure are discussed as well as some analytical methods of attacking the problem; no satisfactory analytical theory exists. Experimental methods of determining base pressure in wind tunnels and ballistic ranges are discussed. The effect of a boattail on total drag and base pressure is discussed and one other method of reducing base drag is considered briefly.

CP10/12 **An Empirical Technique for Estimating Power-On Base Drag of Bodies-of-Revolution with a Single Jet Exhaust.** C.E.BRAZZEL, J.H.HENDERSON.
AGARD Conference Proceedings CP 10, pp.241-261, 10 refs., 1966.
An empirical technique has been formulated for estimating the base drag of bodies-of-revolution with a central jet exhausting through the base. It is based on successful correlation of an extensive amount of experimental data covering a wide range of parametric variation. The basis of the correlation is an apparent relationship between the base pressure ratio and the ratio of momentum flux of the jet to the momentum flux of the equivalent body stream-tube. The elementary form of the derived expressions allows rapid estimates of power-on base drag using a desk calculator.

CP10/13 **Experimental Investigation on the Effect of Tail Surfaces and Angle of Attack on Base Pressure in Supersonic Flow.** A.HEYSTER, F.MAURER, E.OBERDÖRFFER.
AGARD Conference Proceedings CP 10, pp.263-290, 10 refs., 1966.
The results of wind tunnel measurements on base pressure models with and without tail surfaces are described. The longitudinal position of typical tail surfaces with wedge or double-wedge profiles and different planforms was changed in order to see the influence on pressure distributions measured on the model base. Mean values of these distributions show strong and repeatable variations depending on the longitudinal position of the tail surfaces.

CP10/14 **Wind Tunnel and Computer Studies of a Low Drag Bomb with Various Tail Stabilizers.** F.J.REGAN, J.H.SHANNON, F.J.TANNER.
AGARD Conference Proceedings CP 10, pp.291-317, 19 refs., 1966.
For the past few years several organizations within the US Department of Defense, the British Royal Aircraft Establishment (RAE) and the Australian Weapons Research Establishment (WRE) have been engaged in a tripartite bomb stability programme. This paper describes the background and intent of this programme including the evolution of the basic research store. The scope of the instrumented bomb programme is discussed, together with the available wind tunnel data. A preliminary computer-free-flight comparison is made.

CP10/15 **The Flight Dynamics of a Bomb with Cruciform Tail.** W.R.CHADWICK.
AGARD Conference Proceedings CP 10, pp.319-339, 10 refs., 1966.
A mathematical model has been used to determine the influence of a nonlinear yaw-induced roll moment and side moment on the dynamic stability. Two problem areas were studied, the first associated with roll yaw resonance and the second with catastrophic yaw. It is shown that problems in resonance stability may be considerably greater than those predicted by linear theory and that launch disturbances in a single plane in space may degenerate rapidly into circular catastrophic yaw.

CP10/16 **Magnus Effects.** F.J.REGAN.
AGARD Conference Proceedings CP 10, pp.341-364, 36 refs., 1966.
The attempts to measure the Magnus effect that have been reported in the open literature are summarized with the application to spinning projectiles in mind. Attention is primarily confined to work of the past ten years. These data are examined from the point of view of the type of facility (ballistic range, wind tunnel, free flight), Mach number range, Reynolds number and type of shape (finned or non-finned). Theories are examined as to type of flow (potential or viscous) and if viscous effects are studied the type of boundary layer (compressible, laminar, turbulent) is examined.

CP10/17 **Non-Linear Magnus Moment.** W.R.HASELTINE.
AGARD Conference Proceedings CP 10, pp.365-374, 1966.
At subsonic speeds some spin-stabilized projectiles and rockets experience Magnus moments which are non-linear in yaw angle. The yaw camera and yaw sondes have proved to be powerful tools in the study of the stability of spinning projectiles. Simplified theory can account for rather odd behaviour if non-linear aerodynamics is considered. Some very simple projectiles exhibit Magnus moments which are drastically non-linear at quite small yaw angles and hence have limit cycles in yaw, flying with a steady, nonzero, oscillatory yaw in addition to their yaw of repose.

CP10/18 **A New Technique for Measuring the Yaw of a Shell.** H.G.HADEN.
AGARD Conference Proceedings CP 10, pp.375-380, 3 refs., 1966.
The ballistics branch of RARDE has developed a method of observing the spin and yaw of a shell along the whole trajectory. A pinhole in the side of the shell admits sunlight on to an axially situated, V-shaped photocell, generating voltage pulses as the shell spins. These are transmitted to a ground based receiver, and the time intervals between the pulses enable the spin and yaw to be evaluated. This technique has been used successfully to find nutation and precession periods, yaw damping and spin deceleration. It is of particular use in observing yaw at the vertex in high angle fire.

CP10/19 **Obtaining Accurate Aerodynamic Force and Moment Results from Ballistic Tests.** G.CHAPMAN, D.B.KIRK.
AGARD Conference Proceedings CP 10, pp.381-401, 10 refs., 1966.
An examination is made of various sources of error that can affect aerodynamic parameters deduced from ballistic tests. A mathematical approach is made to determine the dependence of the results on the various random errors. A statistical treatment follows, employing a Monte Carlo technique to perturb exact trajectories, which verified the mathematical approach. Facility calibration and model preparation features important for accurate aerodynamic results are discussed. Finally a new approach to data analysis and its advantage over present system is presented.

CP10/20 **Review of the High Altitude Research Program (HARP).** C.H.MURPHY, G.V.BULL.
AGARD Conference Proceedings CP 10, pp.403-437, 24 refs., 1966.
Project "HARP" is directed toward the use of guns for scientific probing of the upper atmosphere, the attractive features being economy and the high inherent accuracy of guns for placement at altitude as well as in ground impact. The guns used vary in size from 5 in. and 7 in. extended ones on mobile mounts to relatively fixed 16 in. ones. Altitude performance varies from 20 lb five-inch projectiles to 240,000 ft to 185 lb sixteen-inch projectiles to 470,000 ft. Data are primarily wind profiles measured by radar chaff, aluminized balloons and parachutes, and trimethyl-aluminium trails. Sun sensors, magnetometers, and temperature sensors have been flown.

CP10/21 **VHF and UHF High-G Telemetry Instrumentation for HARP Vehicles.** W.H.MERMAGEN, W.J.CRUICKSHANK, F.VRATARIC.
AGARD Conference Proceedings CP 10, pp.439-464, 12 refs., 1966.
Telemetry systems capable of surviving gun-launched accelerations in the order of 60,000 g have been developed for the High Altitude Research Program. Results of measurements of electron densities and temperatures in the upper atmosphere are presented and discussed, as are vehicle roll rates and pitch-yaw frequencies during high altitude flights. It has been shown that the technique of using guns to launch instrumented payloads into the upper atmosphere is both practical and useful, and the inclusion of on-board instruments to observe the dynamical behaviour of flight vehicles provides a useful tool for aerodynamic research in the real atmosphere.

CP11/1 **Loss of Vision from High Intensity Light.**
AD-653-917 AGARD Conference Proceedings CP 11, (Unclassified Version), 274 pp., 1966.
N67-29341 The papers presented in this volume represent a large part of the total programme of a symposium held in Paris, in March, 1966. Papers of a classified nature have been omitted. The papers reproduced relate to the following subject fields: retinal effects; functional effects and protection; hazard prediction, selection and training. Abstracts of the individual papers are given in the succeeding items.

CP11/1/1 **Visual Decrement in Humans Following Thermonuclear Detonations.** J.F.CULVER.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.23-38, 11 refs., 1966.
Details are given of two cases of chorioretinal burns which occurred during a high altitude, night-time, long-range, missile-delivered thermonuclear detonation. The two men concerned were examined within 24 to 28 hrs of their injurie being sustained, and at intervals subsequently. It is stressed that it is essential to ascertain the exact size and location of such retinal damage in order to make a prognosis of the final visual outcome.

CP11/1/2 **What is the Functional Damage Threshold for Retinal Burn?** J.J.VOS, W.T.HAM, Jr., W.J.GEERAETS.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.39-53, 7 refs., 1966.
Threshold irradiation dosage for a retinal burn can be determined by examining the fundus by opthalmoscopy. There is no guarantee however that this threshold coincides with the functional threshold. A reduction in enzyme activity in the retina below the threshold for opthalmoscopic or histologically detectable lesions has been demonstrated. Interpretation of such data in terms of a quantitative model of enzyme destruction enables the sensitivity to temperature rise of retinal enzymes to be determined; this in turn facilitates the determination of the threshold of functional damage.

CP11/1/3 **Visual and Retinal Effects of Exposure to High Intensity Light Sources.** M.M.ZARET, G.M.GROSOF.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.55-65, 17 refs., 1966.
This paper presents a quantitative analysis of: (i) transient loss of visual function (flash blindness), and (ii) irreversible thermal injury of the retina. The measure selected for flash blindness has been the bleaching of a significant fraction of the visual pigments, and the criterion for retinal burn has been the minimal lesion seen opthalmoscopically.

CP11/1/4 **Immediate and Delayed Retinal Vascular-Changes Following Exposure to High Intensity Light.** C.T.DOLLERY, E.M.KOHNER, J.W.PATERSON, P.S.RAMALHO.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.67-72, 2 refs., 1966.
Exposure of the pig retina to intense unfocussed light from a xenon lamp produces immediate and delayed changes in the retina and its vascular bed. A series of experiments designed to evaluate this response are reported. It was found, inter alia, that high intensity light may cause severe retinal damage without any change in the opthalmoscopic appearance during the first hour after exposure.

CP11/1/5 **A Study of Effects of Laser Irradiation on Head and Eye of Small Animals in Terms of Neuro-Motor Behavior.** W.H.KIRBY, Jr., J.J.KOVARIC, L.M.STURDIVAN.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.77-87, 5 refs., 1966.
This is an abridged version of the paper presented. The purpose of the study reported was the determination of a range of important responses in terms of neuro-motor activity from nil to lethality for laser irradiation focused on the head and eye of small animals, namely mice, rats and guinea pigs. Experimental design and instrumentation are briefly described. Data so far collected are discussed.

CP11/1/6 **The Time Course of Flash Blindness.** J.L.BROWN.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.91-107, 8 refs., 1966.
Flash blindness must be measured in relation to visual tasks demanded in a given situation. Its duration depends on the method of measurement as well as the physical characteristics of the blinding exposure. This paper reviews the quantitative laboratory studies which have been performed to investigate the effects of: flash luminance, duration; and spectral character; visual acuity equirement of the criterion visual task; illumination provided for the criterion task; and relative positions of retinal images of the task and the flash.

CP11/1/7 **Effects of Simulated Retinal Burns on Detectability and Legibility.** V.D.HOPKIN, T.C.D.WHITESIDE.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.109-120, 10 refs., 1966.
Blind areas in the visual field of human subjects were simulated by use of the after-image of an intense light source. The subjects' ability to perform a legibility task was greatly affected by the size of the blinded area, and by whether it was located in the fovea or near the periphery.

CP11/1/8 **Preserving Vision Despite Exposure to High Intensity Light.** C.McCULLOCH, J.R.ELDER.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.121-142, 13 refs., 1966.
Preliminary experiments have suggested that shading of areas of the retina, particularly the macular region, can give considerable protection from glare. Engineering of the task that must be performed and then design of shading of the retina may, in combination, allow continuous efficient performance both before and after exposure to bright light.

CP11/1/9 **The Success of US Navy Equipment Development Programs in Meeting the Flash Blindness Problem.** J.F.PARKER, Jr., R.A.BOSEE.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.143-158, 8 refs., 1966.
The US Navy programme on this subject is reviewed. A low-transmission visor system has been developed which appears to be entirely adequate for daytime operations. A brief description is given of the ELF (Explosively-actuated Light Filter) goggles under development; the ELF system comprises clear goggles designed to close automatically upon a signal from a sensing unit. The Navy flash blindness training programme is summarized.

CP11/1/10 **Photochromic Substances.** P.J.DOUZOU.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.159-163, 1966.
This brief paper highlights the use of photochromic substances against dazzle. Photochromic substances absorb in the medium or near ultra violet and have the property of becoming reversibly coloured. Thus a non-coloured substance with an absorption spectrum in the ultra-violet can by means of light excitation become coloured; by the action of thermal quanta, a reversible reaction is obtained.

CP11/1/11 **The Relative Danger of Retinal Burn and Flash Blindness for Various Yields of Nuclear Explosions.** J.J.VOS.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.171-202, 16 refs., 1966.
In this analytical treatment of the title subject, the following aspects are considered: data concerning the nuclear flash; the critical distance, the pupil and the blinking reflex, the danger of retinal burn; recovery time after flash blindness; flash blindness in the direct image; the retinal exposure by indirect flash; required levels of panel illumination; protection.

CP11/1/12 **Prediction of Eye Safe Separation Distances.** E.O.RICHEY.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.203-224, 8 refs., 1966.
A method is given for predicting the distances at which the thermal radiation from nuclear detonations will be hazardous to the unprotected human eye. This method relates calculated retinal exposure to experimentally determined eye effects data.

CP11/1/13 **Resistance to Flash Blindness and Aircrew Selection.** A.MERCIER, G.PERDRIEL.
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.225-232, 1966.
The resistance to dazzle in aircrew has been investigated. Experiments using Comberg's recording nyctometer have shown that the time lag for return to a useful visual acuity (5/10) after exposure to flash does not change with the subject's age, but is markedly long in 10% of the aircrew tested. Efforts to increase dazzle resistance by using anthocyanosides are discussed.

CP11/1/14 **Appendix: Units of Light Measurement.**
AGARD Conference Proceedings CP 11, (Unclassified Version), pp.273-274, 1966.
This appendix is based on B.S.233, 1953 and lists terms relating to units of light measurement and their definitions. Relations between the various units are presented in tabular and diagrammatic form.

CP12/1 **Recent Advances in Aerothermochemistry: Volume I.** I.GLASSMAN (Editor).
AD-658-781 AGARD Conference Proceedings CP 12, Vol. 1, 441 pp., 1967.
N67-38681 These proceedings comprise the bulk of the papers presented at the 7th AGARD Colloquium sponsored by the AGARD Propulsion and Energetics Panel and the Fluid Dynamics Panel, held in Oslo during May, 1966. Volume 1 contains papers dealing with energy transfer, and atomic and molecular beam experiments. Abstracts of the individual papers are given in the succeeding items.

CP12/1/1 **Microscopic and Macroscopic Approach to Chemical Rate Processes.** K.E.SHULER.
AGARD Conference Proceedings CP 12, Vol. 1, pp.1-20, 19 refs., 1967.
A brief review is given which presents the outlines of (i) microscopic approach including the operational definition and experimental determination of reactive cross-sections, reaction cross-sections and formal scattering theory, and collision trajectory calculations; and (ii) the macroscopic approach which includes a discussion of the connection between reactive cross-section and rate coefficient, the relation between the statistical rate coefficient and the reactive cross-section via the Boltzmann equation, and many body interaction and the influence of magnetic fields.

CP12/1/2 **Unimolecular Thermal Dissociation of Small Molecules.** J.TROE, H.G.WAGNER.
AGARD Conference Proceedings CP 12, Vol. 1, pp.21-44, 1967.
Experimental investigations on the unimolecular decompositions of three- and four-atomic molecules are reviewed and discussed. Data are available on the dissociations of CO_2, CS_2, CCS and N_2O, of H_2O, O_3, SO_2, NO_2, BrCN, ClCN, NOCl, F_2O and NF_2, and of H_2O_2, NH_3, C_2H_2, NO_2Cl, F_2C_2, $FClO_2$ and (CN_2). The experimental data is compared with theoretical models.

CP12/1/3 **The Relaxation and Dissociation of Small Molecules.** T.A.BAK, E.R.FISHER.
AGARD Conference Proceedings CP 12, Vol 1, pp.45-57, 25 refs., 1967.
The relaxation and dissociation of diatomic molecules is briefly discussed in the two approximations for which a complete discussion can be given, i.e. the almost adiabatic case where only a small amount of energy is transferred in a collision, and the extremely non-adiabatic classical case where a large transfer of energy in a collision is possible. The quantum mechanical transition probabilities are then calculated and a formulae is given for the rate of dissociation.

CP12/1/4 **Effects of Certain Energy Transfer Processes on Population Distributions in Expanding Gas Flows.** K.N.C.BRAY, N.H.PRATT.
AGARD Conference Proceedings CP 12, Vol. 1, pp.59-110, 36 refs., 1967.
Recent literature concerned with aerothermochemistry reveals an increasing trend to study flows involving physical complex processes. This paper is a preliminary attempt to analyze some of the possible interactions between such processes. Some of the theoretical predictions are applied to experimental data of Ar + Na and Ar + N_2 + Na mixtures published by Hurle and Russo. It is found that their postulate of electron temperature freezing at the throat of a nozzle cannot be predicted by the present theory. However, the mechanism of radiation trapping discussed in this paper does provide a plausible explanation of their experimental results. A lengthy discussion is published with this paper.

CP12/1/5 **Application of the Sodium D Line Reversal Method to the Measurement of Vibration Temperatures of Nitrogen Behind a Propagating Shock Wave and after Expansion in a Nozzle. (In French).** H.GUENOCHE, R.CHAREYRE.
AGARD Conference Proceedings CP 12, Vol. 1, pp.111-130, 15 refs., 1967.
Describes comparisons between the observed time history of sodium line reversal temperatures and nitrogen vibrational temperatures in the region of vibrational relaxation behind incident shock waves. Also described are sodium line reversal measurements made in a nozzle expansion flow and in the assumed equilibrium region behind the shock wave attached to a cone placed in that flow.

CP12/1/6 **A Shock Tube Study of the Infrared Emission from HCl; Vibrational Relaxation Times for the Upper States.** P.BORRELL, R.GUTTERIDGE.
AGARD Conference Proceedings CP 12, Vol. 1, pp.131-146, 19 refs., 1967.
The infrared emission from the third vibrational level of shock heated HCl has been observed and measured. The relaxation appears to follow a simple exponential form with a somewhat longer relaxation time than that measured previously. The two mechanisms of excitation considered were direct excitation and excitation by rate determining population of the first level followed by rapid equilibrium of the upper levels.

CP12/1/7 **The Role of Vibrational Excitation in Atom Switching Reactions.** S.H.BAUER.
AGARD Conference Proceedings CP 12, Vol. 1, pp.147-164, 27 refs., 1967.
It is shown that shock tubes have proved essential for the exploration of rates of chemical conversions over a wide range of elevated temperatures, at moderate densities, under strictly homogeneous conditions. The analytical results show that not only are there restrictions on the relative efficiency of utilizing the energy associated with the different molecular degrees of freedom, but also that the relative kinetic energy of translation plays practically no role; it is the vibrational energy of D_2 which dominates the rate of exchange. Several predictions based on this mechanism are being investigated; partial verifications have already been obtained.

CP12/1/8 **Shock Reflection and Surface Effects in the Shock Tube.** J.R.BUSING, J.F.CLARKE.
AGARD Conference Proceedings CP 12, Vol. 1, pp.165-190, 17 refs., 1967.
A thin-film resistance thermometer, mounted on the end wall of a shock tube, is used to record surface temperatures and heat transfer following reflection of the primary shock wave. This information is combined with the results of theoretical investigations to produce simultaneous information about surface accommodation effects and gas thermal conductivities at high pressures and moderate temperatures.

CP12/1/9 **Modulated Atomic Beams and Their Uses.** W.L.FITE.
AGARD Conference Proceedings CP 12 Vol. 1, pp.191-215, 40 refs., 1967.
Discusses the principal features of modulation techniques applied to atomic and molecular beam investigations, with particular reference to problems of signal-to-noise ratio. Modulation methods in the measurement of collision cross-sections in crossed beam experiments is then illustrated. Neutral-neutral reactive collisions are also discussed briefly. The application of reflected modulated beam techniques to study the interactions of gases with surfaces are given and some recent findings are briefly reviewed.

CP12/1/10 **Thermal Energy Molecular Beam Measurements of Atom-Atom Differential Scattering Cross Sections.** H.PAULY.
AGARD Conference Proceedings CP 12, Vol. 1, pp.217-235, 28 refs., 1967.
The experimental investigation of the forces between neutral atoms can best be made by the measurement of differential scattering cross-sections since angular distribution of scattered particles is a sensitive function of the interatomic potential. Precise measurement methods employ the crossed molecular beam technique, which assures a defined scattering centre. The apparatus for the measurement of differential scattering crossed sections is described together with the theory. Experimental results for small and large angle scattering are discussed giving the information which may be obtained from such measurements.

CP12/1/11 **Thermal Energy Molecular Beam Measurements of Inelastic Cross-Sections for Rotational Quantum Transitions.** J.P.TOENNIES.
AGARD Conference Proceedings CP 12, Vol. 1, pp.237-276, 42 refs., 1967.
Reviews the connection between collision cross-sections and the macroscopic rate expressions which describe the bulk behaviour of the gas. Advantages and disadvantages of conventional methods are summarized. Some relationships among various collision cross-sections are mentioned and the calculation of inelastic cross-sections discussed. For detecting inelastic scattering two techniques were used, (i) the particles were observed by the velocity shift resulting from the loss or gain of kinetic energy, and (ii) the change of rotational state of the molecules was directly observed. The experimental results and their interpretation are discussed in detail. A survey is also given of recent unpublished measurements of total cross sections which provide information on the intermolecular potential between molecules and molecules and atoms.

CP12/1/12 **Performance of an Arc-Heated Supersonic Molecular Beam and Its Application to Molecule-Molecule Collision Studies.** E.L.KNUTH, N.M.KULUVA.
AGARD Conference Proceedings CP 12, Vol. 1, pp.277-338, 47 refs., 1967.
Bases for designs of components of an intermediate high-energy high-intensity molecular beam are presented. Intermediate energies and high intensities are realized as a consequence of heating the beam gas in an electric arc and then converting the energy of thermal motion into energy of directed motion in a supersonic jet. Beam choppers are used and a through-flow ionization detector, which sees the chopped beam signal as an a.c. signal superimposed upon a d.c. background, possesses the versatility required for application to the several different studies in progress. The capability of the system to produce 1 eV total cross-section is demonstrated.

CP12/1/13 **Supersonic Nozzle Beams – Some Recent Experimental Results.** N.ABUAF, J.B.ANDERSON, R.P.ANDRES, J.B.FENN.
AGARD Conference Proceedings CP 12, Vol. 1, pp.339-361, 19 refs., 1967.
A brief review of the literature dealing with the usefulness of nozzle source beams as a means of studying relaxation processes which can occur in freely expanding jets, and their effectiveness in generating beams at energies in the range of above 1 eV.

CP12/1/14 **Chemical Reaction Cross-Sections Determined by Molecular Beams in the 10 eV Energy Range.** N.G.UTTERBACK.
AGARD Conference Proceedings CP 12, Vol. 1, pp.363-375, 7 refs., 1967.
The production of the molecular beams by ionization by electron impact, electrostatic acceleration, and neutralization by resonant charge transfer is discussed. The application of such beams to determine chemical reaction cross-sections is considered in detail for specific examples. Other methods for producing neutral beams in this energy range are discussed. Of particular interest is the possibility for producing beams of excited atoms and molecules.

CP12/1/15 **The Production of a 2 eV Pulsed Argon Beam Using a Shock Tube Source.** T.V.JONES.
AGARD Conference Proceedings CP 12, Vol. 1, pp.377-409, 29 refs., 1967.
Discusses the use of aerodynamic molecular beam methods to produce a fast beam from a shock tube. The basis used is the continuum expansion of a gas to a high Mach number where flow density and temperature is such that it becomes free molecular; subsequent collimation of the flow is used to produce a beam.

CP12/1/16 **Total Cross-Section Measurements for K on He in the Energy Range of 0.35 to 16.5 eV.** J.POLITIEK, J.LOS, J.J.M.SCHIPPER.
AGARD Conference Proceedings CP 12, Vol. 1, pp.411-422, 14 refs., 1967.
A molecular beam apparatus has been constructed which uses the phenomenon of cathode sputtering for the production of an atom beam. A potassium target is bombarded by an ion beam from a uno-plasmatron source, after which the sputtered potassium atoms are collimated. The detector is a surface ionization platinum tungsten wire. Total cross-sections have been measured for the system K-He in the velocity range of 1400 m/sec to 9000 m/sec. The velocity dependence of the cross-section interpreted as an inverse power potential dependence gives S = 11.

CP12/1/17 **On the Design of Experiments with a Shock-Tube-Driven Molecular Beam.** G.T.SKINNER.
AGARD Conference Proceedings CP 12, Vol. 1, pp.423-441, 20 refs., 1967.
Theoretical and experimental considerations which govern the design of typical experiments are discussed. Examples include the measurement of small angle recoil of target particles, which has some features in common with chemical sampling. Problems encountered with the use of a quadrupole mass spectrometer as a detector are discussed. Some comments are made on the interrelationship between analytical problems in data reduction and experimental operating conditions as encountered in designing differential cross-section experiments.

CP12/2 **Recent Advances in Aerothermochemistry: Volume 2.** I.GLASSMAN (Editor).
AD-658-782 AGARD Conference Proceedings CP 12, Vol. 2, 402 pp., 1967.
N68-10107 This is the second of two volumes of papers read at the 7th AGARD Colloquium sponsored by the AGARD Propulsion and Energetics Panel and the Fluid Dynamics Panel. The Colloquium was held in Oslo from 16th to 20th May, 1966. The papers in this volume relate to non-equilibrium flow phenomena. Abstracts of the individual papers are given in the succeeding items.

CP12/2/1 **Recent Studies of Non-Equilibrium Flows at the Cornell Aeronautical Laboratory.** J.G.HALL, A.L.RUSSO.
AGARD Conference Proceedings CP 12, Vol. 2, pp.443-475, 33 refs., 1967.
Three particular studies are reviewed; they related to (i) vibrational relaxation in supersonic nozzle flows of diatomic gases; (ii) non-equilibrium effects occurring in high-enthalpy airflows over thick wedge-flat plate bodies where strong (Prandtl-Meyer) flow expansion occurs at the wedge-plate corner; (iii) calculation of the inviscid non-equilibrium flow field about an Apollo-type re-entry body at arbitrary angle of attack.

CP12/2/2 **Steady One-Dimensional Flow of a Gas with Relaxation.** E.BECKER.
AGARD Conference Proceedings CP 12, Vol. 2, pp.477-506, 16 refs., 1967.
The main conclusions of the mathematical study of this subject are as follows: in one-dimensional flow of a relaxing gas (in the special case of two relaxation processes) under rather general assumptions about the thermodynamic behaviour of the gas, fully dispersed waves exist and are uniquely determined if the upstream velocity of sound. If the upstream velocity is larger than the frozen velocity of sound, a partly dispersed wave uniquely exists.

CP12/2/3 **Spectrum-Line Reversal Temperature Measurements Through Unsteady Rarefaction Waves in Vibrationally Relaxing Gases.** T.A.HOLBECHE, J.G.WOODLEY.
AGARD Conference Proceedings CP 12, Vol. 2, pp.507-567, 33 refs., 1967.
Some investigations of the structure of unsteady expansion waves produced in vibrationally-relaxing (but undissociated) gases in a shock tube by the rupture of a second diaphragm are reported. The desirability of checking the spectrum-line-reversal technique by a method based on the infra-red emissions of CO of NO added to the flow for future relaxation or recombination studies is also discussed.

CP12/2/4 **Interferometric Measurement of Nonequilibrium Flow Fields Around Cones and Comparisons with Characteristic Calculations.** J.H.SPURK, D.T.KNAUSS, J.M.BARTOS.
AGARD Conference Proceedings CP 12, Vol. 2, pp.569-592, 16 refs., 1967.
The interferometric measurement of the density field and comparison with theoretical predictions is reported for two typical experiments: (i) flow around a cone in oxygen at approximately 10,000 ft/sec. and (ii) flow around a cone in dry air at approximately 20,000 ft/sec. flow velocity.

CP12/2/5 **Mass Spectrometric Studies of Impurity Ionization in Shock-Heated Argon.** B.STURTEVANT, C.P.WANG.
AGARD Conference Proceedings CP 12, Vol. 2, pp.593-606, 6 refs., 1967.
Studies of the ionization kinetics of impurities in shock-heated argon using a sampling mass spectrometer are described. The ions produced by thermal ionization in the early stages of the relaxation processes behind a reflected shock wave are extracted from the shock tube through a small orifice in the end wall after they have diffused through the dense thermal layer adjacent the wall, and are separated and studied individually with the mass spectrometer. The ion diffusion process is analyzed in detail to assess the possibility that the sampling process alters the reaction products. This mode of sampling is compared with others.

CP12/2/6 **Non-Equilibrium Nozzle Flow with Condensation.** P.P.WEGENER, J.-Y.PARLANGE.
AGARD Conference Proceedings CP 12, Vol. 2, pp.607-634, 27 refs., 1967.
Condensation of vapour and vapour-gas mixtures in supersonic nozzle flows is discussed. The limiting conditions of equilibrium and frozen flow, and the thermo-dynamics of the collapse of the supersaturated flow are demonstrated. New results are presented on the nature of the condensate produced by homogeneous nucleation of water vapour in inert air.

CP12/2/7 **Discussion of the Stability of Solutions Occurring in the Analysis of Relaxation Flows.** (In French). R.PRUD'HOMME.
AGARD Conference Proceedings CP 12, Vol. 2, pp.635-682, 18 refs., 1967.
The following are considered: equations representing flow with chemical reactions; relaxation flow in a nozzle; theories treating the stability of relaxation flows; general study of the stability of the solutions of multireactive relaxation flows.

CP12/2/8 **Comparative Evaluation of Several Approximate Methods of Analysis of Non-Equilibrium Nozzle Flows.** R.W.McINTYRE, R.S.E.LESLIE.
AGARD Conference Proceedings CP 12, Vol. 2, pp.683-699, 5 refs., 1967.
This paper is essentially an abridged version of Bristol Siddeley Report AP 5343, February 1966. A one-dimensional model is used to represent the non-equilibrium nozzle flow. The approximate methods compared are the partial equilibrium method and the sudden freezing method (composite freezing point and multiple freezing points).

CP12/2/9 **Applicability of Sudden-Freezing Criteria in Analysis of Chemically Complex Rocket Nozzle Expansions.** W.G.BURWELL, V.J.SARLI, T.F.ZUPNIK.
AGARD Conference Proceedings CP 12, Vol. 2, pp.701-759, 29 refs., 1967.
Discussion is presented of calculated results obtained using the approximate and the exact one-dimensional kinetic flow procedures. Only a minimum of detail is given to describe each procedure. Information is presented for three representative propellant systems (viz. $H_2 - O_2$, $H_2 - F_2$, $N_2H_4/UDMH - N_2O_4$).

CP12/2/10 **Measurements of Relaxation Effects in Nozzle Flow of Hot Combustion Gases by Means of a Shock Tube Technique: II** T.JUST, H.PIPPERT.
AGARD Conference Proceedings CP 12, Vol. 2, pp.761-776, 9 refs., 1967.
Rough calculations of several authors have led to the conclusion that no thrust from air-breathing engines can be expected if the flight Mach number exceeds 7 or 8. Here, experimental investigation is reported of chemical relaxation effects by measuring temperatures at various points along different nozzles The experimental techniques used are described. The average mass flow rate through the nozzle was of the order of 1 kg/sec.

CP12/2/11 **Unsteady, Diffusing, Reacting, Tubular Flow with Application to the Flow in a Glow Discharge Tube** E.EMANUEL.
AGARD Conference Proceedings CP 12, Vol. 2, pp.777-797, 10 refs., 1967.
A theory is given for the concentration profile of a diffusing, reacting, partially dissociated gas as it convects down a flow discharge tube. Initially, the atom concentration profile is a step function. The theory further requires incompressible two-dimensional or axisymmetric Poiseuille flow. With increasing time, the concentration changes in a layer that convects down the tube, and the width of the layer also increases.

CP12/2/12 **Experimental and Analytical Consideration of Turbulent Heterogeneous Mixing in the Wake.** V.ZAKKAY, H.FOX.
AGARD Conference Proceedings CP 12, Vol. 2, pp.799-[illegible], 29 refs., 1967.
The problem of turbulent mixing of two streams is discussed. The profiles and decay downstream of coaxial mixing are shown to behave in an analogous form to the near and far wake problem. Theoretical and experimental investigation of the near and far wake was carried out at $M_\infty = 4$ and 12 for two different configurations. Injection at the base of the model was performed at $M_\infty = 4$, in order to investigate the transitional phenomenon which occurs between the base problem and the problem of coaxial mixing.

CP13 **Oblique Ionospheric Radiowave Propagation.** Editor T.B.JONES.
AD-863-589 AGARD Conference Proceedings CP 13, 554 pp., many refs., 1969.
N70-16426 Records the papers and the discussions at the eleventh Technical Meeting of the AGARD Electromagnetic Wave Propagation Committee held in Leicester. 38 papers are included on the various facets of this wide subject. They cover the radiation phenomena in the 1-30 Mc/s band and particularly the problems of forecasting the lowest usable high frequency. Other supporting papers deal with ray tracing, models, and Doppler techniques. A name and subject index is provided.

CP13/1 **The Physical Proportion of the Lower Ionosphere.** J.A.RATCLIFFE.
AGARD Conference Proceedings CP 13, Chapter 1, pp.3-4, 1969.
Abstracted discussion only is printed. The paper presented a general review of the physical properties of the lower ionosphere and the D-region in particular.

CP13/2 **Measurements of Electron Density in the Undisturbed Middle Latitude D-region.** E.V.THRANE.
AGARD Conference Proceedings CP 13, Chapter 2, pp.5-8, 6 refs., 1969
Presents some results from an experimental study of the undisturbed D-region at middle latitudes. Two different techniques were used to measure the electron densities below 90Km.

CP13/3 **Rocket Measurements of the Lower Ionosphere.** J.A.KANE.
AGARD Conference Proceedings CP 13, Chapter 3, pp.9-24, 22 refs., 1969.
Describes some rocket techniques now being used to obtain electron density profiles in the D-region. Rocket results from both the auroral zone disturbed and the mid-latitude quiet D-region are presented, together with a discussion of the available knowledge of the ionization production processes.

CP13/4 **Radio Studios of the Lower Ionosphere.** W.J.G.BEYNON.
AGARD Conference Proceedings CP 13, Chapter 4, pp.25-33, 8 refs., 1969.
This paper surveys present information on the ionospheric absorbtion of short waves and more particularly absorbtion in the D- and lower E-regions.

CP13/5 **Diurnal and Seasonal Variation of Absorption in the Ionosphere Determined from Field Strength recording at 2.6 Mc/s.** H.SCHWENTEK.
AGARD Conference Proceedings CP 13, Chapter 5, pp.35-38, 8 refs., 1969.
Measurements of absorption on the Norddeick-Lindau link (frequency 2.61 Mc/s) have been made from 1961 to 1965 and have allowed a semi-empirical expression of absorbtion to be offered.

CP13/6 **Measurements of Absorbtion at Oblique Incidence over a 1000Km Path, and their Interpretation in Terms of a Model of the Lower Ionosphere.** R.W.VICE.
AGARD Conference Proceedings CP 13, Chapter 6, pp.39-48, 7 refs., 1969.
Describes experiments during the I.G.Y. of pulse amplitudes and delays at a frequency of 10.74

MHz over a 1000Km transmission path between Johannesburgh and Salisbury. The two main modes of propagation agree reasonably well with the model atmosphere described.

CP13/7 **Medium Wave Reflection Properties of the Ionosphere over TSUMEB.** W.ELLING
AGARD Conference Proceedings CP 13, Chapter 7, pp.49-50, 1969.
A short paper giving results of vertical mediu.n wave pulse echo soundings at TSUMEB, South West Africa. They covered two periods, one during the sunspot maximum in 1957-1958 and the other during the sunspot minimum in 1964-1965, each period lasting about 8 months. In addition sweep frequency ionograms, ranging from 250 to 4000Kc/s, were recorded.

CP13/8 **The Practical Prediction of Lowest Useful Frequencies.** G.W.HAYDON.
AGARD Conference Proceedings CP 13, Chapter 8, pp.51-60, 1969.
The bases for predicting the lowest useful frequency for high frequency sky wave communication are outlined and the evolution of criteria is reviewed. Prediction methods using computers are emphasised.

CP13/9 **Propagation Characteristics and Communication System Performance.** D.L.NIELSON.
AGARD Conference Proceedings CP 13, Chapter 9, pp.61-70, 9 refs., 1969.
This paper makes a case for the more specific description of usable frequencies by means of error rate. Quality of signal is measured in binary error rate and defined for a specific system by such parameters as signal-to-noise ratio, multipath, Doppler spread and acceptability thresholds.

CP13/10 **Some Observations of Signal Strength of Skywaves and Noise Levels near the LUF with Reference to Modes of Propagation.** R.H.TREHARNE.
AGARD Conference Proceedings CP 13, Chapter 10, pp.71-82, 7 refs., 1969.
It is agreed that the angle of arrival of signals may vary over a wide range of angle and that the vertical polar diagrams of aerials used for such radio paths deserve study. Observations of noise level using aerials of different polarization and directivity at various distances from centres of population are described.

CP13/11 **The Control of F-Layer LUFs by the Defocussing Effect of the Lower Layer.** R.G.MALIPHANT.
AGARD Conference Proceedings CP 13, Chapter 11, pp.83-112, 17 refs., 1969.
It was previously thought that the LUF for F-layer propagation was frequently determined by ionisation in a lower layer and that in consequence the signals were cut off by the lower layer. This paper shows this to be false and states that the mechanism is a defocussing effect which does not give an absolute cut off and which can be overcome by an increase in power or in aerial gain. The significance is described by data derived from a computer ray-tracing program.

CP13/12 **Magneto-ionic Effects in Polarization and Absorption.** A.D.MORGAN.
AGARD Conference Proceedings CP 13, Chapter 12, pp.113-125, 9 refs., 1969.
Discusses the polarization and absorption of radio waves in the ionospnere using the Appleton-Hartree equations. The results show that for frequencies near the lower limit of the H.F. band considerable increase in signal level can be given by correctly polarized aerials. The absorption analysis is extended to the calculation of LUF.

CP13/13 **Field Strength Predictions for Back Scatter Ionospheric Sounding.** L.W.BARCLAY.
AGARD Conference Proceedings CP 13, Chapter 13, pp.127-136, 8 refs., 1969.
A theoretical assessment is made of the expected returns from a back-scatter sounder in England operating across an overland path for two frequencies. It is shown that the returns are restricted to relatively narrow range bands and this is confirmed by a limited number of experiments.

CP13/14 **A review of Oblique Ray Tracing and its Application to the Calculation of Signal Strength.** T.A.CROFT.
AGARD Conference Proceedings CP 13, Chapter 14, pp.137-171, 23 refs., 1969.
Reviews recent developments in ray tracing for frequencies from 2 to 10 MHz, with emphasis on their use for signal strength calculations. Many examples are included and the view is expressed that computer ray tracing will be a valuable tool in the future but that more ionospheric data is required.

CP13/15 **The ITSA Three Dimensional Ray Tracing Program.** K.DAVIES, R.M.JONES.
AGARD Conference Proceedings CP 13, Chapter 15, pp.173-198, 20 refs., 1968.
A three dimensional ray-tracing program is described. The computer program is restricted to conditions under which ray theory is valid but includes effects due to the earth's magnetic field and of electron collisions. Examples of its use are given.

CP13/16 **The Application of Ray Tracing Techniques to Research at Medium Frequencies.** J.W.FINNEY.
AGARD Conference Proceedings CP 13, Chapter 16, pp.199-207, 11 refs., 1969.
Ray tracing is applied to a pilot study of night-time sky wave medium frequency propagation. A program has been modified to calculate absorption and polarization coupling losses.

CP13/17 **Calculation of the Field Strength of a Radio Transmission for Given Electron Density and Collision Frequency Profiles.** H.KOPKA, H.G.MÖLLER.
AGARD Conference Proceedings CP 13, Chapter 17, pp.209-218, 3 refs., 1969.
A ray tracing program has been used to obtain a better understanding of experimental observations during summer time on the Lindau-Sodankylac 2000Km path.

CP13/18 **Some Results from Ray Tracing Applied to H.F.Ionospheric Communication.** K.FOLKESTAD.
AGARD Conference Proceedings CP 13, Chapter 18, pp.219-223, 1 ref., 1969.
Ray tracing is applied to H.F. ionospheric communications. A method for computing ray-paths and ionospheric absorption is described and some sample results are presented. The applicability of the method is discussed.

CP13/19 **A Mathematical Model of Vertical Antennas of Finite Length over an Inhomogeneous Earth.** V.R.ARENS.
AGARD Conference Proceedings CP 13, Chapter 19, pp.225-248, 32 refs., 1969.
Mathematical models are derived for vertical antennas of finite length and height over a homogeneous earth on which a ground screen of finite length is placed. Results of automatic computer-calculated patterns are presented.

CP13/20 **Polarization and Fading near the L.U.F.** E.C.HAYDEN.
AGARD Conference Proceedings CP 13, Chapter 20, pp.249-276, 12 refs., 1969.
Suggests a basis for signal classification. Poincarés method for representing states of wave polarization on a spherical map is outlined and it is said that this makes it extremely valuable for visualising and calculating the effects of wave polarization on antenna response.

CP13/21 **Use of the Doppler Technique to Study the Fading of High-Frequency Ionospheric Radio Signals.** D.M.BAKER, K.DAVIES.
AGARD Conference Proceedings CP 13, Chapter 21, pp.277-284, 5 refs., 1969.
A technique is briefly described for the determination of the frequency components in a fading signal reflected from the ionosphere. Examples are given of frequency records for the middle latitudes taken on quiet and disturbed days.

CP13/22 **The Reflection Coefficient of an Ionosphere Containing Large Scale Irregularities.** J.D.CALDWELL, E.E.STEVENS, E.S.WARREN.
AGARD Conference Proceedings CP 13, Chapter 22, pp.285-302, 7 refs., 1969.
The reflection coefficient for a pulse of radiowaves reflected from an ionospheric containing large scale fluctuations in the electron number density is calculated as a function of the angle of incidence and of the pulse duration.

CP13/23 **Short-Term and Averaged Characteristics of Nonreciprocal HF Ionospheric Paths.** G.W.JULL.
AGARD Conference Proceedings CP 13, Chapter 23, pp.303-322, 12 refs., 1969.
This chapter reports an investigation into the ability of the ray theory to explain nonreciprocity of H.F.Ionospheric paths. Ray theory predicts nonreciprocity in phase for single magnetoionic waves transmitted between horizontally polarized antennas. If the antennas are elliptically polarized, there can also be nonreciprocity in amplitudes.

CP13/24 **The Radio Noise Environment at High Frequencies.** F.HORNER.
AGARD Conference Proceedings CP 13, Chapter 24, pp.323-333, 11 refs., 1969.
Attention is drawn to some of the limitations of existing noise data and it is stated that the estimation of the integrated noise on relatively good sites involves many assumptions which need to be substained.

CP13/25 **Comparison of Predicted and Observed L U.F.** H.G.MÖLLER.
AGARD Conference Proceedings CP 13, Chapter 25, pp.335-356, 15 refs., 1969.
Oblique incidence absorption measurements are examined which were made by means of pulse or C.W. signal strength observations or by means of L.U.F. data reduced from oblique pulse sweep-frequency records.

CP13/26 **L.U.F. Observations on Two Transequatorial Circuits During Sunspot Minimum.** C.G.McCUE.
AGARD Conference Proceedings CP 13, Chapter 26, pp.357-370, 12 refs., 1969.
L.U.F. observations were made on two long-distance step-frequency radio circuits in the Pacific Area during the sunspot minimum of 1964-5. These are compared with predictions of the absorption limiting frequency of the two circuits. These are unsatisfactory, the difficulties of measuring L.U.F. are emphasised and some unexplained features of L.U.F variations are listed.

CP13/27 **Some Recent Oblique Measurements in the H.F. Band on the Path KIRUNA-STOCKHOLM.** R.LINDQUIST.
AGARD Conference Proceedings CP 13, Chapter 27, pp.371-384, 6 refs., 1969.
Recordings on the 960 Km path during 1959-66 using two fixed-frequency pulsed transmitters on 3.0 and 6.7 MHz were made. Since March 1966 these have been complemented by half-hour recordings of oblique soundings mainly in the 3.6 – 14.0 MHz band. The paper discussed the M.U.F. and L.U.F. deduced from the recordings and compare them to ionosonde measurements at midpath and with monthly median predictions.

CP13/28 **The Vertical and Oblique Incidence Reflection Coefficients of the Ionosphere.** L.E.PETRIE, E.L.HAGG, A.G.STAPLEY
AGARD Conference Proceedings CP 13, Chapter 28, pp.385-391, 6 refs., 1969.
The apparent reflection coefficients have been measured using pulse amplitude data. Pulse transmissions from Ottawa on 2.75 Mc/s were recorded at vertical incidence and at a distance of 160 Km.

CP13/29 **Field Strength Determination at High Frequencies.** P.A.BRADLEY.
AGARD Conference Proceedings CP 13, Chapter 29, pp.393-411, 3 refs., 1969.
Field strength calculations by the methods of Piggott and Haydon have been made on a N-S path of 960 Km between Lerwick and Slough. These are for three receiving aerials at Slough. Agreement with experimental results is far from complete but favour Piggott's method.

CP13/30 **Correlation of Predicted and Observed Values of L.U.F. on a Quasi-Antipodal Circuit.** H.J.ALBRECHT.
AGARD Conference Proceedings CP 13, Chapter 30, pp.413-415, 6 refs., 1969.
A short review mainly of Melbourne-London data on 7 and 3.5 MHz. Most of the data has already been published.

CP13/31 **Effects of the Lower Ionosphere on H.F.Propagation Modes over a 3700 Km Path.** C.ROBERTS, L.HUMPHREY, R.MATHER.
AGARD Conference Proceedings CP 13, Chapter 31, pp.417-420, 9 refs., 1969.
Reports the interim results of a propagation loss experiment on a path between the Canal Zone and New York. A high-resolution pulse which permits observations of the individual ionospherically propagated modes was used. Two-way oblique soundings were also made for mode structure analysis.

CP13/32 **Time Variations for the Effective L.U.Fs. for 730 and 860 Km Paths.** T.B.JONES, W.KEENLISIDE.
AGARD Conference Proceedings CP 13, Chapter 32, pp.431-438, 3 refs., 1969.
A study has been made at Leicester of the diurnal and seasonal variations of the fade-out and fade-in times of the 1.95 Mc/s pulse transmission from the Hebrides and the 5 Mc/s carrier wave of HBN Geneva.

CP13/33 **Measurement and Short Term Prediction of the Lowest Usable Frequency.** R.D.EGAN.
AGARD Conference Proceedings CP 13, Chapter 33, pp.439-44[illegible] 10 refs., 1969.
Synchronised oblique sounding provides accurate and detailed information on the time-dispersion and amplitude of signals propagated by ionospheric reflection between two stations. It is shown here that the lowest obscured frequency on the oblique ionogram can be closely related to the predicted L.U.F. on a temperate latitude 3800 Km path. Statistical analysis of oblique data obtained on this same path shows that the L.U.F. is amenable to short term publication based solely on oblique soundings. The use of computer for this is described.

CP13/34 **Some Results of an Oblique-Incidence Pulse-Sounding H.F. (4.64 MHz) Experiment between ANDOYA, Norway and COLLEGE, Alaska.** R.R.BARTHOLOMEW.
AGARD Conference Proceedings CP 13, Chapter 34, pp.451-465, 3 refs., 1969.
An oblique-incidence pulse sounding experiment was made for the year of 1964 between Andoya and COLLEGE the path length being 5040 km. A comparison with M.U.F. and L.U.F. predictions show that the predicted propagation spectrum was much narrower than that observed.

CP13/35 **A Proposed Terminology for Ionospherically Propagated Backscatter Modes.** R.R.BARTHOLOMEW.
AGARD Conference Proceedings CP 13, Chapter 35, pp.467-470, 4 refs., 1969.
A standard terminology is needed for describing the mode geometry of backscattered and forward scattered radio energy.

CP13/36 **Ionospheric Oblique Backscatter Observations at 17 Mc/s During the I.Q.S.Y.** W.J.BAGGALEY.
AGARD Conference Proceedings CP 13, Chapter 36, pp.471-486, 9 refs., 1969.
This chapter examines the factors governing the propagation of high frequency radio-waves in backscatter sounding surveys. 17 Mc/s backscatter observations carried out during the I.Q.S.Y. at Sheffield, England are described.

CP13/37 **Oblique Chirp Sounding.** G.H.BARRY, R.B.FENWICK.
AGARD Conference Proceedings CP 13, Chapter 37, pp.487-501, 16 refs., 1969.
The quality of oblique ionospheric pulse sounding signals can be improved by the use of more complex sounding signals. The use of a linear F.M. transmission called Chirp is here described and results comparing it with pulse sounding presented. It is suggested that the advantages are considerable.

CP13/38 **Automatic Analysis of Oblique-Incidence Sounder Data.** J.B.LOMAX.
AGARD Conference Proceedings CP 13, Chapter 38, pp.503-524, 1969.
Equipment to convert the analog signal output from a sounder to a digital representation for computer processing is described. Computer programs have been developed to analyze and plot the data in the form required.

CP14 **Assessment of Skill and Performance in Flying.**
AD-661-165 AGARD Conference Proceedings CP 14, 127 pp., 1966.
N68-12798 Thirteen papers were given at the 23rd Annual Meeting of the AGARD Aerospace Medical Panel held in Toronto, Canada, September, 1966. They dealt with the problems and possible solutions, measurement of skill and performance, and techniques for assessing efficiency of higher cerebral functions. Abstracts of the individual papers are given in the succeeding items.

CP14/1 **Human Error Research and Analysis Program (HERAP).** R.E.LUEHRS.
AGARD Conference Proceedings CP 14, pp.1-8, 1966.
A meeting in 1964 at the US Naval Aviation Safety Center resulted in the implementation of HERAP for the investigation of the extent of human error in aircraft accidents. The proportion of naval aviation accidents attributable to human error has exceeded those attributable to equipment malfunction or failure. This paper briefly discusses the systematic approach for studying this accident-producing system, the basic considerations in HERAP, and the reasons for studying human error.

CP14/2 **The Analysis of Human Performance Within the Operational Flight Environment.** L.HITCHCOCK, JR.
AGARD Conference Proceedings CP 14, pp.9-14, 1966.
The laboratory detection and evaluation by psychophysical measurements of deterioration in man's ability to pilot a modern aircraft are subjected to certain limitations. This paper presents some of the more popular procedures and attempts to classify them with respect to their dimensional capabilities, and the assumptions which define when and how they may be used. The quantitative analyses presented are said to constitute only first steps towards precise measurement of piloting performance.

CP14/3 **Sustained Pilot Performance Requires More than Skill.** B.O.HARTMAN, G.K.CANTRELL.
AGARD Conference Proceedings CP 14, pp.15-23, 1 ref., 1966.
Very briefly describes the factors, such as sleeping, eating, workloads, which are responsible for the aircrew's physical and psychological fitness for sustained flying proficiency during demanding missions.

CP14/4 **Sleep Rhythms in Transatlantic Civil Flying.** T.C.D.WHITESIDE.
AGARD Conference Proceedings CP 14, pp.25-28, 1966.
A number of East-West and West-East flights have been made in the Boeing 707 and a Super VC 10. The parameters recorded and analyzed were pulse rate from take-off and landing. A log was kept of activities on the flight deck, and of the periods of sleep during the slip period. An attempt is made to relate the degree of tiredness resulting from sleep loss together with the fatigue produced by the flying task, to the pattern of cardiac activity during the flight period.

CP14/5 **Navigation of Helicopters in Slow and Very Low Flight: A Comparison of Solo and Dual Pilot Performance.** R.E.F.LEWIS.
AGARD Conference Proceedings CP 14, pp.29-34, 1966.
The study was made in CH 112 light helicopters using experienced army helicopter pilots. No difference was found between dual and solo performance in terms of the numbers of endpoints reached (entering a circle of one-eighth mile radius at the endpoints). Advantages of a secondary nature however, were shown for dual terms, e.g. smaller, errors in landings beyond the criterion circle, fewer initial heading errors and enroute "sit-downs".

CP14/6 **Development of the Spatial Orientation Trainer.** K.K.GILLINGHAM.
AGARD Conference Proceedings CP 14, pp.35-45, 3 refs., 1966.
The device is intended to serve as a demonstrator of spatial disorientation and as a tester and trainer. It is designed to differentiate between disorientation-accident-prone pilots and disorientation-accident-resistant ones, as well as to give pilots practice in overcoming the disorientation influences. The physiological principles, its mechanisms of action, and potential application to Air Force needs are discussed.

CP14/7 **Measurement of Performance in F-86K Simulator.** E.RIIS.
AGARD Conference Proceedings CP 14, pp.47-56, 1966.
Deals with the pilot study of measuring performance under various conditions in a simulator. The flying programme consisted of enemy interception by radar. The effect of learning is shown to be crucial, different types of work load fed different effects on performance. Alcohol had less adverse effect than expected, but the hangover period was shown to be more dangerous than moderate intoxication.

CP14/8 **Measuring the Pilot's Contribution in the Aircraft Control Loop.** H.F.HUDDLESTON.
AGARD Conference Proceedings CP 14, pp.57-69, 30 refs., 1966.
A review of research over the past fifteen years is followed by a description of recent research on two simulators at the RAF Institute of Aviation Medicine, UK. Four families of psychological variables have been suggested as accounting, to a large extent, for observed inter-operator differences in manual flight control strategies on the basis of this research.

CP14/9 **Prior Learning and Age in Relation to Pilot Performance.** J.M.BROWN.
AGARD Conference Proceedings CP 14, pp.71-78, 9 refs., 1966.
Some effects of the above two variables on pilot performance and flying accidents are discussed. Supporting evidence is drawn from the extensive experience of the Royal Canadian Air Force in training Canadian, NATO and other foreign national pilots. Prior learning is said to be the most important variable.

CP14/10 **Plasma Phospholipid Composition as a Biochemical Index to Stress.** B.D.POLIS, J J.MARTORANO.
AGARD Conference Proceedings CP 14, pp.79-90, 4 refs., 1966.
On the promise that diverse physiological reactions to stress have common chemical parameters, changes in phospholipid composition were investigated in various stress conditions using blood plasma of the human as source material. The data suggest that the phospholipid composition of the plasma reflects the action of cerebral metabolic control factors. The resolution of these factors and the bioenergetic role of phospholipids offer an investigative approach, both to chemical recognition and biological response to stress and to a protective methodology.

CP14/11 **The Electroencephalogram as a Physiological Criterion of Performance.** R.D.SQUIRES.
AGARD Conference Proceedings CP 14, pp.91-100, 1966.
Indications of physiological changes within the central nervous system concomitant with psychologically measured deterioration in performance can be obtained from the electroencephalogram. Continuous monitoring has provided an estimation of an individual's wakefulness and of the extent and duration of his visually directed attention. Equipment designed for such studies has been used to evaluate the effects of certain metabolites and drugs on sleep-walking cycles and on the level of intensity of visual attention.

CP14/12 **The Use of Psychophysiological Measures in the Assessment of Operator Effort.** A.J.BENSON, J.M.ROLFE.
AGARD Conference Proceedings CP 14, pp.101-114, 44 refs., 1966.
The level of activity in physiological systems which are under the control of the autonomic and somatic nervous system, may be considered to reflect the mental and physical effort demanded by the task. The results of experiments on subjects who performed simple closed sequence control tasks, and those of greater complexity provided by the simulated and actual flying task, are described. The limitations of psychophysiological measures in behavioural studies are also discussed.

CP14/13 **Influence of Mild Hypoxia on Visual Perception during Post-Rotary Optical Nystagmus.** A.SCANO, G.MAZZA, R.CAPORALE.
AGARD Conference Proceedings CP 14, pp.115-127, 15 refs., 1966.
Investigates the effects of visual fixation upon targets, exposed for short periods, on duration and characteristics of ocular post-rotatory nystagmus, and its influence on visual perception. Visual fixation redness nystagmus amplitude and duration, as well as slow-phase angular velocity. Nystagmus modifies target perception. Experiments carried out on the same subjects, submitted to mild hypoxia, have resulted in a worsening effect.

CP15 **Radio Antennas for Aircraft and Aerospace Vehicles.** Editor W.T.BLACKBAND.
AD-851-747 AGARD Conference Proceedings CP 15, 403 pp., Many refs., 1967.
N69-25251 Records the papers and discussions of a symposium arranged by the AGARD Avionics Panel and held in Dusseldorf in July 1966. Some 22 papers were presented under three main headings, Antennas for Aircraft, Antennas for Rocket Vehicles and Antennas for Satellites. These are treated individually in the following abstracts.

CP15/1/1 **H.F. Suppressed Aerials for Aircraft.** C.NEW, T.W.SHARPE.
AGARD Conference Proceedings CP 15, Chapter 1-1, pp.7-39, 1967.
This Chapter describes the general problems associated with notch aerials in the range of 2 Mc/sec. to 30 Mc/sec. Methods of matching and tuning are discussed and several aircraft systems are described together with a "radio silence" facility incorporated in one of them. Developments in this field are then outlined.

CP15/1/2 **Aerial Tuner for Notch Aerials.** J.A.LAWSON.
AGARD Conference Proceedings CP 15, Chapter 1-2, pp.41-50, 1967.
A control system is described which can be used to tune notch aerials over the frequency range 2.5 to 25 Mc/sec. It was required to tune notch aerials automatically to any frequency in this range and also to tune manually. The development is described of a simple unit which incorporates a safety device to reduce the power transmitted in the event of a pressure failure in the notch aerial tuner unit.

CP15/1/3 **Aerials for Instrument Landing Systems.** R.A.BURBERRY.
AGARD Conference Proceedings CP 15, Chapter 1-3, pp.51-66, 7 refs., 1967.
Special aerials are required for present Instrument Landing Systems (I.L.S.) in aircraft intended to check the accuracy of ground installations, a number of these are discussed together with the problems associated with feeding more than one receiver and of minimizing the effect of one receiver on another.

CP15/1/4 **Movement of the Phase Centre of I.L.S. Airborne Localizer Aerials on a Varsity Aircraft.** I.L.JONES.
AGARD Conference Proceedings CP 15, Chapter 1-4, pp.67-96, 3 refs., 1967.
Experiments on the variations in the phase centre of I.L.S. Airborne localizer aerials on a Varsity aircraft are described. Initial tests were on a one-ninth scale model and a limited number of tests were done on a full scale aircraft on the ground. Four aerials in four typical localizer aerial sites were studied; wing-up notch aerials, ramshorn aerial on the fuselage, a tail fin dipole, and a dipole in the nose of the aircraft. The results show that the displacement of phase centre with yaw was greatest while the effects of roll and control surface movement were small. A method of prediction is offered.

CP15/1/5 **Determination of the Phase Center and Phase Pattern of Antennas.** J.D.DYSON.
AGARD Conference Proceedings CP 15, Chapter 1-5, pp.97-118, 24 refs., 1967.
Theoretical and experimental methods of determining the apparent phase center of antennas are described and some results of application of these methods to the logarithmic-periodic antennas are presented.

CP15/1/6 **Recent Developments in H.F. Helicopter Antennas.** J.D.COSGROVE, R.C.FENWICK.
AGARD Conference Proceedings CP 15, Chapter 1-6, pp.119-148, 6 refs., 1967.
Describes the results of recent work on the development of an optimum H.F. antenna and coupler for small and medium sized helicopters. It is concluded that open-ended wire antennas incorporating tunable loading coils are optimum on helicopters where only side mounting of antennas is practical. The results of theoretical studies and scale model tests are described and the desigr. of a 2-30 Mc/sec. antenna and coupler is discussed.

CP15/1/7 **The Elliott Cassegrain Scanning Aerial.** J.WELSH, E.LAVERICK.
AGARD Conference Proceedings CP 15, Chapter 1-7, pp.149-164, 2 refs., 1967.
Discusses the principle advantages and chief characteristics of one of the class of Elliott Cassegrain Aerials called the reflecting plate scanner in which movement of a flat reflecting plate is used.

CP15/1/8 **The Design of a Mechanical Yaw and Drift Corrected Reflecting Plate Linear Array.**
AGARD Conference Proceedings CP 15, Chapter 1-8, pp.165-174, 1967.
The requirements for radar survey mapping are discussed and an aerial is described consisting of a linear slotted array which fed a transreflector back to a twist reflector. The performance of an 18 ft. X-Band array of this is given, together with the design of its components and its control.

CP15/1/9 **Microwave Printed Circuit Aerial Research.** E.LAVERICK, J.WELSH.
AGARD Conference Proceedings CP 15, Chapter 1-9, pp.175-184, 2 refs., 1967.
Describes an investigation of printed circuit aerials. Dielectric-fitted triplate slotted arrays were investigated but were difficult to make and set up. Attention was then turned to the sandwich wire form of aerial and a printed circuit form known as the snake-line array was developed with very satisfactory performance.

CP15/1/10 **General Properties and Experimental Measurement Techniques; Review of Aircraft Aerials for the Lower Frequencies.** F.GNAVI, C.SCAGLIA.
AGARD Conference Proceedings CP 15, Chapter 1-10, pp.185-197, 15 refs., 1967.
The problem of receiving aerials for the lower frequencies of M.F., L.F. and V.L.F. to be installed

on aircraft is discussed by means of a very general preliminary analysis of their radiation and input impedance characteristics. In particular, a theoretical proof and assessment of some peculiar properties related to tilt-angle and sensitivity is presented. Experimental methods for scanning the sensitivity product are reviewed and improvements by the use of A.C. in an electrostatic cage are described. Finally the design and measurement of the properties of an A.D.F. sense aerial for the Fiat G-91 Y aircraft are described.

CP15/2/1 **The Guidance Antenna of the Eldo Launcher Europa I.** P.G.SIMON.
AGARD Conference Proceedings CP 15, Chapter 2-1, pp.201-213, 7 refs., 1967.
The general properties of the balanced conical spiral are reviewed and discussed in relation to the requirements for Europa I Experimental results are presented and compared with results by J.D. Dyson in larger conical log-spiral antennas and the results are shown to be compatible.

CP15/2/2 **A Folding Rocket Antenna for Transmission and Experiments.** P.BRUSCAGLIONI, V.CAPPELLINI, P.F.PELLEGRINI.
AGARD Conference Proceedings CP 15, Chapter 2-2, pp.215-218, 2 refs., 1967.
This short paper describes a dipole antenna where whips can be turned from a position aligned to the rocket surface to a position perpendicular to it. The erection system is described and its use discussed.

CP15/2/3 **The Receiving Aerial of a Weightless Body Simulator Laboratory.** G.RINGENBACH.
AGARD Conference Proceedings CP 15, Chapter 2-3, pp.219-232, (in French with translation 379-384), 4 refs., 1967.
O.N.E.R.A. makes use of the free fall of a body in vacuo to simulate weightlessness. The fall takes place from a height of 40 metres in a metal tube which attenuates the telemetry signals and prevents their detection. This chapter discusses the use of a surface waveguide to pick up the signal and to conduct it to the inside of the tube and thence to the receiver. The mean standing wave ratio is less than 2 and the telemetry signals are usable during the whole of the fall

CP15/2/4 **Radomes for Aerospace Vehicles.** R.J.NORDLUND.
AGARD Conference Proceedings CP 15, Chapter 2-4, pp.233-239, 12 refs., 1967.
Airborne requirements for ceramic radomes for operation in hyperenvironments and the problems involved are discussed. Techniques for ceramic nose cones which retain their required electrical and structural properties when subjected to temperatures above 4000°F are also discussed.

C. 15/2/5 **A Low Profile Antenna.** S.B.PITTS.
AGARD Conference Proceedings CP 15, Chapter 2-5, pp.241-250, 1967.
Radiating structures consisting of a co-aerial line with the outer shield broken at periodic points is well known. This chapter describes a variation in which the structure is bonded to the centre or edge of a ground plane. This antenna yields either endfire or broadside patterns or both as a function of frequency. Its low profile, reducing drag, makes it attractive for many aerospace applications.

CP15/2/6 **Ultra-Short Conical Spiral Aerial.** (in French and English). R.GOUILLOU.
AGARD Conference Proceedings CP 15, Chapter 2-6, pp.251-264, (translation pp.385-392)
5 refs., 1967.
The theory of several types of two dimensional aerial, single rod, ring-type and flat spiral is recapitulated and applied to the conical spiral. Several models of the ultra-short conical spiral aerial are described and their measured performance is in good agreement with theory. A conical aerial having a diameter of $\lambda/40$ and a height of $\lambda/25$ is shown to have a band-width of 3% at -3dB, and an efficiency better than 0.5dB.

CP15/3/1 **A Low Sidelobe Mechanically Despun Antenna for Aerospace Application.** D.L.BACKUS.
AGARD Conference Proceedings CP 15, Chapter 3-1, pp.267-293, 60 refs., 1967.
Presents the theoretical and experimental performance of a mechanically despun phased array antenna which is claimed to be promising for aerospace communications and radars. System parameters are listed for a synchronous satellite application. It is shown that increased performance and flexibility can be attained.

CP15/3/2 **Unfurlable Antenna for the Italian Satellite S.Marco.B.** P.F.CHECCACCI, P.FABENI, A.RANFAGNI.
AGARD Conference Proceedings CP 15, Chapter 3-2, pp.295-300, 2 refs., 1967.
The radiating system of the Italian Satellite for the ionospheric experiment consists of two unfurlable steel-tape monopoles each one extending for 250 cm. from the satellite body. Extension devices provide the unwinding and rewinding of the tapes. In order to radiate at 10 and 20 Mc/sec. the antenna is provided with a suitable matching system.

CP15/3/3 **Antennas for Space Applications.** E.A.BLASI.
AGARD Conference Proceedings CP 15, Chapter 3-3, pp.301-320, 11 refs., 1967.
Several types of antennas designed to create no serious space and weight penalties are discussed. These include three mechanically erected and five inflatable antennas.

CP15/3/4 **Low Gain Ring Antenna; General Properties and Application to the ELDO Satellite.** M.BOELLA, C.CUGIANI, A.VILLA, R.ZICH.
AGARD Conference Proceedings CP 15, Chapter 3-4, pp.321-336, 3 refs., 1967.
A type of ring antenna has been studied for applications on satellite in sub-orbital as well as in orbital flight to achieve a small sized structure and a low gain. Admittance properties and radiation patterns are given together with indications for correct design.

CP15/3/5 **A Space Antenna for Radio Astronomical Measurements below One Megacycle.** H.A.LASSEN, R.A.PARK, J.E.TABER.
AGARD Conference Proceedings CP 15, Chapter 3-5, pp.339-350, 1 ref., 1967.
This chapter deals with the problems of radio astronomy at frequencies of one megacycle and below where transmission to the earths surface is prevented by the ionosphere and, in particular on the antenna required to make measurements in this range of frequencies.

CP15/3/6 **Theoretical Analysis of Antennas with Sector Shaped Radiation Pattern for Communication Satellites.** W.REBHAM.
AGARD Conference Proceedings CP 15, Chapter 3-6, pp.353-363, 3 refs., 1967.
This chapter makes the case for a cone shaped radiation pattern to cover the earth's surface with a spherical depression to compensate for the higher path-losses. A theoretical analysis shows promise of providing such a pattern and preliminary experimental results obtained on simple models are given.

CP15/3/7 **The Automatic Tuning Control of a Short Antenna.** V.CAPPELLINI, P.F.CHECCACCI, P.FABENI, G.P.PAZZI, A.RANFAGNI.
AGARD Conference Proceedings CP 15, Chapter 3-7, pp.367-376, 4 refs., 1967.
A spherical antenna operating at 54 Mc/sec for spacecraft with an automatic electronic tuning device to avoid detuning due to dialectric variation when the spacecraft is travelling through the ionosphere is described. Design criteria and experimental results are given.

CP16 **Signal Processing Arrays.** Editor W.T.BLACKBAND.
AD-853-934 AGARD Conference Proceedings CP 16, 446 pp., many refs., 1968.
The papers in this volume were presented at a colloquium sponsored by the AGARD Avionics Panel and held in Düsseldorf in July 1968. The papers and the discussions in them cover aspects of the very wide field implied by the title including frequency scanning radar, Butler matrix and Weullenlarger arrays, Mill's Cross, crossed dipoles and goniometer. Active and passive arrays are discussed and data on allied servo-systems and controls are included. The 23 papers are dealt with in the following abstracts.

CP16/1 **A Survey of Signal Processing Arrays.** A.KSIENSKI.
AGARD Conference Proceedings CP 16, Chapter 1, pp.1-43, 85 refs., 1968.
This paper consists of an introduction, a literature survey, and a critique of signal processing arrays. The types described include synthetic arrays, self-phasing and retrodirective arrays, correlation arrays and decision theoretic arrays.

CP16/2 **A Generalized Class of Signal Processing Arrays.** W.H.NESTER, J.A.KINZEL.
AGARD Conference Proceedings CP 16, Chapter 2, pp.44-62, 6 refs., 1968.
The paper discusses a generalized class of signal processing arrays. This class is characterized by (a) a terminated generalized Fourier series representation in the time domain of the distribution in angle of multiple radiation sources, (b) a selection of the received signal from one of the several sources by time geting and (c) smoothing by narrow band filtering. A few exact and approximate realizations of these arrays are described and experimental and theoretical results are compared for one.

CP16/3 **Synthetic Aperture Radar.** W.M.BROWN.
AGARD Conference Proceedings CP 16, Chapter 3, pp.64-88, 10 refs., 1968.
The paper develops the general theory of side looking synthetic aperture radar systems and offers a simple theory model. The geometry of the system determines the nature of a prefilter in the model and the receiver or processor in the postfilter. Analysis and optimization are carried out for resolution signal to noise ratio and target field. Specially the optimum synthetic aperture length is derived in terms of the noise level and the average transmitted power. Range-Doppler ambiguity limitations and optical processing are discussed briefly.

CP16/4 **Increase of Resolving Power of an Antenna to Analyse an Orthogonal Field.** (In French). S.DRABOWITCH, M.METHAIS.
AGARD Conference Proceedings CP 16, Chapter 4, pp.89-126, 20 refs., 1968.
The resolving power increase of an orthogonal distribution field resolution antenna is discussed. A new method is presented which permits measuring the angular deviation of two objects when the deviation is very much less than the amplitude of the diffraction lobe. Technique, instrumentation, mathematical expressions and other mechanical data are included together with numerous graphs and pertinent photographs. Results obtained agree with the information theory and show an appreciable power gain in relation to Rayleigh's theory.

CP16/5 **Wullerweber Arrays.** R.M.WUNDT.
AGARD Conference Proceedings CP 16, Chapter 5, pp.128-152, 1968.
Two configurations of Wullerweber arrays with extended frequency range are examined and their essential parts described. These provide a multiplicity of fixed high-gain beams and low gain sector beams covering 360 degs. in azimuth and giving broad elevation coverage. A goniometer was developed for direction finding use and has a very low insertion loss.

CP16/6 **Wullerweber Arrays using Doublet Aerials.** D.W.G.BYATT.
AGARD Conference Proceedings CP 16, Chapter 6, pp.153-168, 4 refs., 1968.
This paper describes a Wullerweber array which allows high frequency rings to be within the low frequency rings giving good aerial diagrams and low cost construction.

CP16/7 **Electronic Beam-Rotation for Circular Arrays using Matrix Network.** P.E.K.CHOW, R.G.FENBY.
AGARD Conference Proceedings CP 16, Chapter 7, pp.171-183, 5 refs., 1968.
This paper studies the design of electronic beam-rotation systems which use a matrix network to feed a circular aerial array. Such an arrangement is suitable for electronic rotation of one or more beams with 360 degs. azimuth coverage and may have application to either direction finding or radar systems. Some experimental results are presented.

CP16/8 **A Broad-Band Multi-Beam Array.** N.A.D.PAVEY, J.THRAVES, L.J.T.HINTON.
AGARD Conference Proceedings CP 16, Chapter 8, pp.185-213, 12 refs., 1968.
A technique is described by which a number of beams having arbitrary directions independent of frequency may be generated from a single aerial array. The design of a 32-element multi-beam array for the band 2.5 to 4.1 GHz is considered and experimental results for an 8-element feasibility model are given.

CP16/9 **An X-Band Matrix Array.** J.THRAVES.
AGARD Conference Proceedings CP 16, Chapter 9, pp.215-233, 3 refs., 1968.
The paper describes the construction of an experimental eight element matrix using a lightweight manufacturing technique for mounting in an aircraft. Measured results of the properties of the matrix are given and discussed.

CP16/10 **Design of a Switched Multibeam Aerial in X-BAND for Use on an Experimental C.W. Surveillance Radar.** A.BROWN.
AGARD Conference Proceedings CP 16, Chapter 10, pp.234-253, 5 refs., 1968.
Describes an experimental X-band aerial made recently. Separate aerial systems with two identical 32 port Butler matrices are mounted side by side to give 24 beams in the 64 deg. elevation average required. The beam switching networks use high power Y circulator switches and allow 2, 4 or 8 adjacent beams to be used on both transmission and reception at the same time.

CP16/11 **A Contribution to the Technique of Counter-rotating Antennas.** (In French). S.DRABOWITCH, M.MORLON.
AGARD Conference Proceedings CP 16, Chapter 11, pp.255-279, 11 refs., 1968.
A Type of counter rotating antenna is considered which is to be used for a rotation stabilized satellite. This antenna comprises a circular network whose elements are fed with a variable phase. A high frequency matrix between the beam elements and the dephasers gives an antenna with space harmonics. The main advantages of this antenna are: The number of dephasers is few and independent of the number of beam elements; the phase variation law of these dephasers is linear; and it is possible to influence the shape of the ray diagram.

CP16/12 **Application of Electronically Phased Antennas for Spin Stabilized Satellites.** H.R.ERHARDT, B.T.SUBBOTIN.
AGARD Conference Proceedings CP 16, Chapter 12, pp.280-298, 1968.
This chapter describes the design optimization, fabrication and test of an array of 16 phased radiating elements each consisting of four collinear dipoles for the NASA Technology Satellite. The antenna gives a cone shaped beam for earth coverage which is controlled by PACE (Phased Array Control Electronics) in synchronism with the satellite spin frequency. Finally advanced developments for next generation satellites are discussed.

CP16/13 **Study of Self-Focusing Antennas for Telecommunication Satellites.** C.CUGIANI, V.POZZOLO, A.VILLA, R.ZICH.
AGARD Conference Proceedings CP 16, Chapter 13, pp.299-305, 8 refs., 1968.
An equispaced self-focusing linear array has been considered in the paper. The array factor of the reradiated field has been calculated allowing for the mutual coupling between elements. The back-radiated field has been examined when mutual couplings may be neglected. Finally the present experimental research is described.

CP16/14 **Self-Focusing Aerial Arrays for Airborne Communications.** M.J.WITHERS, D.E.N.DAVIES, R.H.APPERLEY.
AGARD Conference Proceedings CP 16, Chapter 14, pp.307-317, 3 refs., 1968.
This paper discusses the possible use of self-focusing arrays for obtaining increased airborne aerial gain in two-way airborne communications without restricting the angular coverage. An experimental system based upon a hill-climbing technique for the adaptive phasing of the outputs of four aerials is described and some initial results given for operation in the V.H.F. band.

CP16/15 **Active Aerials for Aircraft Communications.** W.T.BLACKBAND, D.E.T.NICHOLS.
AGARD Conference Proceedings CP 16, Chapter 15, pp.319-329, 1 ref., 1968.
This chapter is an account of a means of combining the signals from two aerials in order to get all round cover. This is done by siting the aerials so that between them they radiate at all azimuths, and then arranging that their signals always add in phase. The two aerials are brought into phase by phase shifters which can be mechanically or electronically operated. Experimental results are discussed.

CP16/16 **Hemispherical Scanning with Small Aperture Antennas.** E.M.TURNER.
AGARD Conference Proceedings CP 16, Chapter 16, pp.331-338, 1968.
The results of feasibility studies made on monopoles, spirals, scimitars and one form of a wire antenna are presented and other promising types for multiple beam operation are discussed. These give designs which are considered particularly well suited for E.C.M. Communications, E.C.C.M., and Ferret functions.

CP16/17 **A Wideband, Digitally Variable Time Delay Technique for Array Antennas.** J.B.PAYNE.
AGARD Conference Proceedings CP 16, Chapter 17, pp.339-349, 4 refs., 1968.
This chapter states that intermediate frequency delay steering of a wideband array antenna can be realized and made independent of bandwidth: it also presents a technique for obtaining a wideband, nondispersive, electronically controllable, digital time delay device at i.f. to steer such an array antenna. The design and experimental results from a four-bit digital delay device are discussed.

CP16/18 **Active Microwave Scattering Arrays.** D.L.BAERWALD.
AGARD Conference Proceedings CP 16, Chapter 18, pp.351-375, 13 refs., 1968.
Describes work done at the Rome Air Development Center on active microwave scatterers in the construction and testing of an 81 element square array at X-band. Each of the array units consisted of etched equiangular spiral antennas directly coupled to balanced strip transmission lines. The work has shown that arrays of active independent microwave scatterers can be designed and constructed with known characteristics, focused as desired and operated stably on very low bias power.

CP16/19 **New Technique of Using Aerials in Hertzian Radiometry.** (In French). E.SPITZ.
AGARD Conference Proceedings CP 16, Chapter 19, pp.377-400, 5 refs., 1968.
Surveys radiometric antennas and discusses signals used for a map making aerial survey of the ground. The frequency band of interest is between 8 and 110 GHz. The governing factors are the emissivity of the objects, the transparency of the atmosphere and the performance of the receivers.

CP16/20 **Space Frequency Filter Antennas.** E.M.TURNER.
AGARD Conference Proceedings CP 16, Chapter 20, pp.401-406, 1968.
This short paper presents the concept behind work which is now being done. Broadband frequency independent antennas such as the spirals and the log periodic structures automatically adjust their phase centers so as to keep the patterns and impedance essentially constant over a wide band of frequencies. By the use of muitiple terminals properly placed it is possible to delineate the signals received or transmitted both as a function of frequency and of angle, thus the antenna becomes both a space frequency and a directional filter device. The space frequency filter concept is expected to have wide application in both communication and E.C.M. but is not limited to these applications.

CP16/21 **Variable Phase Shifters.** W.T.BLACKBAND
AGARD Conference Proceedings CP 16, Chapter 21, pp.407-418, 17 refs., 1968.
A survey is made of the various forms of phase shifter and variable delay lines available covering frequencies up to X-band. Mechanical and electronic forms of adjustment are described and the latter include varactors, P.I.N. diodes, ferrites, garnets and ferroelectric materials.

CP16/22 **Electronically Adjustable Ferrite Phase Shifters and their Application in Scanning Leaky-Wave Antennas.** G.BUCHTA.
AGARD Conference Proceedings CP 16, Chapter 22, pp.419-428, 6 refs., 1968.
This chapter describes experiments on two types of ferrite slab phase shifters and discusses their possible applications in scanning leaky-wave antennas.

CP16/23 **Miniaturized Broadband E-Tee Circulator.** G.BUCHTA.
AGARD Conference Proceedings CP 16, Chapter 23, pp.429-433, 3 refs., 1968.
Normally waveguide E-Tee circulators, which are compact, have only a narrowband performance. This chapter describes a modified E-Tee three-part circulator with an exceptionally wide bandwidth of 1000 Mc/s for 20dB isolation at X-band achieved in a device with a total length of half an inch.

CP17/1 **Stability and Control: Pt. 1.** A.G.BARNES (Editor).
AD-665-205 AGARD Conference Proceedings CP 17, Pt. 1, 524 pp., 1966.
N68-17439 The AGARD Specialists Meeting on Stability and Control was held at Cambridge in September 1966. The proceedings are published in two separately bound parts. Pt. 1 contains papers on: dynamic motions of aircraft; general handling; auto-stability and control; stability and control data and their determination. Abstracts of the individual papers are given in the succeeding items.

CP17/1/2 **Dynamic Motions of Aircraft: Survey and Introduction.** C.C.FLORA.
AGARD Conference Proceedings CP 17, Pt. 1, 1-20, 8 refs., 1966.
Considers low-speed control response from the point of view of longitudinal and lateral-directional control, also high-speed control response and aeroelastic aspects. The brief analysis of lateral-directional control indicates, and flight simulation shows, that slender aircraft configurations such as SSTs require quite sophisticated lateral-directional stability augmentation systems for adequate low-speed handling qualities. The high-speed control analysis shows that development of a stability augmentation system to meet a tightly specified rigid body response characteristic for an elastic aircraft in high-speed flight may be impossible with conventional systems.

CP17/1/3 **Some Observations on the Dynamics of Large Slender Aircraft.** W.J.G.PINSKER.
AGARD Conference Proceedings CP 17, Pt. 1, 23-54, 5 refs., 1966
Topics discussed include flight experience on slender aircraft and handling criteria, mode coupling due to inertia imbalance, ground clearance at and after lift off, and cross-wind approach. Recovery from upset by tail gust in the approach is dealt with in some detail from the point of view of aircraft response to tail gust, recovery by elevator control, effect of adverse elevator lift, and alternative means of control. It is concluded that techniques other than elevator control will have to be explored for use with future aircraft.

CP17/1/4 **Developments in Aeroelasticity for Large Aircraft.** J.C.HOUBOLT.
AGARD Conference Proceedings CP 17, Pt. 1, 55-78, 20 refs., 1966.
The purpose of this paper is to review recent development and trends. The aim is more to identify the main problems of concern, to indicate reference work and people, and to evaluate where emphasis is needed, rather than to give details on the various items. The consideration is limited to large fixed-wing aircraft, which encounter the majority of the static aero-elastic, flutter, and buffeting problems that can be listed.

CP17/1/5 **The Role of Flutter Derivatives in Aircraft Stability and Control.** R.D.MILNE.
AGARD Conference Proceedings CP 17, Pt. 1, 79-100, 15 refs., 1966.
Describes a method for dealing with the transient motion of aero-mechanical systems. The technique presented uses the flutter derivatives as the basic data but expresses the solution largely in terms of exponentials. The main limitation is that the solution does not apply for very short intervals of time after the application of impulsive forces to the system. The use of "constant" derivatives as in aircraft stability and control and the familiar, simple harmonic, flutter type of solution are both included as special cases.

CP17/1/6 **Comparison of Computer and Flight Test Results for a Spinning Airplane.** J.H.WYKES, G.R.CASTEEL.
AGARD Conference Proceedings CP 17, Pt. 1, 101-125, 9 refs., 1966.
Presents evidence to show that it is feasible to calculate the spinning characteristics of an aircraft, from incipient spin through recovery phases, using static aerodynamic wind tunnel data and estimated rotary derivatives based on these static test data. The approach removes the constraints of low Reynolds number and Mach number found necessary when using small spin models, and makes it possible to study in a systematic manner the effects of the many important variables influencing the spin response of an aircraft.

CP17/1/7 **Analytical Study of Spinning.** (In French). M.SCHERER, M.-O.AGUESSE.
AGARD Conference Proceedings CP 17, Pt. 1, 127-158, 8 refs., 1966.
The results of the first phase of an analytical study of spinning, carried out jointly by ONERA and the Institute of Fluid Mechanics at Lille (IMFL) are reported. Free flight tests on a spinning model of a delta wing aircraft with 60 deg. of sweep were effected in the IMF2 vertical wind tunnel. A film of the flight of the model enabled the trajectory of the centre-of-gravity and the attitude of the aircraft to be established as a function of time. The dynamics of the spinning motion as determined from these tests and as derived by calculation were compared.

CP17/1/8 **On Nonlinear Longitudinal Dynamic Stability.** M.TOBAK.
AGARD Conference Proceedings CP 17, Pt. 1, 161-173, 9 refs., 1966.
It is of interest to situate functional analysis historically in the general line of development of dynamic stability theory. This paper shows that it represents a logical continuation of this line from the linear into the nonlinear domain by considering an aircraft undergoing a two-degree-of-freedom longitudinal motion consisting of arbitrary variations in time of angle of attack and dimensionless pitching velocity. It is shown how the indicial responses and the pitching moment may be defined as nonlinear functionals. Suitable approximations are then introduced to reduce the equations to more tractable forms.

CP17/1/9 **Flying Qualities Criteria Problems and Some Proposed Solutions.** J.W.CARLSON, R.K.WILSON.
AGARD Conference Proceedings CP 17, Pt. 1, 177-210, 34 refs., 1966.
Discusses some of the shortcomings of current flying qualities criteria, and describes the programme the US Air Force is pursuing to revise and update or otherwise replace these criteria. The results of recent research investigations are reviewed and some promising flying qualities parameters which were identified during these programmes are discussed. Several existing or developmental aircraft are compared with existing handling qualities requirements and some suggested criteria, and potentially useful new criteria are examined.

CP17/1/10 **Some Problems in Control Arising from Operational Experiences with Jet Transports.** B.CAIGER.
AGARD Conference Proceedings CP 17, Pt. 1, 211-226, 8 refs., 1966.
Some particular aspects of the disturbances to jet transports due to turbulence that have been studied at the Canadian National Aeronautical Establishment in the course of a major accident investigation are discussed, and tentative recommendations are made for future research and developments. These aspects include vertical vibration of the flight deck, pilot response in turbulence, and pitch control and design dive speed aspects, it being considered that the requirements for the latter should be made more severe.

CP17/1/11 **A Revised Pilot Rating Scale for the Evaluation of Handling Qualities.** R.P.HARPER, JR., G.E.COOPER.
AGARD Conference Proceedings CP 17, Pt. 1, 227-253, 5 refs., 1966.
The technical content of pilot evaluation generally falls into two categories, namely, the identification of characteristics which interfere with the intended use, and the determination of the extent to which these characteristics affect mission accomplishment. The latter judgement may be formalized as a pilot rating. The development and use of a pilot rating scale is the subject of this report, which deals specifically with the historical background, development of a revised scale, experimental use of pilot rating of handling qualities, and execution of a handling qualities experiment.

CP17/1/12 **Optimization of the Use of Automatic Flight Control Systems for Manned Aircraft.** H.P.WHITAKER, J.E.POTTER.
AGARD Conference Proceedings CP 17, Pt. 1, 255-276, 9 refs., 1966.
A definition of terms used in control and guidance systems is followed by a consideration of manual versus automatic control. Automatic control system synthesis is then discussed, followed by a more detailed discussion of modern control theory synthesis in general. Finally, synthesis using model-reference adaptive control techniques is dealt with, an illustrative example being included. It is concluded that the most successful use of automatic control subsystems for flight vehicles will result when the decision to employ them is based upon sound engineering evaluations of the technical factors involved rather than upon subjective pre-conceptions.

CP17/1/13 **The Design of Autostabilisers with Particular Reference to Low Speed Handling and Ground Attack Operations.** G.BELCHER.
AGARD Conference Proceedings CP 17, Pt. 1, 277-309, 3 refs., 1966.
Some of the techniques used in the design of modern stability augmentation systems are described and it is shown that artificial stabilization is a powerful tool in improving the aircraft response to give better handling qualities. The techniques illustrated here (transient response, root locus, frequency response and spectral density together with cockpit simulators) are used by the system designer to assess design effectiveness. These techniques also deal efficiently with structural coupling problems and some of the non-linearities which occur in aircraft systems.

CP17/1/14 **Problems Posed by the Integration of an Automatic Flight Control System in the Control of a High Performance Aircraft. Example of Application in the Context of the Project for the Civil Supersonic Transport "Concorde".** (In French). R.DÉQUE.
AGARD Conference Proceedings CP 17 pt. 1, 311-329, 2 refs., 1966.
Problems posed by the installation of artificial stabilization systems and automatic piloting aids in supersonic civil aircraft are treated. The flight conditions experienced by such an aircraft are first treated. The various automatic piloting aids are then defined. Finally, the relations between the associated systems are discussed.

CP17/1/15 **Auto-Aeroelastic Mode Coupling: A Comparison of Predicted and Actual Characteristics.** G.J.EVANS, B.J.BEELE.
AGARD Conference Proceedings CP 17, Pt. 1, 331-359, 6 refs., 1966.
Selected results and some conclusions of theoretical studies on an advanced military aircraft are presented; these studies predicted certain problems for which solutions were evolved. However, it was later evident that the structural representation of the airframe was inadequate and this confirmed the need for additional and modified test programmes. Aspects of these, and earlier test programmes, are discussed. Some measured ground results are compared with the theoretical predictions.

CP17/1/16 **Control of Flexible Aircraft Dynamic Response.** H.M.DAVIS, R.L.SWAIM.
AGARD Conference Proceedings CP 17, Pt. 1, 361-391, 47 refs., 1966.
The factors which are important to the success of gust response control are considered and some of the capabilities still needed for gust response control systems are described. Examples used to illustrate the main points are limited to subsonic conditions. A brief history of gust response control research is followed by a consideration of criteria for gust response control. The basic principles used in this type of control are outlined and the main problem, i.e., mode coupling, and that of control force generation are dealt with.

CP17/1/17 **The Significance of Nonlinear Damping Trends Determined for Current Aircraft Configurations.** H.G.WILEY.
AGARD Conference Proceedings CP 17, Pt. 1, 393-408, 7 refs., 1966.
Reviews the basic features and the accuracy of the technique used in wind tunnels at the Langley Research Center of NASA to determine the oscillatory pitch and yaw damping derivatives at transonic and supersonic speeds. A discussion of sting effects on the measured parameters is included. Representative results of some of the experimental research performed for various current and proposed aircraft designs are presented. Emphasis is placed on those aerodynamic and configuration factors that cause unstable or grossly nonlinear damping trends which are not predictable by usual computing methods.

CP17/1/18 **Progress Achieved in the Techniques for Measuring Aerodynamic Derivatives in Wind Tunnels: The Method of Forced Oscillations.** (In French). M.SCHERER, J.LOPEZ.
AGARD Conference Proceedings CP 17, Pt. 1, 411-436, 5 refs., 1966.
In reviewing the progress achieved at ONERA since 1961 in measuring aerodynamic derivatives by the method of forced oscillations, the following are treated: principal experimental arrangements and methods, improvements in measuring equipment and systems; comparisons with in-flight measurements.

CP17/1/19 **Oscillatory Derivative Measurements on Sting-Mounted Wind Tunnel Models at RAE, Bedford.** J.S.THOMPSON, R.A.FAIL.
AGARD Conference Proceedings CP 17, Pt. 1, 437-479, 3 refs., 1966.
Describes equipment for measuring oscillatory derivatives. The detailed descriptions apply to a new three-degree-of-freedom rig for tests in yaw, roll and sideslip, but the general principles are the same as for an older rig for pitch-have tests which is still in use. The general object is to obtain angular stability (not flutter) derivatives, i.e., the values of the frequency parameter are relatively low. Concise details of the test rig and models are given.

CP17/1/20 **Low-Speed Investigations Using Freely-Flying Models.** P.L.BISGOOD.
AGARD Conference Proceedings CP 17, Pt. 1, 481-495, 4 refs., 1966.
Although freely-flying models were used extensively in the very early days of aviation, their use in post-war research has been confined until recently to studies of the transonic and supersonic regimes on the one hand and studies of spinning characteristics on the other, while the potentialities of the freely-flying model as a means of investigating a wider variety of problems, particularly at low airspeeds, often have been neglected. This paper considers some of these potentialities and discusses some of the techniques that have been used and the results that have been obtained in recent tests using free-flying models at low speeds.

CP17/1/21 **Determination of Performance, Stability and Control Characteristics from Measurements in Non-Steady Manoeuvres.** O.H.GERLACH.
AGARD Conference Proceedings CP 17, Pt. 1, 497-523, 10 refs., 1966.
The flight test method discussed in this paper may be characterized briefly as a mixture of two well-known methods. It combines the features of response measurements with those of the determination of the aircraft's drag characteristics by the so-called "accelerometer-method". A distinguishing feature of the method described here in the fact that the aircraft is manoeuvred in such a way that the air-speed varies significantly during the test manoeuvre. Analysis of the measurements described in this paper is based on regression methods.

CP17/2 **Stability and Control: Pt. 2.** A.G.BARNES (Editor).
AD-665-320 AGARD Conference Proceedings CP 17, Pt. 2, 471 pp., 1966.
N68-17460 The AGARD Specialists Meeting on Stability and Control was held at Cambridge in September 1966. The proceedings are published in two separately bound parts. Pt. 2 contains papers on: stability and control data and their determination; simulated studies of handling; human factors aspects; special stability and control problems; operational handling; special subjects (rough air flying, instrument flying, supersonic operation). Abstracts of the individual papers are given in the succeeding items.

CP17/2/1 **Comparison of Measurements and Estimates for Moments of Inertia of Aircraft.** R.ROSE.
AGARD Conference Proceedings CP 17, Pt. 2, 525-538, 9 refs., 1966.
The extraction of stability derivatives from dynamic flight tests requires a knowledge of the moments of inertia of the aircraft and of the inclination of the principal inertia axis, the accuracy of the analysis depends critically on the accuracy of the inertia data. Two courses are open to flight test engineers; they may either accept the inertia estimates made by the aircraft manufacturer, or they may try to measure these characteristics. This paper makes comparisons between measured and estimated data to check whether the present methods of estimation are satisfactory.

CP17/2/2 **Method of Determining Inertial Constants with the Aid of Ground Vibration Tests.** R.KAPPUS.
AGARD Conference Proceedings CP 17, Pt. 2, 539-552, 1 ref., 1966.
A method is presented for calculating the inertial constants of an aircraft, rocket, or other body from ground vibration tests using a suspension which permits motion in six degrees-of-freedom. All the calculations are effected automatically according to a programme established for the IBM 704 computer.

CP17/2/3 **Flight Simulation – Some Aspects of its Use for Studies of Aircraft Handling Qualities.** D.H.PERRY.
AGARD Conference Proceedings CP 17, Pt. 2, 553-576, 10 refs., 1966.
An account is given of work done at RAE, Bedford on the study of aircraft handling qualities using a ground-based flight simulator. Aspects covered include: the simulator, the problem of validation; examples of some flight simulator studies; some general conclusions on the use of flight simulation for handling qualities studies.

CP17/2/4 **Recent Experience with In-Flight Simulation.** W.O.BREUHAUS.
AGARD Conference Proceedings CP 17, Pt. 2, 577-623, 31 refs., 1966.
Reviews the early history of in-flight simulation, considers the validity of simulation techniques, and describes some of the more interesting results of several recent in-flight simulation programmes. These programmes include the investigation of drag-curve shape during the landing approach for light, fighter-type aircraft and large, supersonic transport aircraft, pilot rating variability, effects of turbulence, and the use of variable stability aircraft as instructional aids.

CP17/2/5 **Handling Qualities and Pilot Workload.** C.B.WESTBROOK, R.O.ANDERSON, P.E.PIETRZAK.
AGARD Conference Proceedings CP 17, Pt. 2, 625-648, 35 refs., 1966.
This paper has the objective of defining the relationship between handling qualities and pilot stress and workload. The reasons underlying the importance of pilot workload measurement are discussed and ways to analyze or treat pilot vehicle systems are reviewed. The various measures of pilot workload that have been used or considered are discussed and some new data on the possible use of pupil dilation as a measure of stress are presented.

CP17/2/6 **Physiological and Psychological Measurements of Pilot Workload.** F.G.CUMMING, K.G.CORKINDALE.
AGARD Conference Proceedings CP 17, Pt. 2, 649-657, 12 refs., 1966.
Discusses methods of assessing workload, physiological measures, heart rate recording, and combinations of physiological measures. It is concluded that physiological measures of workload are capable of providing useful data in situations where other methods of assessment are likely to be either dangerous (by possibly overstressing the operator) or impracticable (by difficulty in quantifying performance). Heart rate recording has the advantages of ease of recording and apparent sensitivity to changes in task loading.

CP17/2/7 **Effects of Task Variables on Pilot Models for Manually Controlled Vehicles.** D.T.McRUER, H.R.JEX.
AGARD Conference Proceedings CP 17, Pt. 2, 659-701, 52 refs., 1966.
Summarizes some of the more important recent developments in analytical pilot models for manually controlled vehicles, with emphasis on the effects of task variables on the types of models required and on the model parameters. Some of the main conclusions are that validated analytical pilot models are available for a wide range of task variables and that to handle the wide range of problems different forms of pilot models are required (e.g., compensatory, pursuit, periodic, etc.).

CP17/2/8 **Pilot Induced Instability.** R.C.A'HARRAH, R.F.SIEWART.
AGARD Conference Proceedings CP 17, Pt. 2, 703-727, 14 refs., 1966.
The purpose is to review in light of actual flight experience the criteria for evaluating the pilot-induced instability tendencies which were put forth in AGARD Report 443. The original work was derived from dynamic flight simulation and was presented without the benefit of flight correlation. As a result, considerable discussion ensued as to the applicability of the simulation results to the real flight situation, and the present paper is intended to aid in establishing the credence of the original work.

CP17/2/9 **A Study of the Longitudinal Behaviour of an Aircraft at Near-Stall and Post-Stall Conditions.** H.H.B.M.THOMAS.
AGARD Conference Proceedings CP 17, Pt. 2, 729-769, 14 refs., 1966.
The geometric and aerodynamic features of a design, which result in the variation of the pitching moment coefficient with incidence usually associated with deep-stall trouble, are identified and discussed. The two basic and important factors, namely, the pitching moment due to angle of attack and that due to elevator deflection, are dealt with. The interrelation between the aerodynamics and the behaviour of the aircraft in stalling tests of the kind called for by airworthiness authorities is considered.

CP17/2/10 **Analysis of the Stability and Control of an Aircraft at Incidence beyond that of Maximum Lift.** (In French). P.POISSON-QUINTON, E.ERLICH.
AGARD Conference Proceedings CP 17, Pt. 2, 771-792, 16 refs., 1966.
The aerodynamics of the phenomenon of deep-stall are first recapitulated. Two specific and representative examples are then considered; deep-stall of a jet-propelled transport and deep-stall of a variable-sweep aircraft; wind tunnel tests carried out by ONERA are reported. Brief mention is also made of such tests on the "Caravelle" at large incidence.

CP17/2/11 **Theoretical Considerations, Wind-Tunnel Research and Flight-Test Results on the Super-Stall Characteristics of the HFB 320 HANSA.** H.WOCKE.
AGARD Conference Proceedings CP 17, Pt. 2, 793-811, 1966.
Design of the HFB 320 HANSA business jet aircraft began in 1961. This paper considers the wing design aspects, wind tunnel test results, stall test flights, stall characteristics of the aircraft at large angles of attack, wind-tunnel tests aimed at improving the stall characteristics, solution of the super-stall problem as presently applied in the aircraft, the "anti-stall" system (consisting of a stick shaker as an artificial stall warning device and a stick pusher to prevent the aircraft getting into dangerous angles of attack), and simulator studies with the anti-stall system.

CP17/2/12 **Factors Affecting Pilot Landing Techniques.** K.J.DYDA, N.M.LEFRITZ.
AGARD Conference Proceedings CP 17, Pt. 2, 813-830, 3 refs., 1966.
Over three years of simulator testing of subsonic and supersonic transports has resulted in data indicating some of the factors affecting pilot technique in approach and landing. Approach and landing flight regimes were studied in an FAA-sponsored flight simulation programme. The aircraft characteristics, instrument displays, and atmospheric environment were extensively varied. The data collected in this programme included pilot opinion rating, pilot/aircraft performance, and pilot workload measures, and are presented in this paper.

CP17/2/13 **The Effect of Low Altitude Gusts on Automatic Landing.** J.C.HALL.
AGARD Conference Proceedings CP 17, Pt. 2, 831-853, 3 refs., 1966.
Describes part of an automatic landing development programme on the Trident. The first stage of this programme was autoflare. The effect of gusts on the pitch performance is discussed in this paper, since this was a particular problem in clearing autoflare. The various sections of the paper deal with realization of the problem, data available on low altitude gusts, measurement of gusts, analysis of gust measurements, development of autopilot pitch channel to improve flare performance in gust conditions, and proof of safety of final autopilot standard.

CP17/2/14 **A Few Notes on the Problem of Speed Stability.** J.BUHRMAN, F.E.DOUWES DEKKER, C.M.KALKMAN.
AGARD Conference Proceedings CP 17, Pt. 2, 855-870, 9 refs., 1966.
An attempt is made to distinguish between speed stability as a form of stability under constraint

and speed stability in its general sense, which also covers all other factors contributing to the pilot's opinion on his ability to maintain constant flight path angle and airspeed during the approach. It has become clear that this ability not only depends on lift and drag characteristics of the aircraft but rather on a complex of properties of both aircraft and engine.

CP17/2/15 **Mixed Pilot and Automatic Longitudinal Control During Landing Approach.** R.BROCKHAUS.
AGARD Conference Proceedings CP 17, Pt. 2, 871-905, 10 refs., 1966.
Some characteristics of the aircraft and the human controller are investigated theoretically to show what difficulties arise in a mixed pilot and automatic longitudinal control system. First, the control of speed and height is coupled, i.e., the longitudinal control is a multi-variable problem. Second, the transfer functions of the aircraft longitudinal mode have been found to have non-minimum-phase character, which has a restrictive effect on the controllability.

CP17/2/16 **A Statistical Model of Atmospheric Turbulence and a Review of the Assumptions Necessary for Its Use.** F.E.PRITCHARD.
AGARD Conference Proceedings CP 17, Pt. 2, 907-936, 23 refs., 1966.
Presents an updated and extended statistical model of atmospheric turbulence and discusses the common assumptions that are used to simplify this turbulence model as well as earlier models. The nature of the power spectral densities of atmospheric turbulence is described and the mathematical techniques required for the turbulence models are briefly discussed. A low-altitude (up to about 1000 ft above the ground) spectral model is presented for the three turbulence velocity components.

CP17/2/17 **NASA Research Experience on Jet Aircraft Control Problems in Severe Turbulence.** R.J.WASICKO.
AGARD Conference Proceedings CP 17, Pt. 2, 937-955, 20 refs., 1966.
Presents the results of the NASA research programme, which showed that the following main considerations could contribute to the jet transport upset and recovery problem: the low Dutch-roll damping with yaw damper inoperative could increase the pilot's work load in turbulence and detract from the longitudinal control task; the flexible aircraft's response to turbulence produces increased cockpit accelerations which are further amplified at the pilot's head when a conventional seat cushion is used; inadequate use of pitch attitude displayed information and over-concentration on airspeed control can induce large flight path oscillations in severe turbulence.

CP17/2/18 **Cockpit Displays.** D.J.WALTERS.
AGARD Conference Proceedings CP 17, Pt. 2, 957-977, 1966.
Outlines the possibilities and limitations in cockpit displays which now exist and suggests ways in which the characteristics of different techniques can be used together to obtain an optimum cockpit layout. The different types considered include mechanical displays, head-up displays, electronic instrument displays, and control and display integration systems. The author proposes the use of a three-tiered system including an electronic head-up display, an electronic head-down display and a set of non-electronic instruments displaying continuously all basic information with the minimum of links between the sensor and the display.

CP17/2/19 **Operational Experience at Mach 3.** A.S.WHITE, P.H.ANDERSON.
AGARD Conference Proceedings CP 17, Pt. 2, 979-998, 1966.
A brief description is given of operational experience at Mach 3 gained on the North American XB-70 aircraft in following a flight path roughly equivalent in distance to a route surrounding the British Isles. Sustained Mach 3 flight was attained with only two minor changes to the initial aerodynamic configuration, namely, the aileron feel bungee was replaced with a heavier spring to double the gradient and the operational procedures were modified to put the tips to the one-half position at 300 knots.

CP18 **Stress Corrosion Cracking in Aircraft Structural Materials.** H.G.COLE (Editor).
AD-669-282 AGARD Conference Proceedings CP 18, 246 pp., 1967.
N68-24397 These proceedings contain the papers presented at a two-day symposium held in Turin during April 1967. Seven formal papers covering general theory, aluminium alloys, non-stainless steels, stainless steels and titanium alloys were followed by national surveys of work on stress corrosion cracking. Abstracts of the individual papers are given in the succeeding items.

CP18/1 **General Theory of Stress Corrosion.** M.G.FONTANA.
AGARD Conference Proceedings CP 18, 20 pp., 29 refs., 1967.
For the purposes of this paper, stress corrosion is considered to be the premature environmental cracking of alloys. The many mechanisms which have been proposed to explain stress corrosion are discussed. Factors which are significant in stress corrosion and which are examined include; crack morphology; strengthening mechanism; metallurgical factors; composition; environments; tensile stresses; strength level; hydrogen penetration; initiation and propagation; conjoint action of stress and corrosion. Discussion.

CP18/2 **Laboratory Aspects of Aluminium Alloys.** H.CORDIER.
AGARD Conference Proceedings CP 18, 13 pp., 17 refs., 1967.
The processes contributing to the stress corrosion cracking of AlZnMg and AlZnMgCu alloys are considered. The paper is basically a resumé of work on the mechanism of stress corrosion cracking and metallurgical measures to avoid it. There is also a brief description of a laboratory method for testing for stress corrosion cracking. Discussion.

CP18/3 **Some Engineering Aspects of Stress Corrosion Cracking in High Strength Aluminium Alloys.** J.J.WALLER.
AGARD Conference Proceedings CP 18, 9 pp., 1967.
Problems, and their solutions, which confront the design engineer when he is concerned with structural parts of high strength aluminium alloys are presented, with special reference to the prevention of stress corrosion failures occurring in service. Emphasis is on die-forged parts as these are the most prone to stress-corrosion cracking. The problem is treated from the initial stage of forging design right through until the completed unit is assembled in a major airframe component. Discussion.

CP18/4 **Engineering Aspects of Stress Corrosion Failure in Martensitic Steels.** E.A.STEIGERWALD.
AGARD Conference Proceedings CP 18, 42 pp., 25 refs., 1967.
Emphasis is on the delayed failures which occur in environment containing water or water vapour. These systems are particularly susceptible to catastrophic failures due to brittle crack propagation. Shot peening and coatings alleviate the tendency for stress corrosion cracking, but as the results produced are inconsistent, they must be evaluated for each application. Discussion.

CP18/5 **Stress Corrosion Cracking of High Strength Stainless Steels.** E.E.DENHARD, Jr.
AGARD Conference Proceedings CP 18, 35 pp., 46 refs., 1967.
Reviews stress corrosion characteristics of high-strength stainless steels with emphasis on aircraft applications. Attempts to correlate laboratory results with those obtained under natural exposure and in service conditions. Suggests maximum stress levels for design considerations. Covers cold-worked austenitic, martensitic and precipitation-hardening steels. Discusses the mechanism of failure and reviews protective measures and their effectiveness. Discussion.

CP18/6 **Stress Corrosion of Titanium Alloys.** J.B.COTTON.
AGARD Conference Proceedings CP 18, 20 pp., 20 refs., 1967.
Although titanium and its alloys are resistant to corrosion in many media including aqueous solutions of chlorides, stress corrosion of some titanium alloys can take place in halide environments. The circumstances under which this can occur are summarised with particular reference to exposure in hot unstabilized chlorinated hydrocarbons, to hot dry sodium chloride, and to aqueous saline solution at ambient temperature. Discussion.

CP18/7 **Stress Corrosion Cracking of Very Strong Low-Alloy and Maraging Steels. Laboratory Aspects.** L.MATTEOLI, T.SONGA.
AGARD Conference Proceedings CP 18, 64 pp., 103 refs., 1967.
Mechanical and metallographic properties of high-strength constructional steels; hardening mechanism of martensite; sustained load failure of high strength steels; mechanism of hydrogen embrittlement in steel; methods to distinguish hydrogen embrittlement from stress corrosion cracking; stress corrosion of high-strength low alloy steels; stress corrosion of maraging steels. Discussion.

CP18/8 **National Surveys of Work on Stress Corrosion Cracking.** H.G.COLE.
AGARD Conference Proceedings CP 18, 23 pp., 1967.
Each member country was asked to report on its current research and development work on stress corrosion cracking. Contributions were received from: Canada (G.J.Biefer), France (P.Lacombe), Germany (L.Graf), Italy (E. di Reesso and A.Griselli), Norway (M.A.Winfeldt), UK (H.Brooks), USA (W.K.Boyd). The national surveys are summarized here, the information from all contributors being collated under the headings: Aluminium alloys; Steels; and Titanium alloys. Further data on the national efforts are given where appropriate.

CP19/1 **Fluid Physics of Hypersonic Wakes.**
AD-658-705 AGARD Conference Proceedings CP 19, Vol. 1, 523 pp., 1967.
N67-37601 These proceedings comprise the texts of papers presented at the AGARD Specialists' Meeting on the title subject held at Fort Collins, Colorado, in May, 1967. The proceedings comprise two separately bound volumes. Volume 1 contains papers dealing with flow over bodies, inviscid and viscous wakes, near and far wake characteristics, pressure and heat transfer on hypersonic bodies, dissociating flows, and mass density measurements in hypersonic wakes. Abstracts of the individual papers are given in the succeeding items.

CP19/1/1 **Kinetic Processes in Hypersonic Wakes.** A.Q.ESCHENROEDER.
AGARD Conference Proceedings CP 19, Vol. 1, 54 pp., 83 refs., 1967.
The roles played by chemistry, ionization and energy transfer processes are discussed in the context of hypersonic wake flows. Of primary interest is the influence of the microscopic gas behaviour on the observable features of the wake. Emphasis is placed on pure air processes for both blunt and slender body shapes. Areas of possible future research also briefly reviewed are: (i) influence of internal mode energy transfer processes on reaction rates, (ii) ablative contaminant kinetics in wakes, and (iii) influence of turbulent fluctuations on reaction rates.

CP19/1/2 **Diagnostic Studies of Laminar Hypersonic Cone Wakes.** E.M.MURMAN, C.W.PETERSON, S.M.BOGDONOFF.
AGARD Conference Proceedings CP 19, Vol. 1, 36 pp., 16 refs., 1967.
An object of the experiment was the complete determination of all flow field variables (pressure, density, velocity, etc.); particular reference is made to the several types of instruments needed to complete the task. A conventional helium wind tunnel was used to generate the flow at a nominal Mach number of 16. A unique feature of the experiment is the use of a magnetic suspension system which is capable of supporting axisymmetric bodies. The experiment was purely fluid mechanical in nature, no physiochemical effects being considered.

CP19/1/3 **Wake Measurements Behind a Cone Suspended Magnetically in a Mach Number 4.3 Stream.** F.K.BROWAND, M.FINSTON, D.K.McLAUGHLIN.
AGARD Conference Proceedings CP 19, Vol. 1, 42 pp., 10 refs., 1967.
Measurements are reported from pitot pressure surveys behind a 7 deg. half-angle cone for several angles of attack. The Reynolds number being low enough to ensure a laminar wake in the region investigated (from the cone base to 5½ diameters downstream). A brief description is also given of the magnetic suspension system used in the hypersonic tunnel, and the data acquisition techniques.

CP19/1/4 **Experimental Analysis of Near Wake of a Slender Body without Lateral Support.** (In French). M.SIRIEIX, J.DELERY.
AGARD Conference Proceedings CP 19, Vol. 1, 47 pp., 21 refs., 1967.
Describes methods developed by ONERA for performing experimental wind tunnel analysis of the near wake without (or nearly without) parasitic interactions induced by mountings. Use is made of a magnetic mounting with a telemetry device, at Mach 5 and for a wide range of Re. Results are presented for various forebody configurations, the deadwater area, and for the transition development within the wake of a high aspect ratio slender body.

CP19/1/5 **Near Wake of a Slender Cone in Hypersonic Flow.** E.M.SCHMIDT, R.J.CRESCI.
AGARD Conference Proceedings CP 19, Vol. 1, 30 pp., 15 refs., 1967.
An experimental investigation was made at Mach 7.7 to study the flow and near wake regions of a sharp 10 deg. half-angle cone. Heat transfer and pressure measurements were made on the cone surface to give an indication of the boundary layer at the separation point under various test conditions. A complete pressure survey was made in the near wake region. Measured stagnation temperature profiles enabled computation of all desired flow properties and therefore provided a basis for comparison with the theoretical investigations of the overall flow field.

CP19/1/6 **Investigation of the Boundary Layer and of the Non-Viscous Wake, on Sharp and Blunted Cones at Incidence in Hypersonic Flow.** J.VALENSI, R.GUILLAUME, D.GUFFROY, B.ROUX, J.MARCILLAT.
AGARD Conference Proceedings CP 19, Vol. 1, 32 pp., 12 refs., 1967.
Experiments have shown that boundary layer transition occurs, when incidence is smaller than the semi-angle of the cone, on the part of the surface least inclined to the wind. The measured values of pressure, density and heat transfer rate are in excellent agreement with those calculated. For sharp cones, when incidence exceeds the cone semi-angle, separation of the boundary layer occurs together with vortex formation from the apex. The vortices also occur on blunted cones even when the incidence is very small; transition can occur in this case.

CP19/1/7 **Reynolds Number Effects in the Near Wake Behind a Wedge at Supersonic and Hypersonic Speeds.** W.F.MERZKIRCH.
AGARD Conference Proceedings CP 19, Vol. 1, 20 pp., 13 refs., 1967.
Summarizing the results of experimental data obtained by H.K.Larson and the author which are due to be published in a NASA Technical Note, it is reported that:- A separation shock can be formed in the supersonic wake at high Re only, when the boundary layer thickness is small compared to the base height, whereas this shock cannot be formed in hypersonic flow, even at high Re, due to small Mach angles.

CP19/1/8 **Study of Wakes of Cylinders and Wedges in Rarefied Gas Flow.** (In French). P.TREPAUD, R.PERY, J.P.BOEHLER, H.VIVIAND, E.A.BRUN.
AGARD Conference Proceedings CP 19, Vol. 1, 33 pp., 12 refs., 1967.
The results of an experimental study of wakes behind cylinders and wedges (total angle = 10 deg.), at Mach 4, in rarefied gas flow, are presented. The values of the Reynolds number, based on cylinder diameter or wedge length, are 533 and 870 for the cylinder, and 2540 for the wedge. The experimental techniques used are described. The results show that the near wake has lost the well defined structure found at High Reynolds numbers. Measurements of surface pressure and base pressure have been carried out at Mach 2 and 4, and over a range of Reynolds numbers 34 to 1400 for the cylinder, and 137 to 2660 for the wedge.

CP19/1/9 **An Experimental Investigation of Base Mass Injection on the Laminar Wake Behind a 6 Deg. Half-Angle Wedge at M = 4.0.** R.L.CHAPKIS, J.FOX, L.HROMAS, L.LEES.
AGARD Conference Proceedings CP 19, Vol. 1, 30 pp., 24 refs., 1967.
A series of tests were performed in the Jet Propulsion Laboratory (JPL) 20 in. supersonic wind tunnel in order to determine the effects of injecting nitrogen through the base of a wedge. These tests have shown that dramatic and significant changes to the wake structure are caused by a relatively small rate of injection. The tests were performed at Mach 4.0, a Reynolds number per inch of about 0.25×10^5 and stagnation temperature of about 100 deg.F.

CP19/1/10 **Radial and Axial Velocity Profiles of Hypersonic and Supersonic Wakes Measured by the Sequential Spark Method.** C.LAHAYE, E.G.LEGER, A.LEMAY.
AGARD Conference Proceedings CP 19, Vol. 1, 36 pp., 7 refs., 1967.
The technique of using a sequence of sparks for velocity profile measurements across the wake of hypersonic projectiles is briefly described and the data reduction method is outlined using one particular case. Measured radial velocity profiles in wakes of hypersonic (15000 fps) and supersonic (4000 fps) spheres are presented for various positions in the wake and for various ballistic range pressures. These results are then discussed. The axial profiles constructed from these radial profiles are then presented and the measurements are compared with the available theoretical estimates and measurements obtained using other methods.

CP19/1/11 **An Experimental Study of the Pressure and Heat Transfer on the Base of Cones in Hypersonic Flow.** E.J.SOFTLEY, B.C.GRABER.
AGARD Conference Proceedings CP 19, Vol. 1, 36 pp., 18 refs., 1967.
Experimental measurements of the base pressure and heat transfer on flat based 9 deg. cones have been made in a hypersonic shock tunnel. Free stream Mach numbers varied from 12.6 to 20. Independent variations of Reynolds number and wall temperature ratios were made at $M_\infty = 12.6$. Nose bluntness varied from "sharp" ($R_N/R_B < 0.005$) to $R_N/R_B = 0.3$. Only limited angle of attack effects were noted. In all cases the boundary layer on the cone surface was laminar.

CP19/1/12 **Hypersonic Investigations on the Local and Average Heat Transfer in Cavities and After Steps of Bodies of Revolution.** W.WYBORNY, H.-P.KABELITZ, H.-J.SCHEPERS.
AGARD Conference Proceedings CP 19, Vol. 1, 34 pp., 20 refs., 1967.
In axisymmetric cavities and after steps of bodies of revolution measurements of heat transfer and pressure were made at Mach-numbers up to 16 and varying Reynolds numbers. The heat transfer tests were made by means of a thin film colorimeter method; they concern local as well as average heat transfer rates. By optical observation detailed results on the flow behaviour could be gained. The measurements were made in the DVL-gun-tunnel. The results are compared with theoretical solutions.

CP19/1/13 **Solution of the Time-Dependent Navier-Stokes Equations for the Flow of Dissociating Gas over a Circular Cylinder.** S.M.SCALA, P.GORDON.
AGARD Conference Proceedings CP 19, Vol. 1, 63 pp., 35 refs., 1967.
Presents numerical solutions to the complete time-dependent Navier-Stokes equations for a two-dimensional flow, namely, the transient hypersonic flow around a right circular cylinder, including finite reaction rate chemistry for the dissociation of a diatomic gas. In particular the mathematical question of convergence is treated in detail.

CP19/1/14 **Mass Density Measurements in Hypersonic Wakes.** J.G.G.DIONNE, C.M.SADOWSKI, L.TARDIF, J.E.H.VANOVERSCHELDE.
AGARD Conference Proceedings CP 19, Vol. 1, 30 pp., 10 refs., 1967.
Mean and fluctuating mass density measurements have been carried out in hypersonic wakes over a wide range of ambient densities. An electron beam probe was found suitable at pressures of from 1-10 Torr. At ambient pressures above 10 Torr., mean mass densities were measured using a laser probe. Both methods were characterized by their capabilities of good spatial and temporal resolution.

Measured mean radial density distributions at several downstream positions, as well as power spectra of the fluctuations are presented. Some discussions will also follow of the fluorescence spectra excited in air and nitrogen by electron bombardment at energies ranging from 25 to 75 kilo electron volt.

CP19/2 **Fluid Physics of Hypersonic Wakes.**
AD-658-706 AGARD Conference Proceedings CP 19, Vol. 2, 505 pp., 1967.
N67-37521 Thirteen papers presented at a Specialists' Meeting of the Fluid Dynamics Panel, Colorado, USA, in 1967 are reproduced in this Volume. The papers deal with the measurement of electron densities, turbulence densities, radiation and boundary layer phenomena, of slender bodies, cones and spheres at hypersonic velocities. An appendix gives a list of speakers and questioners, and reports of discussions on the papers after their presentation. Abstracts of the individual papers are given in the succeeding items.

CP19/2/1 **Experimental Studies of Turbulence Characteristics in the Hypersonic Wake of a Sharp Slender Cone.** A.G.BOYER, E.P.MUNTZ.
AGARD Conference Proceedings CP 19, Vol. 2, 31 pp., 24 refs., 1967.
The investigation was conducted in a hypersonic shock tunnel and employed a new application of the electron beam excitation technique to measure directly the scale and velocity of the turbulent density and temperature fluctuations and to monitor their axial history in the wake of a sharp 10 deg. half-angle cone model free flying in a Mach 12.6 flow. The use of the electron beam excitation technique for the investigation of turbulent flows has been analyzed. The electron beam technique and a shock tunnel is demonstrated to be an important combination in the study of turbulent hypersonic wakes.

CP19/2/2 **Studies of Turbulence in the Wakes of Hypersonic Spheres under Simulated Re-Entry Conditions.** D.ELLINGTON, G.TROTTER.
AGARD Conference Proceedings CP 19, Vol. 2, 38 pp., 17 refs., 1967.
The techniques of cooled-film anemometry have been applied to the study of mean and fluctuating quantities in the hypersonic wakes of free flight spheres launched in the CARDE ranges. The measurements have yielded information on the temperature and velocity field over an extended length of wakes. Statistical analysis of this data in terms of correlation function and power spectral density has also been undertaken. This information is compared with results of measurements of other wake parameters such as mass and electron density.

CP19/2/3 **Some Statistical Properties of Turbulent Wakes.** J.H.HERRMANN, W.G.CLAY, R.E.SLATTERY, R.E.RICHARDSON.
AGARD Conference Proceedings CP 19, Vol. 2, 26 pp., 9 refs., 1967.
Turbulent wakes of hypervelocity spheres launched from light gas guns at the Lincoln Laboratory Re-entry Simulating Range have been studied by analyzing densitometer tracings of schlieren photographs. The correlation functions, spectral density, and variance of the turbulence of gas density in the wake of spheres of 3/16, 3/8 and 5/8 inch diameter, travelling at 20,000 fps, have been measured and are compared with the author's previous work on 8000 fps spheres.

CP19/2/4 **Pulsations in the Wakes of Hyperballistic Spheres during Atmospheric Re-Entry.** D.A.SPENCE, R.L.DOMMET, P.G.SMITH.
AGARD Conference Proceedings CP 19, Vol. 2, 18 pp., 7 refs., 1967.
Two 17 inch diameter copper spheres were fired on the Woomera range as part of project Dazzle, and re-entered the atmosphere almost vertically at speeds of 16000 ft/sec. Head-on V.H.F. radar returns from the turbulent portions of the wakes showed marked periodicity in echoing cross-section, corresponding to the successive formation of peak echoing areas at a frequency of approximately 5 cycles/sec. in a region several thousand diameters behind the head. These peaks, corresponding it is thought to sharp maxima in the local velocity, decaying rather slowly until overtaken by the final electron loss mechanism. Their production frequency is two orders of magnitude lower than that corresponding to the Strouhal number for vortex shedding from the sphere, and it is suggested that they are due either to a surging process in the near wake or to a periodic breakthrough of the turbulent portion of the far wake into the surrounding entropy layer.

CP19/2/5 **Radar Investigation of the Wakes of Blunt and Slender Hypersonic Velocity Projectiles in the Ballistic Range.** S.ZIVANOVIC, P.E.ROBILLARD, R.I.PRIMICH.
AGARD Conference Proceedings CP 19, Vol. 2, 36 pp., 11 refs., 1967.
Describes the experimental results of scattering of electromagnetic waves in the millimeter wavelength range from the wakes of hypersonic projectiles. The four radars employed for the measurements are briefly described. The results obtained from wakes of both blunt and slender bodies are discussed in some detail. The wake radar cross-section, and location of the various transition phenomena can be obtained directly from the measured amplitude and the phase of the returned signal. In addition, various statistical properties of wake scattering, such as spatial correlation function, probability distribution function and spectra of wake fluctuation can be obtained.

CP19/2/6 **Electrostatic Probe Measurements in the Turbulent Wake of Hypersonic Spheres Fired in a Ballistic Range.** D.HECKMAN, C.CANTIN, A.KIRKPATRICK.
AGARD Conference Proceedings CP 19, Vol. 2, 44 pp., 10 refs., 1967.
Electrostatic probes have been used in the CARDE ballistic ranges to investigate the plasma characteristics of the turbulent core of the hypersonic wake. Cross correlations of the collected current signals obtained with arrays of electron or ion probes yield information relation to the space correlation, convection velocity, and moving frame auto-correlation of the charge density fluctuations in the wake cone. Also obtained are power spectra and autocorrelations from individual probe signals. Experimental data derived in the wake of 1.0 and 2.7 inch diameter non-ablating spheres at velocities exceeding 15,000 feet per second in air and at pressure between 1 and 100 mmHg are presented.

CP19/2/7 **Studies of Electronic Wakes in the Hyperballistic Tunnel.** (In French). M.LAUG.
AGARD Conference Proceedings CP 19, Vol. 2, 22 pp., 11 refs., 1967.
Projectiles, usually spheres, were fired at approximately 6,000 m/s in the ISL hyperballistic range. Their ionized wakes are analyzed by the resounding cavity method (250 MHz), the input impedance of which is record on a Smith abacus. The frequency of collisions between electrons and neutral particles, and the total number of electrons inside the cavity are then derived. From these data, the electron density curves as a function of distance have been drawn. The instrumentation is described.

CP19/2/8 **Wake Electron Density Measurements behind Hypersonic Spheres and Cones.** R.A.HAYAMI, R.I.PRIMICH.
AGARD Conference Proceedings CP 19, Vol. 2, 51 pp., 38 refs., 1967.
The experimental data is significant for a number of reasons. For spheres, the measured electron density level extends from the recompression zone immediately behind the sphere into the far wake and so includes all regions of the wake where different electron-removal mechanisms are believed to exist. Different pressure regimes, in which various measured fluid dynamical effects are shown to have a profound influence on electron density decay, are also covered. Scalability of near-wake has been demonstrated previously and an example which shows binary scaling extending to the far wake is presented. The wake electron density data behind cone models fired at velocities of 23,000 fps are believed to be unique. Data for firings of a 12.5 deg. half-angle cone with ¼ inch base diameter at different range pressures and ratios of N_2-O_2 concentration are presented.

CP19/2/9 **Utilization of Short Duration Arc Wind Tunnels for the Studies of Ionized Wakes.** (In French). J.DOREY, D.COMPARD.
AGARD Conference Proceedings CP 19, Vol. 2, 30 pp., 23 refs., 1967.
The authors summarize experimental and theoretical studies dealing with the plasma sheath surrounding models in the arc wind tunnels of ONERA; the study of the impact layer by means of electrostatic probes and reflectometric methods has made it possible to reach a satisfactory agreement between the experimental results and the calculated determinations for a chemical non-equilibrium flow. Wake experimentation which is now in progress on hemisphere-cone type models with body-base diameters of 65 and 186 mm are described. They are held by thin wires which break at gust start. The displacement of the model during the useful phase may be short, and is in all cases recorded. It is planned to attempt to seed the impact layer in order to determine the effect on the ionized gas of an injection of substances capable of increasing or decreasing the electronic density.

CP19/2/10 **Material Effects of Low Temperature Ablators on Hypersonic Wake Properties of Slender Bodies.** J.CRESSWELL, B.KAPLAN, R.PORTER, C.SARKOS.
AGARD Conference Proceedings CP 19, Vol. 2, 56 pp., 8 refs., 1967.
Reported and interpreted in this paper are the results of theoretical computations of flow field properties in the non-equilibrium boundary layer and wake of a slender conical body for both epoxy and Teflon ablation materials and for two altitudes. The results reveal that the physical and chemical characteristics of low-temperature ablators create important effects upon the aerothermochemical properties of hypersonic boundary layer and wake flows. Furthermore, the relative significance of each causal mechanism is found to exhibit a notable sensitivity to the density level (i.e., altitude).

CP19/2/11 **Measured and Predicted Ablation-Product Radiation in the Near Wake.** J.D.STEPHENSON.
AGARD Conference Proceedings CP 19, Vol. 2, 45 pp., 24 refs., 1967.
The study is an effort to predict and measure emission from the near wake of models fired in a ballistic range. The experiments were conducted in the Ames Prototype Hypervelocity Free-Flight Facility, a ballistic range with a counter-current shock-heated airstream, in which spherically blunted models, 1.3 cm in diameter, were fired through air or nitrogen at speed of approximately 7.5 km per sec. The radiation from the near wake was resolved spectrally with two photographic prism spectrographs and spatially with a set of bandpass radiometers. During the tests the models attain essentially steady-state ablation before reaching the station where the radiation measurements are made. Most of the data discussed in the paper were obtained with polyethylene as the ablation material.

CP19/2/12 **Ballistics Range Measurements of Wake Electron Density and Spectral Emission.** C.J.INFOSINO R.R.GASTROCK, R.A.LEVERANCE.
AGARD Conference Proceedings CP 19, Vol. 2, 32 pp., 1 ref., 1967.
Experiments in ballistic ranges have been made, to determine the electron density and the spectral emission from the wake of projectiles subjected to re-entry flight conditions. These projectiles have been flown at velocities from 12,000 to 19,000 ft/sec at simulated altitudes of 50,000 to 125,000 feet. Models range in size from 0.25 to 1.25 inch base diameters and include spheres, cones and hemispheres-cylinder shapes. In addition to varying the flight condition, and the model size and shape, the model material is also varied. Materials include stainless steel, copper aluminium, nylon phenolic, Teflon and many others.

CP19/2/13 **Boundary Layer Phenomena Observed on the Ablated Surfaces of Cones Recovered after Flights at Speeds up to 7 km/sec.** T.N.CANNING, M.E.WILKINS, M.E.TAUBER.
AGARD Conference Proceedings CP 19, Vol. 2, 29 pp., 9 refs., 1967.
Ballistic range tests were conducted to determine the extent of laminar flow which may be attainable on ablating cones. The experiments consisted of free flight of 1 cm diameter 30 deg. half-angle plastic cones in air at velocities up to 7 km/sec and maximum local Reynolds numbers from 3 to 12 million. The ballistic range was long enough to allow the models to decelerate aerodynamically to low speeds and to be recovered intact. Microscopic examination of the surfaces of recovered models showed several interesting patterns depending on the type of boundary-layer flow experienced.

CP20 **Sub-Surface Communications.**
AD-669-768 AGARD Conference Proceedings CP 29, 661 pp., 1966.
N68-25187 Twenty-nine papers presented at the 12th Symposium of the AGARD Avionics Panel, Paris, April 1966 are reproduced. The papers related to lithospheric propagation and propagation involving water and ice. The papers are presented under sections headed: theory (of electromagnetic propagation); literature review; measurements of physical constants; models and measurements concerning propagation; noise; antennae (impedance, efficiency). Abstracts of the individual papers are given in the subsequent papers.

CP20/1 **Numerical Results Concerning a Surface Wave Guided by the Surface of the Sea.** (In French). M.BOUIX.
AGARD Conference Proceedings CP 20, 3-16, 4 refs., 1966.
The theory, originally presented by J.Zenneck (Annalem der Physik, Vol. 4 (23), 846-866, September 1907), relating to a wave guided by the surface plane of separation of two media when one has the electromagnetic properties of sea water and the other those of air, is recapitulated. Expressions are derived for various parameters and values of these are tabulated.

CP20/2 **The Air-to-Ground Problem for Three Media. Calculation of the Field in a Perfectly Conducting Earth Produced by a Vertically Polarized Electrical Source at an Elevated Altitude. Numerical Applications.** (In French). P.HALLEY.
AGARD Conference Proceedings CP 20, 17-56, 8 refs., 1966.
The analysis presented seeks to calculate the electromagnetic field in the ground, and principally, the electrical and magnetic fields tangential to the surface plane of the earth, produced by a vertical dipole electrical source placed at some distance (from several tens to several hundreds of km) in the air and immediately above the ground, transmitting at a frequency such that the ground can be considered as a perfect conductor.

CP20/3 **Important Effects of a Dielectric-Metal Physical Discontinuity on the Propagation of the Electromagnetic Wave which Encounters it.** (In French). P.HALLEY.
AGARD Conference Proceedings CP 20, 57-96, 6 refs., 1966.
This paper, in treating the principal effects of a dielectric-metal physical discontinuity, considers their consequences upon electromagnetic communication across the surface of the earth (land or sea). The following are studied (i) propagation in an unbounded, homogenecus medium of finite conductivity; (ii) the refraction of a plane homogeneous wave on the diopter plane separating a dielectric from a conducting medium which behaves as a metal; the main characteristics of metallic refraction.

CP20/4 **Electromagnetic Fields in the Ocean near a Shore Line.** J.E.SPENCE, E.J.SULLIVAN, J.J.BEVILLE.
AGARD Conference Proceedings CP 20, 97-113, 3 refs., 1966.
Presents the results of an analytical study on the relative importance of electromagnetic energy propagation via air into the ocean versus propagation through the soil and ocean floor into the sea. Vertical profiles of the horizontal electric field are plotted for several values of frequency, ocean depth, and the distance from the shore line. The relative importance of the soil path is seen to be greater for shorter distances from the shore and for deeper oceans.

CP20/5 **Electromagnetic Propagation in an Idealized Earth Crust Waveguide.** J.R.WAIT.
AGARD Conference Proceedings CP 20, 115-132, 2 refs., 1966.
Presented here are some theoretical solutions which should provide insight into the mechanisms of propagation of subsurface waveguides. To reduce the complexity, the model is highly idealized as a homogeneous lossy dielectric slab which is bounded by two semi-infinite conducting media. The source is a vertical electric dipole which is either above or below the upper surface of the horizontal slab. It is believed that by this method the features of this type of subsurface propagation are adequately displayed. A numerical example is worked in which there are three loss mechanisms of the same order of magnitude.

CP20/6 **Influence of a Sub-Surface Insulating Layer on Electromagnetic Ground Wave Propagation.** J.R.WAIT.
AGARD Conference Proceedings CP 20, 133-146, 3 refs., 1966.
The exact formal solution for an electric dipole over a planar stratified medium is evaluated in the asymptotic limit. Special attention is given to the situation where one of the strata is effectively an insulator. In this case, a waveguide type of propagation is possible which, in some cases, may be significant.

CP20/7 **Lithospheric Radio Propagation: A Review.** S.B.LEVIN.
AGARD Conference Proceedings CP 20, 147-178, 42 refs., 1966.
The feasibility of linking sub-surface stations by radio propagation entirely through the rocks of the earth's crust, over paths several hundred to thousands of kilometers long depends upon several sets of geophysical factors which are enumerated in this paper. Methods of estimating electrical parameters of the lithosphere and also for estimating probability of lithospheric radio propagation are summarized. The conclusion is that it will be necessary to experiment with 10 km deep boreholes to resolve some of the uncertainties which still exist in this form of radio communication.

CP20/8 **Propagation of Radio Waves in the Earth's Crust.** (In French). A.M.RJAZANCEV, A.V.SHABELNIKOV.
AGARD Conference Proceedings CP 20, 179-210, 176 refs., 1966.
This paper presents an overall survey of the theoretical and experimental works which contain data on the physical and electrical properties of the earth's crust and their relation to the temperature, pressure and humidity. Methods are examined for calculating the field in an absorbant medium for which the electric properties are constant in time and space, or which vary in space in a known direction.

CP20/9 **Some Measured Electrical Characteristics of the Earth's Crust.** M.ACKER, L.J.MUELLER.
AGARD Conference Proceedings CP 20, 211-238, 8 refs., 1966.
Presents the results of measurements made in two drill holes extending 3 km into basement igneous rock. The data consist of resistivity well log measurements made in the holes, and also laboratory measurements of the electrical characteristics of core samples extracted from the holes. Theoretical calculations were also made for the relationship between electromagnetic propagation loss and parameters of the electrical characteristics.

CP20/10 **A 10 kHz Effective Conductivity Map of North America.** E.L.MAXWELL, R.R.MORGAN.
AGARD Conference Proceedings CP 20, 239-264, 17 refs., 1966.
A brief discussion of the conduction processes in rocks is followed by a consideration of the natural parameters which usually affect or determine these processes and the resultant conductivity. The procedure used in preparing the 10 kHz conductivity map is then considered. Results are also reported of measurements made in the Arctic regions of Canada because of the absence of information in this area. Suggestions are made for overcoming the difficulties encountered in this programme.

CP20/11 **The Electrical Resistivity of Water Saturated Crystalline Rocks.** A.S.ORANGE, W.F.BRACE, T.R.MADDEN.
AGARD Conference Proceedings CP 20, 265-285, 12 refs., 1966.
Electrical resistivity of eight igneous rocks and two crystalline limestones was measured at pressures up to 10 kb. The rocks were saturated with tap water or salt solutions, and the pore pressure was maintained near zero. The dependence of resistivity on temperature, porosity and pore fluid salinity suggested that conduction was primarily electrolytic throughout the entire pressure range, even though the porosity of some rocks was less than 0.1%. The resistivity increased with increasing pressure.

CP20/12 **Results of in situ Rock Resistivity Measurements.** K.VOZOFF, T.CANTWELL, H.LAHMAN, A.ORANGE.
AGARD Conference Proceedings CP 20, 287-307, 14 refs., 1966.
Four-electrode d.c. earth resistivity measurements were made in sixteen areas of the USA where precambrian rocks appear at or near the surface. The primary object was to find extensive areas which might be used for sub-surface electromagnetic communication. It was found that resistivity in most areas was very inhomogeneous, but did not exceed 10^4 ohm metres. The conclusions are that there can be little hope for successful sub-surface communications in the upper 5-10 km of the earth's crust.

CP20/13 **Surface to Surface and Sub-Surface to Air Propagation: Quasi-Static and Near-Field Ranges.** P.R.BANNISTER.
AGARD Conference Proceedings CP 20, 309-333, 13 refs., 1966.
The electrical and magnetic field components produced by vertical and horizontal dipoles are treated theoretically for the quasi-static and near-field ranges. The depth of the transmitting dipole is less than or equal to zero, while the height of the receiving antenna above the plane conducting homogeneous earth varies from zero to some height z which is much less than the ionospheric reflecting height. The horizontal separation ρ between the transmitting and receiving antennas is comparable to the receiving antenna height z . The derivations are based upon the quasi-static and near-field approximations to the vector potentials for vertical and horizontal dipoles and upon application of the reciprocity theorem. It is observed that the sub-surface to air propagation equations reduce to well-known expressions when $\rho >> z$.

CP20/14 **Attenuation of VLF Radio Waves Propagating over the Antarctic Icecap.** J.H.CRARY, D.D.CROMBIE.
AGARD Conference Proceedings CP 20, 335-338, 2 refs., 1966.
A brief digest of this paper is given reporting where the recordings were made and a procedure for analyzing the data for the ice cap in both darkness and light. The recordings were made at Bynd Station, Antarctica, of 16 kc/s signals from GBR Rugby, propagating over both short and long great-circle paths, which have lengths of 16,300 km and 23,800 km respectively. The observations indicate that the strongest signals are received over the great circle path which is in darkness (giving two daily values of maximum signal which are used for the analysis).

CP20/15 **Radar Altimeter Techniques in the Arctic Environment.** R.J.LUKAS, R.C.CRUICKSHANK.
AGARD Conference Proceedings CP 20, 339-354, 9 refs., 1966.
This paper is concerned with an investigation of commonly employed radar techniques and their potential for providing accurate and reliable vertical height data in the Polar environment. The experiments conducted by the US Army Electronics Command Avionics Laboratory have confirmed that the electrical properties of polar ice and snow do, in fact, cause microwave frequencies to suffer high reflection losses, and low transmission losses within the medium. CW altimeter errors as great as 150 ft were recorded for an actual altitude of 300 ft. Pulse altimeter errors were negligible.

CP20/16 **Communication Through the Earth.** (In French). R.GABILLARD.
AGARD Conference Proceedings CP 20, 355-386, 11 refs., 1966.
The experimental studies reported consisted of establishing communication by low-frequency electromagnetic waves between transmitters and receivers placed at different depths in mine galleries or in natural cavities in the earth. Telegraphic and telephonic communication has been obtained up to a distance of 4 km using a vertically polarized subterranean wave. A link has been achieved with a horizontally polarized wave between the earth's surface and a gallery at a depth of 500 m.

CP20/17 **Model Results in Underground Communications.** A.F.GANGI.
AGARD Conference Proceedings CP 20, 387-408, 8 refs., 1966.
The propagation of electromagnetic waves in the earth was investigated using scale models. Laboratory experiments on scale models simulating an idealized flat earth structure have been performed and checked with theory. Experimental measurements of the propagation of electromagnetic pulses were also obtained from laboratory models. These pulses can be launched and detected in the models by the use of log-periodic or other wide band antennae.

CP20/18 **Very Low Frequency Propagation: An Account of Transmission Experiments at 40 Hz.** (In French). H.GUTTON.
AGARD Conference Proceedings CP 20, 409-423, 1966.
The work reported was undertaken with the object of investigating the possibility of using radio waves of frequencies of the order of tens of Hertz for communication between a submerged submarine and the surface of the sea. The following are treated: theoretical study; study of reception and characteristics of the receiver; study of the parasitic field; transmission source; experimental results.

CP20/19 **Observations on the Propagation Constant of the Earth-Ionosphere Wave Guide in the Frequency Band 8 c/s to 16 kc/s.** F.W.CHAPMAN, D.LLANWYN JONES, J.D.W.TODD, R.A.CHALLINOR.
AGARD Conference Proceedings CP 20, 425-451, 48 refs., 1966.
Recent observations at King's College, London concerning the determination of the propagation constant of electromagnetic waves over the earth's surface are described. The experimental results are interpreted in terms of the waveguide mode theory of propagation by assuming various electron and heavy ion density profiles for the ionosphere. The present work agrees well with other observations made over a limited frequency range and enables the propagation constant to be determined from 8 c/s to 16 kc/s.

CP20/20 **Undersea E.L.F Measurements of the Horizontal E-Field to Depths of 300 Meters.** E.F.SODERBERG.
AGARD Conference Proceedings CP 20, 453-470, 4 refs., 1966.
Presents and discusses measurements made by a two-man submersible "diving saucer" off the coast of Baja, California for two particular time periods in March 1965. The object was to provide an introductory look at the levels of extremely-low-frequency noise in the ocean. Within certain limitations, the results indicate the possibility of bottom-conducted atmospheric energy near a shore line.

CP20/21 **Subsurface Radio Propagation Experiments.** C.K.H.TSAO, J.T. de BETTENCOURT.
AGARD Conference Proceedings CP 20, 471-490, 17 refs., 1966.
Propagation experiments were conducted on Cape Cod, Adirondack region of New York State, and in Cheyenne Mountain in Colorado to determine the feasibility of communication between vertical linear antennae located in drill holes in the rock below overburden, and similar antennae located on the surface of the ground. Analysis of the experimental results and theoretical considerations indicate that the usefulness of the through-the-rock mode is severely limited by the bulk conductivity. For shallow antenna depths, particularly if the overburden is thin or absent, substantial transmission ranges can be achieved by using the up-over-down mode of propagation.

CP20/22 **Notes Regarding Possible Field Strength Versus Distance in Earth Crust Wave Guides.** A.D.WATT, G.F.LEYDORF, A.N SMITH.
AGARD Conference Proceedings CP 20, 491-519, 23 refs., 1966.
Propagation between buried terminals via two paths at distances up to 100 km is considered. The first path is that of a doubly refracted wave which travels in the earth ionosphere region. The second is a wave propagated in the basement rock between the conducting overburden and the conducting region at depths of tens of kilometers. The terminals are located in the basement rock directly below the highly conducting overburden. It is shown that in the range of distances considered, relatively more efficient propagation will frequently be via the path in the basement.

CP20/23 **ULF-ELF Earth Mode Communications via Horizontal Electric Dipoles at the Surface.** D.R.WORD, F.X.BOSTICK, Jr., L.A.AMES.
AGARD Conference Proceedings CP 20, 521-541, 9 refs., 1966.
ELF signals induced in the earth are shown to offer a means for reliable, short range, low data rate communications. This paper is concerned with use of the horizontal electric dipole as a source. The basic field relationships are presented and parameters necessary for the evaluation of this communications mode are discussed in the light of obtainable information capacity.

CP20/24 **Electromagnetic Background Noise in the ELF Range.** L.BROCK-NANNESTAD.
AGARD Conference Proceedings CP 20, 543-556, 8 refs., 1966.
A brief review is given of the properties of the earth-ionosphere cavity and its excitation by lightning. The propagation into a stratified earth is treated in some detail and, as a typical application, a new method for geophysical investigations in shallow waters is described. Various measuring techniques are discussed briefly.

CP20/25 **Atmospheric Noise from 20 Hz to 30 kHz.** E.L.MAXWELL.
AGARD Conference Proceedings CP 20, 557-593, 11 refs., 1966.
This paper discusses measurements of atmospheric noise which have been made in Malta, GC; Point Barrow, Alaska; Boulder, Colorado; Tokyo, Japan; Hawaii, Miami, Florida and at various locations throughout Central and South America. Most of the measurements were average measurements of the vertical electric field intensity and amplitude probability distributions of the vertical electric fields. The atmospheric noise spectra obtained provide a good basis for rough estimates of noise field intensities at any global location.

CP20/26 **An Account of Electromagnetic Recordings at Very Low Frequencies made in a Bathyscaphe in Deep Water.** (In French). E.SELZER, L.LAUNAY, S.W.LICHTMAN.
AGARD Conference Proceedings CP 20, 595-606, 8 pp., 1966.
Very low frequency waves up to 200 Hz have been monitored during the last three years by means of the French bathyscaphe "Archimede" at depths from 2,000 to 8,000 m. The recordings thus obtained have been subjected to detailed spectral analysis. The principal characteristics of these spectra are presented, and a preliminary attempt at interpreting them is made.

CP20/27 **Review of the Earth Mode Communication Program at Air Force Cambridge Research Laboratories.** L.A.AMES, J.W.FRAZIER, A.S.ORANGE.
AGARD Conference Proceedings CP 20, 607-619, 78 refs., 1966.
In this programme emphasis is placed on geological and geophysical problems encountered. Communications modes studied included: (i) "deep-strata", wherein radio frequency electromagnetic waves are propagated between buried antennae over a path entirely within rock strata, and (ii) "conduction current", consisting of ULF conduction field communications between long, grounded dipoles.

CP20/28 **Study of Reception in the Sea by a Dipole and a Volumetric Antenna.** (In French). B.BLACHIER.
AGARD Conference Proceedings CP 20, 621-628, 1966.
This paper treats low frequency magnetic dipoles and gives formulae for the signal-to-noise ratio in air (taking into account the effect of temperature) and in the sea (for the two cases of shallow and deep immersion). The concept of a volumetric antenna is explained, with which gains of 40 dB can be achieved, representing an increase in the depth of immersion of 12 m.

CP20/29 **Impedance and Radiation Efficiency of Buried Dipole Type and Loop Antennas.** J.GALEJS.
AGARD Conference Proceedings CP 20, 629-657, 14 refs., 1966.
The performance of an insulated buried finite top-loaded vertical electric dipole is compared with horizontal dipole antennae, and also with finite insulated loops. The variational formulations recently developed by Galejs serve as a basis of the analysis, and they are further extended in some cases. Lengthy mathematical development are not given. The reader is referred to the literature for the complete mathematical details.

CP21* **Performance Forecast of Selected Static Energy Conversion Devices.** Editors G.W.SHERMAN,
AD-671-685 L.DEVOL.
N68-28714 AGARD Conference Proceedings CP 21,* 1168 pp., many refs., 1967.
This book is a collection of the papers presented at the 29th meeting of the AGARD Propulsion and Energetics Panel of AGARD at Liege, Belgium, June 12-16, 1967. It also records the discussions and includes some material subsequently prepared by the authors. The main divisions are:– Batteries, Fuel Cells and Solar Cells. The book also contains a section presenting biographies of the authors and an index of contributors names. The 33 papers presented are dealt with individually in the following abstracts.

CP21/1 **Primary and Secondary Galvanic Cells – History and State-of-the-Art Summary.** K.J.EULLER, A.FLEISCHER.
AGARD Conference Proceedings CP 21, Paper 1, pp.3-53, 56 refs., 1967.
A short history of the 100 year development of the most common systems of primary cells and storage batteries is given and is followed by a compressed compilation of data. A brief survey of future developments is given and in particular low maintenance lead batteries and improved methods of fast charging are discussed.

CP21/2 **The Effect of Depth of Discharge on the Cycle Life of Positive Lead-Acid Plates.** E.VOSS, G.HUSTER.
AGARD Conference Proceedings CP 21, Paper 2, pp.57-72, 2 refs., 1967.
The paper describes experiments with pasted positive lead-acid plates at various depths of discharge under closely controlled conditions. The end of cycle life was determined by two failure criteria:– "first cycle life" when there was failure to maintain a capacity equivalent to the depth of discharge and "second cycle life" when there was failure to maintain at least 40% of the standard capacity. The analysis shows a log-linear relationship for the first and an inverse proportional relationship for the second. A mathematical treatment on the basis of a simplified model is given and is in good agreement with the experimental results.

CP21/3 **Charge, Discharge and Self-Discharge Characteristics of Thin Film Nickel Oxide Electrodes.** B.E.CONWAY, M.A.SATTER.
AGARD Conference Proceedings CP 21, Paper 3, pp.79-118, 49 refs., 1967.
The formation and reduction of thin film oxides on nickel has been examined by several methods and the behaviour is compared with that for silver electrodes. The origin of hysteresis effects in the formation and reduction processes is discussed and thin film effects have been examined.

CP21/4 **Cadmium Silver (II) Oxide Secondary Batteries.** H.BODE.
AGARD Conference Proceedings CP 21, Paper 4, pp.125-139, 12 refs., 1967.
The properties of a hermetically sealed version of a silver oxide-cadmium cell are discussed and compared with those of the well known sealed nickel hydroxide-cadmium cell. The difficulties arising from the silver oxide electrode are considered in detail.

CP21/5 **The Sealed Zinc-Silver Battery.** T.F.DIRKSE.
AGARD Conference Proceedings CP 21, Paper 5, pp.144-163, 6 refs., 1967.
The history and current state of the art is described. The limitations of the zinc-silver secondary are described and an outline is presented of the areas in which research should proceed in order to make significant improvements. A summary of what is currently being done is provided.

* This book was issued under the title "Performance Forecast of Selected Static Energy Conversion Devices, AGARD Propulsion and Energetics Panel 1968" and was subsequently numbered Conference Proceedings 21. It should be requested by the full title.

CP21/6 **Studies of Available Energies in Ni-Cd, Ag-Zn, and Ag-Cd Batteries.** (in French and English). Y.LECOUFFE.
AGARD Conference Proceedings CP 21, Paper 6, pp.168-198, 1967.
Studies on the energy characteristics of these electrochemical combinations are described. The other characteristics of these batteries are discussed and an assessment made on the prospects for development.

CP21/7 **Silver Oxide Batteries Present and Future.** C.L.CHAPMAN.
AGARD Conference Proceedings CP 21, Paper 7, pp.202-223, 1967.
The paper deals first with the silver oxide cell in its present state of development and discusses its limiting factors and advantages in various applications. The factors which control performance are examined in detail and reference is made to the problems which have to be solved and to the degree to which recent advances have already provided at least partial solutions. The paper then attempts to present the future possibilities.

CP21/8 **High-Energy Combinations.** (In French and English). J.P.HARIVEL.
AGARD Conference Proceedings CP 21, Paper 8, pp.228-279, 4 refs., 1967.
Batteries using a lithium anode and an electrolyte of an organic compound have been developed. Thus far, 12 volt batteries of 70 ampere hour capacity have been built with a mass energy density of 250 watts hours per kilogram but the problems of storage have not yet been fully solved. Experiments on other electrolytes are being made and the prospects of development are being considered.

CP21/9 **Sintered Plaque Nickel Cadmium Batteries for Ground Services.** F.A.SCHNEIDER.
AGARD Conference Proceedings CP 21, Paper 9, pp.291-326, 16 refs., 1967.
Reasons are presented for the use of thick plaques and some recent developments in manufacture are described. Finally some insulation problems are discussed.

CP 10 **Inorganic Separators.** E.HAÜSLER.
AGARD Conference Proceedings CP 21, Paper 10, pp.328-357, 26 refs., 1967.
Separators for electrochemical power sources are divided into two classes, those not having any conductive quality in which an ion-conducting contact between the electrodes is by means of pores and those in which ion conductivity appears through contact with the liquid-electrolyte alone (ion exchanger). It is the latter type of separator which is discussed in this paper. The theory of ion exchangers is briefly reviewed and the advantages of inorganic separators emphasised. Difficulties are discussed and information is given on early results from tests for the development of layers of alkaline earth hydroxides.

CP21 11 **Selection of Separator Materials.** J.J.LANDER.
AGARD Conference Proceedings CP 21, Paper 11, pp.362-391, 26 refs., 1967.
The importance of separator materials is emphasised in relation to the development of successful batteries. It is stated that adequate test and evaluation techniques for separator materials may be expected to be a part of any battery development program and must become a part of the total battery technology.

CP21 12 **Progress in Metal/Air Batteries.** H.G.OSWIN.
AGARD Conference Proceedings CP 21, Paper 12, pp.396-460, 21 refs., 1967..
All known work on metal/air cells is reviewed and it is stated that only primary zinc/air and magnesium/air cells are available at present as fully engineered power sources. Other secondary air-cells in the course of development are discussed.

CP21 13 **Electrochemical Sources of Pulse Power.** E.J.CASEY.
AGARD Conference Proceedings CP 21, Paper 13, pp.466-491, 19 refs., 1967.
The capability of electrochemical cells to deliver short pulses of very high power has begun to be exploited in recent years. This paper introduces terminology thought to be necessary for comparison of complete cycling or repetitive pulse-power systems, reviews one system and the experience with pulse-power systems based on the thin-plate rechargeable nickel-cadmium, and on the warm-alkaline, continuous-feed hydrogen-oxygen system. Development needs and guidelines are outlined.

CP21 14 **Fuel Cells – Present Position and Future Prospects.** M.BARAK.
AGARD Conference Proceedings CP 21, Paper 14, pp.496-524, 38 refs., 1967.
The practical application of fuel cells has been dominated in U.S.A. by the N.A.S.A. space programmes for Gemini and Apollo which has produced units with an energy density considerably greater than possible by any storage battery system. The installations are described in this paper together with follow up systems. Work proceeding in other countries is also described. The use of fuel cells for traction and domestic electricity generation are mentioned and methanol as a fuel is discussed.

CP21/15 **Low Temperature Hydrogen Cells of the C.G.E. – Existing Batteries and Future Prospects.** (In French and English). P.DUBOIS, C.EDON.
AGARD Conference Proceedings CP 21, Paper 15, pp.528-556, 1967.
The principal characteristics of the electrodes used now by the Compagnie Generale d'Electricite (French General Electric Co.) are described and their characteristics and applications discussed. Some details are given of various types of fuel cell generators now being studied by the C.G.E.

CP21/16 **Primary Hydrogen-Oxygen Fuel Cells for Space.** E.M.COHN.
AGARD Conference Proceedings CP 21, Paper 16, pp.557-570, 1967.
It is predicted that by 1975 Grove-type fuel cells may reach 70% gross thermal efficiency but that a better cathodic catalyst of optimised electrode structure and inert matrices will be needed. Better solutions to chemical engineering problems are even more urgent and the best approach might be the development of more novel systems.

CP21/17 **Hydrogen – Oxygen Fuel Cells – VARTA Fuel Cell Systems.** A.WINSEL.
AGARD Conference Proceedings CP 21, Paper 17, pp.575-594, 11 refs., 1967.
The fuel cell systems developed by VARTA are described. With the gas diffusion electrodes many applications are stated to be possible and these are presented with working data.

CP21/18 **Hydrazine Hydrogen Peroxide Fuel Cell.** G.GRUNEBERG, F.WEDDELING.
AGARD Conference Proceedings CP 21, Paper 18, pp.599-611, 4 refs., 1967.
The special feature of these cells are low temperature performance and quick starting. The characteristics, construction and performance are described and it is stated that cost of production is low but cost of operation is high.

CP21/19 **Hydrazine-Air Fuel Cell Power Systems.** M.R.ANDREW, W.J.GRESSLER, J.K.JOHNSON.
AGARD Conference Proceedings CP 21, Paper 19, pp.615-629 2 refs., 1967.
After a lapse of about four years work on cells has been restarted by Shell Research Ltd and it is stated that work now proceeding is expected to show more than double the output of batteries of the same size made in 1962. The type of air electrodes to be used is still under consideration and the type of air blower and heat exchanger have not yet been finalized.

CP21/20 **Hydrocarbon and Methanol Fuel Cell Power Systems.** K.R.WILLIAMS, A.G.DIXON.
AGARD Conference Proceedings CP 21, Paper 20, pp.634-651, 5 refs., 1967.
The only fuel cell power systems fuelled by hydrocarbons or methanol that are at present capable of satisfactory performance employ the generation of hydrogen by steam reforming. The hydrogen is subsequently fed to a fuel battery. Some of the obstacles to the development of systems which use these fuels directly are discussed.

CP21/21 **Regenerative Fuel Cells.** R.L.KERR.
AGARD Conference Proceedings CP 21, Paper 21, pp.658-711, 41 refs., 1967.
Regenerative Fuel cells, unlike the primary hydrogen-oxygen fuel cell, have fallen behind in development as power sources. This paper explores the efforts in this area and projects the future capabilities of this neglected device.

CP21/22 **A Contribution to the Catalysts in Galvanic Fuel Cells.** H.H.VON DOHREN.
AGARD Conference Proceedings CP 21, Paper 22, pp.716-736, 11 refs., 1967.
A short general survey of research and development of catalysts for fuel cells is presented. The behaviour of D.S.K. anodes having Raney nickel incorporated and subject to various operating conditions are discussed in more detail. Finally the influence of promoters on the electrochemical performance of anodes is given, and their technical merits for fuel cells are listed.

CP21/23 **High Temperature Magnesium-Chlorine Cell.** P.DROSSBACH, H.HOFF.
AGARD Conference Proceedings CP 21, Paper 23, pp.741-762, 15 refs., 1967.
Describes a Magnesium-Chlorine cell with an equilibrium potential of 2.65 volts at 480°C The output was 1.15 watts/sq.cm. at an internal resistance of 1.74 ohms. It is possible to reduce the internal resistance by minor changes in the construction of the cell which leads to 2.1 watts/sq.cm. at a chlorine pressure of only 0.1 atm.

CP21/24 **Systems Considerations Using Fuel Cells.** E.F.SCHMIDT.
AGARD Conference Proceedings CP 21, Paper 24, pp.766-796, 6 refs., 1967.
Systems considerations are of fundamental importance for optimum design of power systems using fuel cells. Different types of fuel cells require different subsystems and different methods of system integration. After describing various subsystems available today, an energy fuel chart for fuel cell systems is discussed and compared with a flow chart of a diesel engine.

CP21/25 **The History and State-of-the-Art of the Solar Cell.** R.RAPPAPORT.
AGARD Conference Proceedings CP 21, Paper 25, pp.802-822, 29 refs., 1967.
After a historical review the present status of cells made with various semiconductors is presented. Silicon, even though theoretically not the best, is seen to be the best all round material for solar energy converison. For high temperature applications Ga As is the optimum material. For thin film applications, CdS and CeTe are able to give over 5% efficiency and their power-to-weight ratio is superior to silicon. Work on radiation damage is reviewed and it is shown that silicon cells with lithium doping show promise of long-life radiation-resistant operation.

CP21/26 **Development Status of Solar Generators based on Silicon Photo-Voltaic Cells.** O.C.BUTCHER, D.BASNETT, A.G.WEBB.
AGARD Conference Proceedings CP 21, Paper 26, pp.829-863, 7 refs., 1967.
Current design technique for silicon solar cells of several types are discussed and the performance is related to operating conditions in terrestrial and space applications. Test results show the effect of charged particle bombardment of space cells and emphasise the significance of this factor in generator design. Methods of mounting solar cells in space applications are examined using the ESRO2 satellite as an example. More recent techniques are discussed.

CP21/27 **Recent Developments in Silicon Solar Cells.** F.C.TREBLE.
AGARD Conference Proceedings CP 21, Paper 27, pp.868-898, 9 refs., 1967.
Current state-of-the-art silicon solar cells and panel assembly are described and the specific weight area, and cost of a typical array estimated. Radiation damage and temperature dependence data are presented. Developments aimed at improving these parameters are reviewed and thin single crystal cells are described in detail. Finally an account is given of recent work on cover slips and cements.

CP21/28 **Thin Film Cadmium Sulfide Solar Cells.** D.C.REYNOLDS.
AGARD Conference Proceedings CP 21, Paper 28, pp.902-920, 8 refs., 1967.
Reviews the more plausible models of the mechanism of operation of thin film cadmium sulfide solar cells and interprets the most recent experimental results. The available data from recent flight tests are evaluated and compared with expected results based on laboratory tests. Potential applications in both space and earth environments are outlined.

CP21/29 **Mono-Grain Layer Solar Cells.** T.S.teVELDE.
AGARD Conference Proceedings CP 21, Paper 29, pp.926-941, 4 refs., 1967.
Solar batteries in the form of a flexible sheet can be made by special techniques which are explained in detail. Single crystallites of silicon cadmium sulfide, or other suitable semiconductor are embedded in a plastic sheet. As an example sandwich cells of cadmium sulfide – copper sulfide are discussed. The advantages of such cells are listed.

CP21/30 **Cadmium Telluride Solar Photocells.** (In French and English). M.RODOT.
AGARD Conference Proceedings CP 21, Paper 30, pp.944-1006, 31 refs., 1967.
After a brief historical review, the technology now used to prepare photoelectric cells in thin layers of CdTe having 5% conversion efficiency is described. The properties of CdTe are discussed and the present performance of these cells is given and the present status of studies of degradation presented. Finally, the difficulties of increasing efficiency to the 8% obtained from single crystals are discussed.

CP21/31 **Optical and Technological Problems of Solar Cell Generators.** H.MENKE, J.RATH.
AGARD Conference Proceedings CP 21, Paper 31, pp. 1011-1029, 1967.
It is emphasised that the main components of generators; solar cells, cover slides, and adhesives, should all be tested under environmental conditions to determine the performance of the complete generator in space. The paper then describes the most important test methods.

CP21/32 **Germanium Solar Photoelectric Cells.** (In French and English). J.TAVERNIER, P.SIBILLOT, E.LeGRIVES.
AGARD Conference Proceedings CP 21, paper 32, pp.1022-1124, 12 refs., 1967.
Germanium solar cells are shown to be well suited for high intensity solar conversion devices. Preliminary experiments have been made up to 20 W per sq. cm. and a conversion efficiency more than twice that of silicon cells was obtained.

CP21/33 **Future Applications for Static Energy Conversion Devices.** W.H.WOODWARD.
AGARD Conference Proceedings CP 21, Paper 33, pp.1128-1152, 1967.
It is stated that there is no one electric power generation system that can meet all present and future space requirements. However the number of possible systems is such that selection is essential. The N.A.S.A. is intending to concentrate on eight systems for the next five to ten years. The intention is to develop each to a point where potential system users may select a power system for a particular spacecraft program.

CP22 **Fluid Dynamics of Rotor and Fan Supported Aircraft at Subsonic Speeds.**
AD-669-226 AGARD Conference Proceedings CP 22, 604 pp., 1967.
N68-22486 The texts of papers to the AGARD Fluid Dynamics Panel Specialists' Meeting on the title subject, held in Germany in September 1967 are presented. Emphasis is on the following subject areas; rotors and fans in hover and transition; interference with the airframe and the ground, ground effects on rotors and fans, noise problems and testing techniques. In the main, the papers relate to low disc-loading types. Abstracts of the individual papers are given in the succeeding items. In addition to the papers reproduced here, a further three papers are published in AGARD Advisory Report 13.

CP22/1 **Aerodynamic Study of a Helicopter Blade Element.** (In French). P.POISSON-QUINTON, A. de SIEVERS.
AGARD Conference Proceedings CP 22, 36 pp., 16 refs., 1967.
A special mounting for two-dimensional transonic investigations is being built at the variable density S3 wind tunnel at Modane, to simulate correctly the local Mach and Reynolds numbers of a modern rotor in flight. Preliminary research has dealt with the effect of manufacturing imperfections of a real helicopter blade and with the maximum lift and L/D improvements by means of a cambered nose section covering the symmetrical aerofoil; theoretical calculations of the symmetrical and cambered profiles were carried out by rheoelectric methods.

CP22/2 **Lifting Rotors Operating at High Speeds or Advance Ratios.** G.J.SISSINGH, J.SWEERS.
AGARD Conference Proceedings CP 22, 23 pp., 1 ref., 1967.
Flight tests are conducted on a compound helicopter, in which the lift and moment distribution over the rotor blade are measured simultaneously with blade bending and torsion moment, at flight speeds ranging from hover to 232 knots (430 km/h). The measurements are compared with theoretical airload distributions and blade bending moments. The effect of the advance ratio on the response and stability characteristics of the flapping motion is studied.

CP22/3 **Rotor Induced Flow.** A.R.SEED.
AGARD Conference Proceedings CP 22, 24 pp., 7 refs., 1967.
Circulation control by blowing enables very high lift coefficients to be generated on a circular section aerofoil, so that a lifting rotor equipped with such a section can generate high thrust coefficients with comparatively few blades. An experimental investigation by hot wire anemometers on a two-bladed rotor shows that the induced velocity at the rotor disc has a periodic component which increase with rotor thrust coefficient. Vortex theory is also used to give an indication of the induced flow field in forward flight. The conclusions drawn from these analyses of the circulation controlled rotor are shown to apply to conventional rotors operating at comparable loadings. The use of an electromagnetic analogue for induced flow measurements is briefly discussed.

CP22/4 **A Contribution on the Determination of Overall Forces of Inclined Propellers.** B.LASCHKA, A.MULLER, P.EBELING.
AGARD Conference Proceedings CP 22, 20 pp., 9 refs., 1967.
An approach to determine these forces and moments in a quick and sufficiently accurate way is outlined. Besides the geometry of the blades only the (theoretical or experimental) performance charts of the propeller with axial incidence have to be available as a basis for the calculations in terms of power and thrust coefficients versus advance ratio for different blade settings. A rough analysis of harmonics of higher order is possible. Comparison with experimental results of a NASA tested propeller reveals good agreement even at high incidence and advance ratio.

CP22/5 **Analytic Determination of the Axial Velocity Through a Propeller Moving Perpendicular to its Axis.** P.MANDL.
AGARD Conference Proceedings CP 22, 26 pp., 11 refs. 1967
A theory is developed for predicting the inflow through a propeller with finite blade number, moving at right angles to its axis. The mathematical model employed for the wake is that of a system of spiral surfaces, generated by skewed helices descending below the propeller disc at a prescribed rate. A fundamental integral equation is derived relating the radially and time-varying downwash field to the radially and time-varying circulation distribution along the blades. Explicit expressions are obtained for the variation of the inflow with both blade azimuth and blade span for any value of the advance ratio.

CP22/6 **Rotary Wing Boundary Layer and Related Researches.** W.H.TANNER.
AGARD Conference Proceedings CP 22, 14 pp., 20 refs., 1967.
The results are presented from several phases of the Bell Helicopter Co. "Fundamental Aerodynamic Rotor Research" (FARR) programme. Initial objectives of the FARR programme, the results of which are reported, include: (i) determination of transition on a hovering rotating blade in a high centrifugal force field; (ii) definition of the direction of flow in and out of the boundary layer and measurement of the actual boundary layer velocity profiles and radial velocity magnitudes; (iii) development of an understanding of the effects of the blade tip vortex and its formation; (iv) development of mathematical models to explain the observed phenomena.

CP22/7 **Control, by Blowing, of Boundary Layer and Circulation Applied to Trailing Edge Rotor Blade Tip Flaps.** (In French). R.DORAND.
AGARD Conference Proceedings CP 22, 31 pp., 14 refs., 1967.
The purpose is to determine the suitable relative depth of the flap as a function of the amount of power delivered to the rotor by the blowing slit, to be able to perform the following manoeuvres correctly: (i) vertical recovery by overall downward deflection of the flaps; (ii) transition to autorotation by overall upward deflection of the flaps; (iii) lateral and longitudinal control during engine testing and in forward flight, by cyclic flap deflection.

CP22/8 **Control of Downstream Diffusion on a Ducted Propeller.** (In French). M.LAZAREFF.
AGARD Conference Proceedings CP 22, 13 pp., 1967.
The basic interest offered by the development of diffusion of the downstream jet of a ducted propeller operating at a speed close to hovering is summarized. This problem has been extensively studied by Sociéties Bertin and Nord-Aviation. The outstanding overall results are given and discussed. It is shown that large diffusion of the jet facilitates the adaptation of the fairing inlet in transitional flight. It is concluded that the ducted propeller can only be used to its full advantage if it is fitted with a downstream diffusion highly adjustable in flight.

CP22/9 **The Conversion of the Rotor/Wing Aircraft.** R.J.HUSTON, J.P.SHIVERS.
AGARD Conference Proceedings CP 22, 28 pp., 5 refs., 1967.
The main problem of transition from wing-borne to rotor-borne flight is the possibility of a large attitude disturbance during the first revolution of the rotor. A wind-tunnel study indicates that large-amplitude cyclic pitch is one means of eliminating the source of the aircraft disturbance for a three-bladed rotor/wing aircraft. The use of four blades may so reduce the disturbing moments that cyclic pitch is not required to eliminate them.

CP22/10 **Analyses of Stowed Rotor Aerodynamic/Aeroelastic Characteristics.** R.E.DONHAM.
AGARD Conference Proceedings CP 22, 33 pp., 1967.
Methods have been developed for determining the airload distribution on the blade of the rotor during inflight transition from the fixed wing mode to the compound helicopter mode as well as inflight transition in the reverse direction. The transient responses of the rotor during transition have been examined. Using subsonic kernel function techniques, the stiffness required of the blade to prevent aeroelastic divergence has been determined. The applicability of the analytical methods is substantiated by correlations with experimental results of investigations on a 33-foot diameter three-blade rotor in a 40 x 80 ft wind tunnel.

CP22/11 **Initial Studies of Jet Lift Systems with Fan-Like Exhaust Characteristics for V/STOL Transport Aircraft.** T.K.SZLENKIER, A.W.BISHOP, A.HARTMANN.
AGARD Conference Proceedings CP 22, 28 pp., 20 refs., 1967.
During 1964-65, Dornier and Hawker-Siddeley conducted joint studies of V/STOL military transports with jet lift engines. Although such engines have an excellent specific volume and weight, the exhaust velocity and temperature are higher than for lift fans, leading to inferior ground erosion, noise and infra-red radiation characteristics. High intensity mixing nozzles can be used to reduce the velocity and temperature of lift jets, but in a conventional installation an unacceptable thrust loss would occur due to jet interference with engine bay walls and exhaust doors. Therefore two systems were proposed, one permitting free mixing and another incorporating a simple ejector giving a small thrust augmentation. Test results are presented and discussed.

CP22/12 **Aerodynamics of V/STOL Aircraft Powered by Lift Fans.** D.H.HICKEY, W.L.COOK.
AGARD Conference Proceedings CP 22, 17 pp., 11 refs., 1967.
Wind-tunnel data for large-scale V/STOL models powered with lift fans are presented and analysed to show the important parameters affecting induced lift, drag, and pitching moment. It is shown that the downwash from lifting fans or engines mounted upstream of a wing unload the wing during transition. Lift-fan powered VTOL aircraft have significant overload STOL capability if a gas power transfer control system is used, but with a separate control system the capability may be small. It is shown that boundary layer control can provide good inlet performance for very thin fan installations that have small inlet radii.

CP22/13 **An Analytical and Experimental Study of Jet Deflection in a Cross-Flow.** C.T.CROWE, H.RIESEBIETER.
AGARD Conference Proceedings CP 22, 19 pp., 2 refs., 1967.
An equation based on a simple theoretical model was derived for jet trajectories as a function of the jet-cross-flow dynamic pressure ratio. Important data lacking in the analysis was the rate at which the jet spreads out in the direction normal to the cross-flow. A smoke tunnel study was undertaken to determine the spread-rate factor. Data on the smoke trajectories within a deflected jet and the dynamic pressure along the jet were reduced and applied to give an equation for jet trajectories which agrees with experimental results over a wide range of dynamic pressure ratios.

CP22/14 **Jet Interference Measurements on a VTOL Model with Jet Simulation by Fans.** H.FÜTTERER, L.HARMS.
AGARD Conference Proceedings CP 22, 26 pp., 13 refs., 1967.
Wind-tunnel tests and the characteristics of these fan engines are described. The influence of the fan efflux flow on the lift and pitching moment of the fuselage, wing and tailplane is determined from three-component measurements. The ratio of flight speed V_∞ to the jet velocity V_j of the fan units is changed in the range from $V_\infty/V_j = 0.2$ to about 0.6 and the jet inclination of a combined thrust-lift engine is varied from $\theta = 0$ deg to 90 deg. The basic assumptions on which this particular technique is based, the calibration tests performed, and the data-reduction methods are described.

CP22/15 **Inlet Measurements on a VTOL-Aircraft Model.** R.GÖTHERT.
AGARD Conference Proceedings CP 22, 22 pp., 8 refs., 1967.
For a VTOL-aircraft project with three jet engines installed in the fuselage, wind-tunnel investigations were made to provide the aerodynamic characteristics of the air intakes during the hovering and transition phase. Two engines produce pure jet lift and the third is a combined lift-cruise engine. The most essential results of the lift engine intake measurements are presented. Various intake-flap systems which have to cover the bell-mouth inlets during cruise flight and should improve the inlet flow conditions during hovering and transition, were studied.

CP22/16 **Power Effects on Two-Fan-In-Fuselage Fighter Configuration.** R.B.JENNY.
AGARD Conference Proceedings CP 22, 19 pp., 1967.
Models tested represented a supersonic VTOL fighter configuration with three fans in the fuselage, and a subsonic VTOL fighter configuration with two fans in the fuselage. The fan performance was found to be quite sensitive to inlet geometry but little affected by ground proximity. Exit louvres were found to be effective for controlling the thrust deflection angle, and the effects of louvre area were measured. Interference effects on lift at forward speed were found to be sensitive to the position of the fan relative to the wing, and the interference drag was found to agree quite well with momentum theory.

CP22/17 **Transient Aerodynamic Forces on a Tilt-Propeller VTOL Aircraft in Hovering.** A.R.S.BRAMWELL.
AGARD Conference Proceedings CP 22, 13 pp., 1 ref., 1967.
The transient aerodynamic interference between a lifting blade and the wing of a VTOL tilt-rotor configuration has been investigated. Results show that the interference forces can be very large, especially when the rotor is close to the wing and the wing chord is large. For a rotor of given thrust the transient loads are inversely proportional to the number of blades. The mean value of these forces is small, however, and not seriously likely to affect the performance, being generally much smaller than the downwash "drag" load.

CP22/18 **VTOL Aircraft Noise.** T.J.HARGEST.
AGARD Conference Proceedings CP 22, 17 pp., 15 refs., 1967.
The existing forms of lifting systems, which have been tested in flight, seem incapable of development to the high noise standards that would be demanded if these aircraft were to be operated at significantly commercial weights from city centre terminals. The application of circulation control to the various lifting systems may prove to be of great benefit in reducing noise so that commercially viable VTOL transports could be built which could operate from city centre terminals.

CP22/19 **The Spinning Vortices as Sources of Sound.** E.A.MULLER, F.OBERMEIER.
AGARD Conference Proceedings CP 22, 8 pp., 5 refs., 1967.
Flow and sound fields of a simple aerodynamic sound source, the two-dimensional spinning vortices, are calculated by the method of matched asymptotic expansions, which allows for the computation of an asymptotic solution of the differential equations of the flow, and which is valid both in the near and the far fields. One obtains a seventh power law in a characteristic velocity U for the sound power radiated by unit length of the spinning vortices in contrast to the eighth power law obtained by M.J.Lighthill for three-dimensional flows.

CP22/20 **Influence of the Tip Vortex on Helicopter Rotor Noise.** H.STERNFELD, Jr.
AGARD Conference Proceedings CP 22, 20 pp., 2 refs., 1967.
The predominant factor in the acoustical signature of helicopter rotors is the blade bang or blade slap which arises from the intersection of a rotor blade with the tip vortex shed by a preceding blade in the rotor system. This paper discusses the differences between banging and non-banging signatures and the conditions in blade vortex intersections. Correlation between acoustical signature and the analytical prediction of vortex interaction is shown.

CP22/21 **Helicopter Rotor Test Installation in the Large Wind Tunnel at Modane-Avrieux.** (In French). A.SCHWEISCH.
AGARD Conference Proceedings CP 22, 9 pp., 3 refs., 1967.
The apparatus described permits testing of large diameter rotors: the test section is 8m in diameter and 14m long; rotor rate can be varied continuously from 800 to 2300 r.p.m., a braking device allows

autorotating testing. The system is currently being developed and the instrumentation and expected performance are also described.

CP22/22 **Measurements of the Influence of Mixed Boundaries on the Aerodynamic Characteristics of a V/STOL Wind Tunnel Model.** P.SOUTH.
AGARD Conference Proceedings CP 22, 15 pp., 2 refs., 1967.
The object of this paper is to compare measurements of the wall effects, in an open and in a closed wind tunnel, with existing theory and to describe a series of tests of working sections with mixed boundaries undertaken in an effort to reduce the wall effects. Lift, drag, pitching moment, propeller thrust, and flow angle in the region of the tailplane were measured for a twin propeller tilt wing aircraft model. For completely open and completely closed working sections, the results are compared with the corrections predicted by Heyson's method.

CP22/23 **V/STOL Wind Tunnel Testing – Past Development, Experiences and Future Development.** B.EWALD.
AGARD Conference Proceedings CP 22, 22 pp., 11 refs., 1967.
The testing techniques employed by Vereinigte Flugtechnische Werke and the experiences gained therewith are discussed, together with the similarity laws relating to simulation of air intakes and jets in wind tunnel and static tests. Techniques for simulating air intakes and jets are reviewed. Several wind tunnel programmes carried out by VFW are presented as examples to demonstrate the advantages and disadvantages of the different methods. Future possibilities in the development of thrust simulation techniques are indicated.

CP23 **Displays for Command and Control Centers.** I.J.GABELMAN (Editor).
AD-863-130 AGARD Conference Proceedings CP 23, 514 pp., many refs., 1969.
N70-15408 Records the papers presented at 11th Technical Meeting in Munich, Nov. 11-14, 1966, of the AGARD Avionics Panel. The 34 papers cover almost all aspects of data display and the appropriate equipment. Displays for military command, air traffic control, manned space flight and air defence systems are treated in detail. The individual papers are dealt with in the following abstracts.

CP23/1 **Identification of Data Display Requirements in Command Control.** J.H.PROCTOR.
AGARD Conference Proceedings CP 23, Chapter 1, pp.1-13, 12 refs., 1969.
Presents systematic methods of identifying information requirements during the evolutionary development of a command control system.

CP23/2 **Operational Requirements for Command and Control Displays within A.C.E.** J.B.CARNE.
AGARD Conference Proceedings CP 23, Chapter 2, pp.15-21, 1969.
This chapter illustrates this approach and develops the display requirement for one of the most vital command and control functions within Allied Control Europe (A.C.E.).

CP23/3 **The Development of a Display Working Position with Universal Application for Air Traffic Control Functions.** K.HEIDELAUF.
AGARD Conference Proceedings CP 23, Chapter 3, pp.23-35, 3 refs., 1969.
Describes the results of an investigation by the German B.F.S. on a study of an operational/technical system which envisages increased utilization of automated technical means. The proposed development includes:– the use of universal computer systems, efficient computer systems, use of digitalized radar information, high total reliability and representation of the control information in a concentrated form at display working conditions.

CP23/4 **Considerations Affecting the Choice of Display for an Army Field Force Automatic Data Processing System.** G.WOOLDRIDGE.
AGARD Conference Proceedings CP 23, Chapter 4, pp.37-47, 1969.
The chapter presents the broad military requirements for a general purpose E.D.P. system in the field army, including the types of data to be handled and the processing required. Cartographic and tabular displays will be required and requirements are discussed. Possible lines of development for second-generation systems are discussed.

CP23/5 **Command and Control of Manned Flight Recovery Operations.** J.H.MAGRANGE.
AGARD Conference Proceedings CP 23, Chapter 5, pp.49-66, 23 refs., 1969.
Describes the role of the Department of Defense Manager for Manned Space Flight Support Operations in the manned space flight program efforts of U.S.A. and discusses command and control of manned space flight recovery operations.

CP23/6 **Information Transfer from Command-Control Displays.** S.RINGEL.
AGARD Conference Proceedings CP 23, Chapter 6, pp.67-80, 15 refs., 1969.
A research program to improve combat effectiveness of command-control systems is summarized. The use of the computer as an aid to performance rather than merely as a display driving device is discussed and finally some doubts are raised concerning the relative merits of large group displays and of elaborate graphic generation and display devices.

CP23/7 **Display Requirements Assessment for Command and Control Systems.** R.L.KUEHN.
AGARD Conference Proceedings CP 23, Chapter 7, pp.81-92, 11 refs., 1969.
The major underlying parameters of a display system depend to a great extent on the basic attributes of the human visual system. These are briefly reviewed and resolution, amount of data displayed, display dynamics, coding and screen size are discussed. Illustrations are given of the interrelationship of certain of these.

CP23/8 **Studies in Display Legibility.** C.V.RICHE, G.C.KINNEY.
AGARD Conference Proceedings CP 23, Chapter 8, pp.93-103, 14 refs., 1969.
Deals with data display legibility and its related problems. It reports on work done on a new form of display specifications.

CP23/9 **A Study of the Relationship Among Special System Fonts, Electronics and Subjectivity.** C.P.HALSTEAD.
AGARD Conference Proceedings CP 23, Chapter 9, pp.105-127, 5 refs., 1969.
This chapter is designed to illustrate pictorially the relationship existing between the number of bits in the symbol memory and the font flexibility of the symbol being generated. "ENTROPY" as applied to information theory is a measure of information capacity in terms of the total number of different symbols which a generator can be programmed to provide. Many examples are discussed.

CP23/10 **Computer Display for Viewing of Experimental Data.** Y.LUNDH.
AGARD Conference Proceedings CP 23, Chapter 10, pp.129-136, 1969.
Discusses the use of automatic computing machinery for the analysis of large masses of recorded experimental data. An important feature is the possibility of the scientist to see graphical representations at various stages. Such a system using a digital computer and a C.R.T. display is described and discussed.

CP23/11 **A General Purpose Display System for Command and Control.** D.L.DRUKEY.
AGARD Conference Proceedings CP 23, Chapter 11, pp.137-152, 1969.
A general purpose display system is described which has been developed to provide a user-oriented vehicle for the non-programmer to develop his own display formats at a cathode-ray-tube console.

CP23/12 **The Display Oriented Computer Usage System: A General Purpose Software Package for Display Systems.** W.L.FRANK.
AGARD Conference Proceedings CP 23, Chapter 12, pp.153-173, 1969.
A complete on-line display "Display oriented computer usage system" (DOCUS) is described. Examples of display oriented language are given and costs of program size, programming development and implementation are compared to ad hoc programming solutions. Examples of existing systems are cited.

CP23/13 **Displays in Command and Control.** M.SCHWARTZ.
AGARD Conference Proceedings CP 23, Chapter 13, pp.175-183, 1969.
This chapter is an attempt to cover some important softwave design considerations of display/retrieval systems of the type that would provide a data base probe, offering flexibility and response speeds critical to the user in a command and control situation.

CP23/14 **The Use of the IBM2250 Display Unit in a Typical Command and Control Problem: The Message Handling and Situation Updating.** M.LIPPOLIS.
AGARD Conference Proceedings CP 23, Chapter 14, pp.185-196, 1 ref., 1969.
This chapter discusses the possibility of introducing the use of electronic computers in Command and Control Centers operating according to the traditional manual procedures. It emphasises the relevant importance and the substantial role of the programming support in realizing the man-to-machine interface, and in increasing the flexibility in the operational use of a given display equipment.

CP23/15 **A Flexible and Versatile Display for Command and Control – The BR-90.** F.J.BEACH.
AGARD Conference Proceedings CP 23, Chapter 15, pp.197-209, 1969.
The BR-90 Visual Analysis Console was developed as part of a total system to provide: multiple user access to specific information, user control over a high speed digital computer and tools to manipulate displayed data.

CP23/16 **Composition and Organization of a Computer Operated Display System.** M.MOSCA.
AGARD Conference Proceedings CP 23, Chapter 16, pp.211-218, 1969.
The purpose of this chapter is to provide an outline of the basic system concepts involved in the design of computer-operated displays as used in modern air defense and air traffic control systems.

Three major functions are required, panoramic display of the situation, alphanumeric display for auxiliary data controlled by the computer, and finally manual entry of data and action codes in the computer.

CP23/17 **The Impact of Information Processes on Future Display Devices.** D.W.G.BYATT.
AGARD Conference Proceedings CP 23, Chapter 17, pp.219-233, 2 refs., 1969.
This chapter examines the advantages and disadvantages of the cathode ray tube against the background of modern data systems and compares these with the characteristics of recent display devices, many still in the research stage.

CP23/18 **A High Precision Display System for Command and Control.** H.C.HENDRICKSON.
AGARD Conference Proceedings CP 23, Chapter 18, pp.235-245, 1969.
This chapter describes the technical considerations which are causing a shift in C.R.T. display design from random beam position with analog symbol and vector generation to starter beam positioning with digital symbol and vector generation.

CP23/19 **The Electrostatic Storage Display Tube: A New Projection Display System.** J.M.ENGEL.
AGARD Conference Proceedings CP 23, Chapter 19, pp.247-257, 2 refs., 1969.
Several different tube structures are described all of which offer resolutions of about 2000 TV lines per useful field of view, good contrast and erasure times of under two seconds.

CP23/20 **Photochromic Film Displays for Command and Control.** G.H.DORION, R.W.ROTH.
AGARD Conference Proceedings CP 23, Chapter 20, pp.259-272, 15 refs., 1969.
The reversible nature of photochromic images provides a dynamic display that also gives a true domain to the data. This chapter describes the current photochromic materials being used today, their mode of operation, and representative data display systems using these materials.

CP23/21 **Photo-Recording Present and Future.** D.E.WILCOX, L.McDOWELL.
AGARD Conference Proceedings CP 23, Chapter 21, pp.273-293, 9 refs., 1969.
Most of the present large screen display devices in operational services are based on the application of silver halide film. This chapter applies specifically to computer generated displays, and discusses the design of several equipments now employed by the United States Air Force in Operational Command and Control systems.

CP23/22 **Surface Deformable Media as Applied to the Generation of Projection Command and Control Displays.** G.J.CHAFARIS.
AGARD Conference Proceedings CP 23, Chapter 22, pp.295-310, 1969.
This chapter is designed to acquaint the reader with the present state of surface deformation recording as applied to the generation of projection command and control displays. Principles of electron beam recording on thermoplastic and oil film media are briefly reviewed. Both achieved and anticipated performance are discussed.

CP23/23 **Matrix Controlled Electroluminescent Displays.** C.M.BLANK.
AGARD Conference Proceedings CP 23, Chapter 23, pp.311-327, 14 refs., 1969.
Provides a general review of the state of the art in large area electroluminescent matrix displays and to discuss some of the properties and limitations of these displays. It is concluded that the basic problems lie with the properties of the control element and that not until these problems are solved will a usable display be made.

CP23/24 **Solid State Display.** R.J.LYNCH.
AGARD Conference Proceedings CP 23, Chapter 24, pp.329-349, 12 refs., 1969.
Describes the results of an IBM study of commutation and power transfer techniques as applied to solid state indicator displays. A solid-state circuit ultimately to be made in monolithic form, acts as a single lead analog addressable driver which can electronicaliy select and drive a single element in a light emitting diode matrix.

CP23/25 **Ferroelectric Electroluminescent Displays.** B.J.LECHNER.
AGARD Conference Proceedings CP 23, Chapter 25, pp.351-371, 9 refs., 1969.
A family of new ferroelectric control circuits is described for controlling electroluminescent cells in matrix and other displays. The circuits are addressed by voltage coincidence, store and analog value of video information, and control the brightness of the cell in accordance with this stored value.

CP23/26 **Scanned Laser Display Techniques.** V.J.FOWLER.
AGARD Conference Proceedings CP 23, Chapter 26, pp.373-387, 12 refs., 1969.
Problems associated with the generation, modulation and scanning of multicolor laser beams are discussed, along with descriptions of some techniques now in use in experimental scanned display systems. A new system is described which produces three-color projected images, using a closed-loop method for generating the color video signal.

CP23/27 **Digital Electro-Optic Deflector for Directing Laser Beams.** P.W.SIGLIN, E.F.KRAL.
AGARD Conference Proceedings CP 23, Chapter 27, pp.389-403, 1969.
The design of a high resolution digitally indexed laser beam deflector is described which, it is hoped, will provide 1024 discrete beam positions in both an x and a y direction. Auxiliary elements are discussed and plans are outlined for further development.

CP23/28 **Processing of Radar and Sonar Data for Display in Command and Control Systems.** A.A.ALBANESE.
AGARD Conference Proceedings CP 23, Chapter 28, pp.405-418, 1969.
This chapter emphasises the use of digital techniques in the generation of displays. MIRAGE (Microelectronic Indicator for Radar Ground Equipment) a display data processor and a concept UNICON (Universal Control) as described as they apply to a radar system configuration.

CP23/29 **Real Time Screen Display Systems – 1966.** R.C.KLEIN.
AGARD Conference Proceedings CP 23, Chapter 29, pp.419-434, 4 refs., 1969.
Large screen displays with high intensity, real time presentation of data on screens 6 x 6 meters have proved their effectiveness and reliability in operational command and control installations of the U.S. Air Force. This chapter discusses existing display equipment and its peripherals. It considers variations in the pre-production stage which improve flexibility and scope and the value of a new concept, the hybrid-display.

CP23/30 **A New EIDOPHOR Large Screen TV Projector.** H.J.DURINGER.
AGARD Conference Proceedings CP 23, Chapter 30, pp.435-442, 1969.
Describes a new prototype EIDOPHOR projector planned to be available during 1968. It uses a 2.5 KW Xenon lamp with a guarantee life of 1000 hours and will give large screen presentation of TV pictures.

CP23/31 **Radar Digital Indicators – Technical Solutions and Applications.**
AGARD Conference Proceedings CP 23, Chapter 31, pp.443-456, 1969.
Radar digital indicators are based on the generation in digital form of the deflection signals for the PPI display and are therefore the most suitable to form a complete display of raw radar and flicker-free symbols. This chapter includes discussions of the values required for range scales and the number and type of symbols to be shown on the screen.

CP23/32 **STRIDA II Air Defense System.** J.M.CHABANS.
AGARD Conference Proceedings CP 23, Chapter 32, pp.457-466, 1969.
This chapter describes the data display system used in French Air Defense Stations. STRIDA II is an operational system involving many surveillance radars and many targets. Information may be provided from raw radar data or from computer derived synthetic data. This implies the use of consoles enabling the human operators to intervene in the computing cycle. The organization of work positions is described and main trends of the new generation of display equipment are outlined.

CP23/33 **The Command and Control Display System for NORAD.** K.J.ZIMMER.
AGARD Conference Proceedings CP 23, Chapter 33, pp.467-488, 1969.
Describes the hardware and operational features of a large wall display system used at present by the U.S. Air Force at Cheyenne Mountain in Colorado, U.S.A. Attention is primarily directed to the Camera Processor Projector Unit (C.P.P.U.); however, brief attention is given to the operation of this unit in conjunction with a central computer and an electronic basic display unit. The generation of seven-color projection displays from black and white film is described and details of the ten seconds processing time are given. The 5000 watt Xenon projector lamp and possible developments are described.

CP23/34 **The Display/Control Complex of the Manned Space Mission Control Center.** H.C.H[illegible].DRICKSON.
AGARD Conference Proceedings CP 23, Chapter 34, pp.489-503, 1969.
This chapter describes the system at the Missions Control Center at Houston which directs Gemini and Apollo manned space flights. It contains 140 command consoles most of which have two real-time resolution C.R.T. displays. Five key decisions by Philco and N.A.S.A. allowed the system to have great power and flexibility and to be quickly installed (18 months after Contract).

CP24 **Aeromedical Aspects of Helicopter Operations in the Tactical Situation.**
AD-667-210 AGARD Conference Proceedings CP 24, 276 pp., 1967.
N68-19325 The twenty-six papers which were presented at a symposium held by the AGARD Aerospace Medical Panel during May, 1967, are reproduced here together with discussions and the Chairman's summaries. The papers are grouped under the headings: (i) the helicopter as a casualty evacuation vehicle; (ii) aircrew problems in helicopter operations; (iii) hazards of the helicopter; and (iv) the helicopter as a carrier of personnel and material. An additional paper was given on the hovercraft and its potentialities. Abstracts of the individual papers are given in the following items.

CP24/1 **US Army Helicopters as Personnel and Material Carriers.** R.L.CODY.
AGARD Conference Proceedings CP 24, 3-8, 1967.
A general picture is given of the use of helicopters in assisting land combat troops in Vietnam. The subject is presented from the point of view of environment, the enemy, tactics and techniques, and special missions, in the hope of giving an insight into the operations as a means of measuring the problems inherent to organizing, training, deploying and supporting the organization required to accomplish these missions.

CP24/2 **RAF Experience of Helicopter Operations in Borneo.** D.ELEY.
AGARD Conference Proceedings CP 24, 9-15, 1967.
This short article describes some of the varied activities undertaken by RAF helicopters under extremely arduous conditions. The general meteorological and other operating conditions are outlined. Some pilots were flying throughout all hours of daylight in a strange country without radio contact, and with limited distribution of fuel stocks. Landing clearings were cut in the hilltops where trees were scarcer. Problems were lack of navigation facilities, poor communications with ground troops, weight and C.G. fixing, delivering men and equipment, heat stress, and insects and diseases.

CP24/3 **Royal Naval Experience with Helicopters Operating from Commando Carriers and as Plane Guards.** P.J.WILLIAMS.
AGARD Conference Proceedings CP 24, 17-24, 1967.
The types of operations best suited for helicopters is of the "brush fire" variety where quick reaction creates the correct balance of power necessary for a recognised Government to restore law and order. Examples given are the Kuwait crisis in 1961, Brunei in 1962, and the Malaysian confrontation in Indonesia. Operations from the modified fixed-wing type carriers are outlined. A brief picture is also presented of "plane guard" designed for rescuing ditched aircrew from fixed wing aircraft. It is noted that helicopters are now equipped for night operation on "plane guard" duties.

CP24/4 **RAF Search and Rescue Operations.** M.W.B.WATSON.
AGARD Conference Proceedings CP 24, 25-36, 1967.
The organisation of the Search and Rescue Service in the United Kingdom is described. The Rescue Coordination Centres are based at Plymouth and Edinburgh and are operated by the RAF, but can be alerted by numerous civil sources. The helicopter element is only part of the service and is used primarily to recover personnel of crashed aircraft from the sea. Other tasks include to help the sick and injured on boats and offshore drilling rigs, and rescue swimmers. The problems encountered in these tasks are outlined, and the description of a typical mission shows many of the limitations in such circumstances. In conclusion the crew should provide for both winchmen and doctors and both should be drilled in each others tasks.

CP24/5 **The Helicopter: A Tactical Rescue or Recovery Vehicle.** C.J.BUCKLEY.
AGARD Conference Proceedings CP 24, 37-44, 1967.
The Aerospace Rescue and Recovery Service is the largest single user of rotary wing aircraft in the United States Air Force. The beneficial effects of such a unit on morale of Air Force personnel, (the sense of security of their families at home, and the saving of money due to the rescue of men trained at great expense) are mentioned. Three missions are discussed: (i) local base rescue including fire fighting, (ii) the evacuation of persons from acutely hostile areas, and (iii) long distance recovery from within enemy territory. The author looks into the future when V/STOL aircraft will be used.

CP24/6 **The Use of Helicopters During the Flood of November 1966 in Italy.** A.PAGANELLI.
AGARD Conference Proceedings CP 24, 45-50, 1967.
The numbers of helicopters employed in these rescue operations was 105, and nearly 2000 people were saved. Only one fatal accident occurred, due to a person falling from the strop during a winch rescue. The helicopter proved useful, psychologically, by annulling the feeling of isolation in groups of people and so preventing panic. Bad weather was no great obstacle. No particular difficulties were encountered in assisting a heterogeneous population unprepared for helicopter assistance.

CP24/7 **Operation Skagerak.** K.S.PETERSEN.
AGARD Conference Proceedings CP 24, 51-58, 1967.
The operation was conducted by No. 722 Squadron of the Royal Danish Air Force using Sikorsky S-61A-1 helicopters. A brief description of this aircraft precedes the account of the rescue operation in which 75 survivors were picked up from the ferry boat "Skagerak" disaster. The helicopters were also able to direct ships to the scene to assist with the rescue operations. Survivors were rescued from life rafts, lifeboats and from the sea. The physical and mental effects in both aircrews and survivors are well illustrated in this first-hand account of the operation.

CP24/8 **The Geneva Conventions and the Juridical Protection of Medical Helicopter Transports in Armed Conflict.** (In French). E.EVRARD.
AGARD Conference Proceedings CP 24, 63-84, 6 refs., 1967.
The juridical protection of helicopters on aeromedical missions comes under Articles 36 and 37 of the First Geneva Convention, and Article 39 of the Second Convention. The present juridicial status is ineffectual and inoperative due to gaps, ambiguities and defects which are: lack of a precise definition of protected aircraft, insufficient means of signalling and identification of helicopters on medical missions, obligation of preliminary agreement on flight routes between parties at war, and lack of precision in the practical deliniation of the areas which can be flown over. Suggestions for correcting these faults and for modifying the texts concerned with medical aviation in the 1st and 2nd Geneva Conventions are outlined.

CP24/9 **Helicopter Air Ambulance Problem Areas.** F.J.MILLS.
AGARD Conference Proceedings CP 24, 85-89, 1967.
In this brief article, the major problems of medical air transport helicopters are given as air-to-ground communication difficulties, the lack of helicopter education on the part of ground troops, and improper utilization of evacuation aircraft. In the discussion it was said that the display of the red cross was insufficient identification for the protection of the helicopter, and it was only possible to use this form of transport if the operating country had complete air superiority.

CP24/10 **Helicopter Evacuation in Vietnam.** E.LAIL.
AGARD Conference Proceedings CP 24, 91-98, 1967.
Army Medical Service helicopters and their crews perform a vital role in evacuating wounded from the battlefield. The helicopter's speed and its insensitivity to terrain make it an essential tool as an air ambulance. The type of helicopter now used is the turbine-powered Bell UH-1D. There is provision for six litter patients, blood transfusion service and heated blankets. A resuscitator, although not part of the aircraft equipment is also carried. Some details of the hoist are also given, as well as the crew "make-up" and method of classifying patients for priority of evacuation.

CP24/11 **Acute Casualty Handling.** I.CAPPERAULD.
AGARD Conference Proceedings CP 24, 99-107, 1967.
The role of the Regimental Medical Officer in casualty sorting, dispersal, and classification is outlined. Three degrees of priority are allocated. These are briefly (i) cases requiring resuscitation and urgent surgery, (ii) patients requiring early surgery and possible resuscitation, and (iii) those having spinal injuries and minor fractures or minor wounds. The advantages and disadvantages of both helicopter and road transport evacuation are given. Brief details are included of the casualty clearing station, missile wounds, and principles of wound care.

CP24/12 **The Reception of Air Evacuated Casualties.** R.F.BROWN.
AGARD Conference Proceedings CP 24, 109-116, 1967.
The views of an hospital surgeon, in Aden, on casualty evacuation by helicopter are given. The moving of a patient requires speed which the helicopter can give. The wounded travel well if despatched shortly after injury, but a stop at a first aid post may be necessary if a delay has occurred. The conditions of flight seem to have little effect on the state of the patient on arrival at hospital. Some first aid measures for different wounds should be taught to all ranks, and these are outlined. Planning for helicopter reception at the base hospital is also treated.

CP24/13 **A Portable Oxygen Apparatus.** (In French). A.LANDRAIN.
AGARD Conference Proceedings CP 24, 117-122, 1967.
The apparatus supplies high pressure oxygen and is used by the Belgian Air Force. It is made up from normal aircraft oxygen equipment and comprises essentially a mask, an 8 litre low pressure cylinder, on/off cock and gauge and a Burns valve. The whole is housed in a box equipped with carrying straps. Illustrations of the apparatus are included.

CP24/14 **Helicopter Casualty Evacuation.** A.M.FERRIE.
AGARD Conference Proceedings CP 24, 123-129, 1967.
The organisation and operational control of the helicopter evacuation service is discussed, and examples of the problems encountered in such a service in South Arabia an Borneo are given. It is shown that the helicopter allows for a reduction in motor ambulances and also a reduction in medical man power, but throws extra responsibility on the company medical orderly. Mist and cloud slowed operations but did not prevent casualty evacuation. Locating patrols sometimes proved difficult due to lack of communications.

CP24/15 **Use of Computer Simulation to Evaluate Medical Helicopter Evacuation Systems.** J.E.BIZER.
AGARD Conference Proceedings CP 24, 131-144, 1967.
The study investigated the casualty producing potential of weapon systems and assessed the combinations of effects that may occur when one or more of the systems are employed. When the casualty data are obtained the next logical step is a system capable of performing a thorough evaluation of the impact this casualty load will have on a given medical supply organisation.

The system discussed is a series of computer simulation models. The end result or output will then be improved medical doctrine, tables of organisation equipment and the supporting field, and technical manuals. The results for evacuation are tabulated for both air and ground ambulances.

CP24/16 **An Overall Survey of Helicopter Operations Problems.** S.H.NEEL.
AGARD Conference Proceedings CP 24, 147-154, 1967.
The fact that the helicopter has to provide more power to its rotary wings which provide both thrust and lift, and also that it is a relatively unstable platform which generally has to move in close proximity to the ground, has created new medical problems. These characteristics of the helicopter result in more noise, more vibration, more toxicity, more disorientation, and more fatigue. The noise problem can be alleviated by ear plugs, both noise and vibration by better engineering design. Toxicity is due to engine exhaust and gases from munitions. A study is being conducted at present to determine the extent of this hazard and means for its correction. Spatial disorientation and fatigue are long recognized hazards which account for a large proportion of accidents.

CP24/17 **Operation of Helicopters: Some Visual Problems.** W.A.N.MACKIE.
AGARD Conference Proceedings CP 24, 155-164, 7 refs., 1967.
External visual cues are needed for the helicopter pilot, especially when he brings his machine into hover and then land. The mechanics of the external cues are discussed and the two main points are (i) movement parallel to a surface gives rise to pure flow, and (ii) movement directly towards or away from a plane at a right-angle to the flight path gives rise to apparent radial movement outwards or inwards to the observer. It is suggested that visual requirements of helicopter pilots should be looked at in the light of motion perspective and that test devices could be designed to teach, test and if necessary eliminate those pupils who show poor response to these visual clues.

CP24/18 **Helicopter Vibrations.** (In French). H.SERIS, R.AUFFRET.
AGARD Conference Proceedings CP 24, 165-171, 1967.
A preliminary report is given on the vibration characteristics of the French military helicopter, the Sud Aviation 330. Vibrations levels are found to be relatively high by comparison with the S.A. Super Frelon. There is, in particular, vibration in the frequency band of 17.5 to 20.7 Hz. The high incidence of back pain in helicopter pilots (87.5% in one survey) is discussed, and mechanisms and treatment are reviewed.

CP24/19 **Fatigue in Helicopter Crews in Combat.** J.T.ADAMS.
AGARD Conference Proceedings CP 24, 173-178. 1967.
In this study it is shown that emotional fatigue was more prevalent than physical fatigue, and both were present to a degree sufficient to warrant constant attention. Considering the prevalence of fatigue reactions and symptoms, it is concluded that the measures taken were justified and served to preclude even greater loss in time and possibly personnel through severe illness, accident or combat loss. These measures included precautionary grounding of aircrews and when necessary hypnotics to induce sleep.

CP24/20 **Problems of Training Army Helicopter Pilots.** D.ELEY.
AGARD Conference Proceedings CP 24, 179-187, 1967.
The policy of the British army is that its pilots should be first-class soldiers with the extra skill to fly functionally. After a two or three year tour of duty as pilots they return to normal army duties. This means that there is a continual requirement to train over 100 helicopter pilots. The pilot training includes 60 hours flying on "Chipmunk" fixed wing aircraft, 60 hours on the "Hiller" basic helicopter, and 65 hours on the "Sioux" advanced helicopter. A graph shows that up to 29 years of age the helicopter pilots chances of success improve but over this age they deteriorate rapidly. Future trends are discussed briefly and it is indicated that more helicopter training would be given at the expense of training on fixed-wing aircraft.

CP24/21 **Icing and the Rescue Helicopter.** T.R.RINGER, J.R.STALLABRASS, R.D.PRICE.
AGARD Conference Proceedings CP 24, 191-203, 1967.
The mechanism of natural icing is explained. The three types of ice formation which are likely to occur simultaneously at different stations along a helicopter blade are glaze ice, intermediate or "glime" ice, and rime ice. Simulation of icing can be carried out in wind tunnels for the investigation of formation on aerofoil, engine inlet, windscreen and instruments. For helicopters, however, a spray rig is a more practical method. The methods of protection of helicopters from icing are briefly noted. These are thermal, electrical and chemical. It is emphasized that the rescue helicopter must incorporate either electrical or chemical methods.

CP24/22 **Hazards of Overwater Helicopter Operations.** I.H.COLLEY.
AGARD Conference Proceedings CP 24, 205-211, 1967.
The major hazard is escape after ditching and the author states simply how the current Royal Navy training procedure is carried out for underwater escape. Briefly this is achieved by using a "dunker"

which is a mock-up Whirlwind rear cabin. The dunker is immersed in a tank to give a swirling motion to the water. Trainee head immersion is for only five seconds. Later escape training is carried out through hatches and, most difficult of all, through the door.

CP24/23 **A Helicopter Personnel Escape, Protection, and Survival System.** F.T.THOMASSON.
AGARD Conference Proceedings CP 24, 213-231, 4 refs., 1967.
It is noted that there is no special provision for in-flight escape from helicopters and that no serious consideration has been given to the problem. Also helicopters do not afford adequate protection from crash impacts, fires or ditchings, or provide an acceptable level of injury-free survival during either in-flight or crash emergencies. The US Navy have examined the problem for three methods (i) individual parachute and normal bail-out, (ii) rotatable crew ejection seats with horizontal ejection to clear the rotor blades, and (iii) capsule escape system. The effect on aircraft design was taken into account.

CP24/24 **Crash Injuries in US Army Helicopter Accidents.** K.L.MATTOX.
AGARD Conference Proceedings CP 24, 233-244, 6 refs., 1967.
USABAAR is the United States Army Board for Aviation Accident Research and is located at Fort Rucker, Alabama. It is the Army's repository for world-wide army aircraft accident data. The data presented here are taken from operational major and minor accidents exclusive of Vietnam for the period January 1960 to June 1965. Methods of reducing morbidity and mortality in non-catastrophic helicopter accidents are suggested. In the discussion which followed the paper, it was generally accepted that passengers should be provided with a universal fit protection helmet.

CP24/25 **Emergency Landing and Ditching Techniques in Helicopters. (USABAAR Report P67-1).** G.BRUGGINK.
AGARD Conference Proceedings CP 24, 245-257, 1967.
The purpose of this report is to increase the helicopter pilot's understanding of how to avoid or minimize the hazards associated with emergency landing situations. Crash dynamics of both fixed-wing and rotary-wing aircraft are explained. The main idea is to look upon the cockpit/cabin as a protective container and to keep this reasonably intact whilst using other parts of the aircraft as impact attenuators. The ideal way to use the main rotor, for instance, is to make a zero ground speed tree landing. The rotor acts as an "umbrella", whilst the fuselage settles in the trees. Methods of selecting different terrains and what to avoid are detailed.

CP24/26 **The Hovercraft and Its Potentialities.** J.E.BURTON.
AGARD Conference Proceedings CP 24, 261-266, 1967.
A brief description is presented of the hovercraft principles and design, the scope of the work that the United Kingdom has been doing with respect to the military potential of the hovercraft, and future plans. Hovercraft are considerably cheaper than helicopters, crew skill is less, and generally speaking they are safer than helicopters. However, they have not been developed to be in competition with rotary wing craft but must be considered as complementary to them.

CP25 **Behavioural Problems in Aerospace Medicine.**
AD-669-417 AGARD Conference Proceedings CP 25, 454 pp., 1967.
N68-24859 The papers reported here were presented at the 24th Meeting of the Aerospace Medical Panel of AGARD held in Rhode-Saint-Genese, Belgium during October, 1967. Particular reference to such aspects as diurnal rhythms, sleep and alertness were considered as well as recent medical problems of space and of air warfare. Abstracts of the thirty papers are given in the succeeding items.

CP25/1 **Desynchronisation and Resynchronisation of Human Circadian Rhythms.** J.ASCHOFF.
AGARD Conference Proceedings CP 25, 12 pp., 22 refs., 1967.
Circadian rhythms of activity, body temperature and urine excretion have been measured on human subjects, kept in isolation in an underground bunker, either in constant conditions or exposed to artificial light-dark cycles. The results of the experiments are shown graphically and include external and internal desynchronisation, entrainment to a 26.7 hour day and to a 22.7 hour day, enclosure of four subjects in a bunker for a number of days, and shifts of artificial light-dark cycle simulating flight in either East or West direction.

CP25/2 **Circadian Rhythms and Military Man.** C.H.KRATOCHVIL.
AGARD Conference Proceedings CP 25, 9 pp., 32 refs., 1967.
The high speed transport of large numbers of troops magnifies the problem of adjusting to new time zones. This may well be a factor of major operational importance. Drug therapy is inadequate and may be harmful. The suggested solution is prepositioning of manpower or preadaptation at the home station. The paper reviews some of the aspects of the problem and stresses the need for further investigation.

CP25/4 **The Use of Period Analysis to Evaluate Human Physiological and Psychomotor Performance.** W.McCALLY.
AGARD Conference Proceedings CP 25, 14 pp., 10 refs., 1967.
Presents the application of a so-called least squares spectrum to a number of time series collected in the laboratory. Urine was collected from four subjects during a 36 day space cabin simulator study. A normal twenty-four hour day was used and subjects ate diets of known quantity and composition. Circadian, 3½ day, 7 day and 29 day periods were observed on urine flow. Other time series, (heart rate, respiration rate, ventilation, and 0_2 consumption) have been analyzed over shorter periods. It is apparent that detailed mapping of the spectra of a variety of physiological and performance variables over a wide bandwidth of period, perhaps from one second to one month, at rest and during various levels of environmental stress will ultimately be required.

CP25/4 **Periodic Variations in Indices of Human Performance, Physical Fitness, and Stress Resistance.** K.E.KLEIN, H.M.WEGMANN, H.BRUNER.
AGARD Conference Proceedings CP 25, 19 pp., 42 refs., 1967.
In order to estimate the existence and magnitude of rhythmic day-night variations in human performance, physical fitness and stress resistance, the following variables were measured every three hours over a full day-night cycle: the reaction time and its individual constancy, the maximal psychomotor coordination ability, the Schneider index, the predicted VO_2 max, the cardiovascular responses to tilting, and the "time of useful consciousness" in simulated altitude. The significance of the results for the applicability of functional tests and human efficiency during load is discussed.

CP25/5 **Pilot Response Under Ground Simulation Conditions and in Flight.** A.M.HAMMERTON FRASER, J.M.ROLFE, E.M.B.SMITH.
AGARD Conference Proceedings CP 25, 18 pp., 13 refs., 1967.
The physiological responses of a group of pilots were recorded while at rest and while undertaking a given flight plan under one of three situations, namely (i) in a fixed-base simulator, (ii) in a moving-base simulator, and (iii) in flight. The object was to determine the rank order of subjects in terms of the magnitude of their physiological responses when resting, and the effect of task performance in this order. A method of combining a subject's different physiological responses is demonstrated and conclusions are drawn as to the value of the results in assessing simulator fidelity.

CP25/6 **Methods Used at AMRD in the Study of Normal Sleep and Drug-Induced Sleep on a Visual Alertness Test.** R.D.SQUIRES, W.C.SIPPLE.
AGARD Conference Proceedings CP 25, 6 pp., 5 refs., 1967.
Methods used in an ongoing study of human sleep are briefly described. The ultimate aim was to induce normal, restful sleep by pharmacological means with minimum undesired side effects. The methods used are designed to test the restorative effect of sleep, and the relationship of the time spent in the various stages or levels of sleep to the restorative effect.

CP25/7 **The Effects of Normal Sleep and Drug-Induced Sleep on a Visual Alertness Test.** R.J.OLEYNIK, R.D.SQUIRES.
AGARD Conference Proceedings CP 25, 3 pp., 1967.
This brief paper outlines the methods used in the search for a suitable drug which would elicit restful sleep, permit ease in waking the subject at any time after drug ingestion, and cause no or minimum impairment of performance at any time after taking the drug. The reasons for the selection of the drugs used in the study are given, but results are given only for REM (rapid eye movement) sleep phase. The analysis of visual concentration performance tests will be published later.

CP25/8 **Norepinephrine and Serotonin Effects on Sleep, Alertness, and Temperature Regulation.** T.J.CROWLEY.
AGARD Conference Proceedings CP 25, 17 pp., 13 refs., 1967.
Both Norepinephrine and serotonin occur naturally in the central nervous system and may act as central regulators of temperature in lower animals. Many drugs which lower brain norepinephrine and serotonin levels also diminish alertness and induce sleep. In this study the details of these changes are examined in primates. A possible role is suggested by the experimental results for norepinephrine and serotonin in the diurnal regulation of sleep and temperature.

CP25/9 **Electrocardiographic Survey of Routine Duty Days in Helicopter Pilots.** W.P.SCHANE.
AGARD Conference Proceedings CP 25, 7 pp., 1967.
Briefly outlines the method of conducting the survey and the results obtained in this evaluation of fifty-three instructor helicopter pilots. The most important question related to the impact of helicopter flying upon cardiovascular physiology. In instructor pilots it appears from the data that the impact is not great. The conclusions are that it seems unreasonable to exclude a trained helicopter pilot from flying for trivial and questionable cardiac aberrations.

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CP25/10 **The Morbidity of Army Aviators, A Preliminary Study.** R.BAILEY.
AGARD Conference Proceedings CP 25, 6 pp., 1967.
The method for acquiring diagnosis, bibliographical information, etc. for aviators reporting sick is outlined. The data obtained were transferred to the standard IBM punched card for subsequent processing by computer. The most common symptoms were upper respiratory complaints; this was expected. Ear infections represented 5% of the sick visits, and eye diseases 2.3%. The study was biased toward aviators flying in rotary wing aircraft.

CP25/11 **Study of Alertness and Psychomotor Reactions in Primates Placed in Ballistic Flight.** (In French).
G.CHATELIER, -.BELUGOU.
AGARD Conference Proceedings CP 25, 9 pp., 1967.
An account is given of rocket flights in which two monkeys (Macaca Nemestrina) experienced weightlessness; these experiments confirmed the results of early tests on rats and cats, which showed that the weightless condition led to a lowering of the level of alertness.

CP25/12 **Recent Work on Oxygen Rich Fires.** D.M.DENISON.
AGARD Conference Proceedings CP 25, 5 pp., 13 refs., 1967.
In oxygen-rich atmospheres fire can fatally injure normally-clothed men with devastating speed, and the risk of such accidents is multiplying as the use of these environments increases. A brief review is given of work in this field during the past three years under the headings: ignition in oxygen, the spread of fires in oxygen, methods of extinction, the problems of hyperbaric oxygen therapy, and codes of practice.

CP25/13 **Human-Factors Aspects of Orbital Operations.** A.W.VOGELEY.
AGARD Conference Proceedings CP 25, 23 pp., 1967.
Based on a detailed operational analysis of the demands of man in an orbital laboratory, the paper establishes a reference framework and a set of goals for human factors research. Since most space station activities require a combination of several specific manual operations, a matrix of these inter-relationships is developed. The matrix is combined with a best estimate schedule of station activities to yield a priority list for human-factors research. Appended to the paper are a number of tables giving details of the required operations and activities.

CP25/14 **Status Report on Recent Langley Studies of Lunar and Space Station Self-Locomotion.** D.E.HEWES.
AGARD Conference Proceedings CP 25, 14 pp., 7 refs., 1967.
Studies of the self-locomotion of astronauts are being carried out by NASA. The simulators permit subjects to experience and report first hand sensations and physical effects produced by the simulated space environment. The lunar locomotion studies use an inclined plane technique developed at Langley for simulating lunar gravity. The space station studies utilize a Langley developed simulator capable of rotation which together with the inclined plane can provide weightlessness and rotational conditions required for these studies. Descriptions of the apparatus and results obtained are included.

CP25/15 **Areas of Coincidence in Aerospace and Submarine Medical Research.** C.F.GELL.
AGARD Conference Proceedings CP 25, 8 pp., 16 refs., 1967.
The discussion identifies the bio-medical problems existing in aerospace and submarine-diving activities that have similarity in their physical aspects and the psychophysiological response of man thereto. These problems are identified as time/altitude and time/ocean depth relationships. The physical stressors in both environments are related to lack of breathing oxygen, toxic gases, bends, cold, explosive decompression, atmospheric ionization, circadian rhythm alterations, disorientation, vertigo, and respiratory response in rare gases. Physiological problems are stated as human factors engineering, selection of personnel, reaction to confinement, isolation, training and simulation methods.

CP25/16 **Study of the Biological Action of Cosmic Rays by means of Sounding Balloons.** (In French).
A.PFISTER, G.DELTOUR, H.ATLAN, R.KAISER, L.MIRO.
AGARD Conference Proceedings CP 25, 8 pp., 1967.
Research carried out by the Centre d'Enseigment et de Recherches de Medecine Aeronautique de Paris, during the past three years on the biological effects of the heavy ions of primary cosmic radiation is reported. The studies were effected with balloons which carried recoverable containers to a height of 30,000 m. The experiments fell into two categories: (i) the study of anatomical-pathological lesions provoked in black mice, and (ii) the study of genetic mutations in bacteriological preparations.

CP25/17 **The Radiobiological Hiatus in Space.** E.R.BALLINGER.
AGARD Conference Proceedings CP 25, 6 pp., 1967.
Six tables are given to support the conclusions that continuous nuclear or other exotic propulsion systems may considerably shorten any given mission. It is not improbable that hyperthermic, hypoxic and metabolic reduction techniques may be used in view of the associated reduction in weight of life support systems. These same metabolic modification techniques may well be a means of modifying the expression of radiation damage in a favourable direction.

CP25/18 **Sleep Requirements During Manned Space Flight.** L.J.JOHNSON, Jr.
AGARD Conference Proceedings CP 25, 3 pp., 6 refs., 1967.
In this very brief paper, it is concluded that eight hours normal sleep should be had in a twenty-four hour period when on prolonged space flights. If this is not practicable a different wakefulness/rest ratio must be used, for example, twelve hour work and six hours rest, plus another two hour rest period in each twenty-four hour period. It is recommended that further experimental work is necessary on quality and depth of sleep as affected by differential cycling of the twenty-four hour time period.

CP25/19 **Systematic Evaluation of Thermal Aspects of Air Crew Protective Systems.** R.F.GOLDMAN.
AGARD Conference Proceedings CP 25, 18 pp., 4 refs., 1967.
Initial fabric investigations were made for insulation and evaporative transfer properties. Tests were then made on an anthropometric "sweating" heated copper manikin so that the properties of these fabrics could be evaluated when worn as a uniform. The results of a computer model for human thermal balance are then calculated as a function of wearer work load, ambient temperature, vapour pressure, wind velocity, and solar load. The results are plotted on a psychometric chart. Finally an environmental chamber evaluation of the ensemble may be carried out with human subjects to confirm the experiments and analysis.

CP25/20 **Aircrew Protective Techniques for Hot Humid Environments.** R.GAUDIO, M.McCALLY, W.C.KAUFMAN, N.ABRAMSON.
AGARD Conference Proceedings CP 25, 8 pp., 6 refs., 1967.
Three simple devices were tested to protect aircrew from temperatures of 54 deg.C with 40 to 50% relative humidity. The first, a water-cooled vest significantly improves both thermal tolerance and physiologic responses. The second, breathing cool dehumidified air significantly reduces the ventilatory response to heat stress, but is not protective otherwise. The third is to administer the steroid blocking agent metapyrone; this reduces the excretion rate of sweat Na in response to heat stress but is not thermally protective.

CP25/21 **Recent Advances in the Development of Medical Equipment and Material for Military Aerospace Operations.** J.E.MURPHY, B.H.WARREN.
AGARD Conference Proceedings CP 25, 10 pp., 7 refs., 1967.
Considered are medical equipment required at bases consisting of no more than a landing strip and with water supply, and also an aeromedical evacuation system. Recent advances include the development of a functional sphygmomanometer, portable oxygen system, bacterial isolation unit, humidifier-nebulizer, litter support system, patient access unit, and exploratory study of an intensive care unit. Under development is an air transportable self-contained tactical treatment facilities system.

CP25/22 **Flash Blindness: Development and Trials of Protective Spectacles.** B.ST.L.LIDDY, C.McCULLOCH.
AGARD Conference Proceedings CP 25, 5 pp., 1 ref., 1967.
The problems, design, and testing of developing these spectacles are discussed. Protection against scotoma-producing high intensity flashes can be afforded by using spectacles with bitemporal shading of lens. Flight trials have demonstrated the feasibility of their use in high performance aircraft. Increased pilot hazard must be expected when such glasses are used but this must be balanced against the comparative risk of flash.

CP25/23 **A Review of Some Recent and Current Exploratory Development Efforts in Pressure Suit Technology.** E.R.ARCHIBALD.
AGARD Conference Proceedings CP 25, 25 pp., 19 refs., 1967.
The purpose of the review is to consider the fundamental problems that apply to the design of a full pressure suit. The characteristics of the major types of pressure suit joints are discussed. In addition, several current development efforts being sponsored or conducted by the USAF Aerospace Medical Research Laboratories are described. These lead to the design of a second generation extra vehicular space suit.

CP25/24 **Study of the Normal Values of Vital Capacity and of the Maximum Expiratory Volume/Second in Flying Personnel of the Belgium Air Force.** (In French). J.BANDE.
AGARD Conference Proceedings CP 25, 18 pp., 10 refs., 1967.
After a brief description of the technique used for the determination of vital capacity and of the maximum expired volume/second, the factors which are liable to perturb the measurements are analysed. The study of results obtained with a population of normal subjects has made possible the derivation, for the parameters studied, of linear and exponential prediction formulae as a function of height and of age.

CP25/25 **Mathematical Analysis of the Graph of the Forced Expiration Test.** (In French). J.CLEMENT, K.VAN DE WOESTYNE.
AGARD Conference Proceedings CP 25, 7 pp., 1 ref., 1967.
D.P.Schilder has previously proposed that the major part of the curve of forced expirational flow

can be expressed by the equation $F = AV^2 + BV + C$ (1). If this equation has two real distinct roots, it is possible to express F and V as functions of the time t by

$$(2) \quad V_t = V_\infty \frac{\omega^t - 1}{\omega^t - \delta} \text{ where } V_\infty, \omega \text{ and } \delta \text{ are constant parameters.}$$

$$(3) \quad F_t = \frac{\omega^t}{(\omega^t - \delta)^2} \left[V_\infty (1 - \delta)/g\omega\right].$$

The present authors have applied the formulae (1), (2) and (3) to experimentally determined curves with the object of verifying the limits of validity of the formulae and the reproducibility of the theoretical relative volumes $qt = V_t/V_\infty$ at times 0, 2 and 1 second and also that of the parameters A, B and C.

CP25/26 **Critical and Statistical Study of the Value of Various Concentration Tests used for the Selection of Pilots.** (In French). P.LIEYENS.
AGARD Conference Proceedings CP 25, 19 pp., 5 refs., 1967.
An account is given of an analytical study of the Bourdon-Wiersma test, with particular emphasis on the correlation between the success at various levels of training of the pilot and the results obtained by various factors of the test. It is considered that the accuracy which is attained for a given speed of execution of the test is the most important single criterion.

CP25/27 **Behaviour of Pulmonary Ventilation and Alveolar Gases; Tensions in Athletes, Before, During and After a Five Weeks Stay at the Altitude of 2250 m.** A.SCANO, G.MEINERI.
AGARD Conference Proceedings CP 25, 11 pp., 24 refs., 1967.
The investigations of some respiratory parameters were made at 2300m and 5500m simulated altitude, after which tests were made on the subjects at Mexico City recording the same data. The values were significantly different in the latter tests. The conclusions are that ventilatory adaptation to altitude occurs at an early stage although even after five weeks complete acclimatization has not been achieved.

CP25/28 **A Thermal Model for Retinal Damage Induced by Pulsed Lasers.** J.R.HAYES, M.L.WOLBARSHT.
AGARD Conference Proceedings CP 25, 19 pp., 18 refs., 1967.
At present thermal effects which are mediated by the pigment granules appear to be the primary and possibly the only cause of threshold retinal burns. The experimental techniques used to demonstrate nonlinear, non-thermal effects are readily adaptable to experiments on the retina. Very short pulses (10^{-12} sec) are now available from made locked lasers. Possible future experiments with these shorter pulses (and higher peak powers) will show a significant contribution by some non-linear process.

CP25/29 **Mechanisms of Injury from Vibration.** D.J.SASS, J.R.HAYES, D.E.GOLDMAN.
AGARD Conference Proceedings CP 25, 10 pp., 6 refs., 1967.
Studies were made on anesthetized cats immersed in a transparent water-filled tank and vibrated erect along the longitudinal body axis. Autopsy findings showed similarities to blast injury. Mediastinal emphysema and air embolism were found in cats vibrated erect at relatively low levels of acceleration. At higher levels, mediastinal air dissected downward to inflate the peritoneal cavity and retroperitoneal spaces. The presence of intra-abdominal air was associated with rupture of the liver and tearing of both the portal vein and the inferior vena cava.

CP25/30 **Ballistocardiographic Determination of Stroke Volume and Cardiac Performance.** H.W.KIRCHHOFF.
AGARD Conference Proceedings CP 25, 6 pp., 1967.
One of the main concerns of the German Institute of Aviation Medicine is the early assessment of factors which endanger the fitness of Air Force personnel. To this end, methods have been developed for early and precise diagnosis, and in particular, a series of examination procedures have been developed for cardiovascular and pulmonary function which are believed to be satisfactory in this respect The ballistocardiographic examinations, which can be quickly carried out and which determine the stroke volume and performance of the human heart are described and demonstrated by a few examples to indicate the satisfactory results achieved by the method.

CP26 **Aircraft Instrument and Cockpit Lighting by Red or White Light.**
AD-672-072 AGARD Conference Proceedings CP 26, 292 pp., many refs., 1967.
N68 29237 Records the papers and discussion at a symposium sponsored by the AGARD Aerospace Medical Panel and held in Rhode-Saint-Genese, Belgium, 30-31 Oct. 1967. This Symposium discussed the various types of instrument and cockpit lighting which could be compatible with the various operational roles, some needing much night vision, others needing little or none As a result of discussions by experts and operational users, the following points arose. At low levels of illumination, laboratory studies demonstrate only a slight improvement of night vision with red lit instruments as compared with

white lit instruments. The difference is so small that, even in the few roles needing night vision, it is outweighed by the advantages of low intensity white lit instruments: legibility, simplicity, and lack of accommodative fatigue. The cockpit floodlighting, which should have a variable control, should furthermore be capable of being easily changed from white to red for those pilots needing more night vision. For all conditions, a narrow pencil of white light of variable intensity should be provided for map reading, so as to preserve dark adaption to the peripheral parts of the visual field. 18 papers were presented and these are treated individually in the following abstracts.

CP26/1 **Cockpit Lighting Requirements in the RAF.** A.M.McVITIE.
AGARD Conference Proceedings CP 26, Reference 1, pp.1-1 to 1-6, 1967.
Discusses the problems associated with cockpit lighting from the pilots point of view. To do this the worst case is selected, that of low level night flying when dependent upon external cues. The current types of lighting are briefly reviewed and their attendant problems outlined.

CP26/2 **Visual Functions as Determining Factors for Quality and Amount of Effective Panel and Cockpit Lighting.** D.KURSCHNER.
AGARD Conference Proceedings CP 26, Reference 2, pp.2-1 to 2-4, 8 refs., 1967.
From a series of general physiological requirements as to quality and amount of cockpit lighting, visual acuity, accommodation, adaption, colour sense and visual field are taken as determining factors and conclusions drawn accordingly. It is concluded that wavelengths in the red part of the spectrum, including orange-yellow should be given preference. The intensity should however not exceed 0.02 lux.

CP26/3 **Legibility of Various Sized Letters under Aviation Red "Lunar" White and Neutrally Filtered Incandescent White Lighting Systems.** G.P.INTANO.
AGARD Conference Proceedings CP 26, Reference 3, pp.3-1 to 3-17, 12 refs., 1967.
The three types of cockpit lighting were used to illuminate a simulated instrument panel at seven brightness levels and rated voltage and legibility was measured. The results show increases of performance over previous tests and Aviation red was significantly better than either of the "white" systems which were approximately the same.

CP26/4 **An Examination of Carrier Flight Deck and Hangar Deck Lighting Systems.** R.A.BOSEE.
AGARD Conference Proceedings CP 26, Reference 4, pp.4-1 to 4-10, 1967.
Operational experience with U.S. Aircraft Carriers is described. There has been almost continuous change since World War II through red floodlighting to white The present white floodlighting is discussed in detail and is said to have met with almost universal pilot acceptance. However the implications of this acceptance do not resolve the problem of red and white cockpit lighting on which pilot preference is equally divided.

CP26/5 **Color Discrimination and Chart Reading under Red and Low-Intensity White Light.** G.T.CHISUM.
AGARD Conference Proceedings CP 26, Reference 5, pp.5-1 to 5-16, 1 ref., 1967.
Data are presented on the accuracy of color discrimination required in reading topographical charts and the identification of map features under red and low intensity white light. The accuracy of color discrimination is significantly greater under white light as compared with red light. The results in the identification of chart features are more equivocal as factors in addition to colour apparently influence the accuracy of map reading

CP26/6 **Effect on Vision of Different Methods of Panel Illumination.** (In French). A.MERCIER, G.PERDRIEL.
AGARD Conference Proceedings CP 26, Reference 6, pp.6-1 to 6-3, 1967.
To assess the visual acuity of pilots, studies were undertaken to verify the adaption curve and variations in adaption speed after subjection to dazzling flashes of red, white, and ultraviolet light. The results indicate: (1) The illumination of the instrument panel by a white, red, or ultraviolet light does not affect the pilot who is able to adapt his vision immediately to nocturnal conditions. However, the ultraviolet illumination gives the best adaptometric results. (2) After an artificial flash of white light, pilots quickly regain the ability to read the instrument panel. The red lighting appears to be less effective.

CP26/7 **Merits of Red or White Lighting for Naval Use.** S.M.LURIA, J.A.S.ITINNEY.
AGARD Conference Proceedings CP 26, Reference 7, pp.7-1 to 7-18, 8 refs., 1967.
Compares the effect of red and white light on the subsequent development of dark adaption and its disruption. It also discusses the relative usefulness of red light for ship concealment. Red light results in faster dark adaption and less disruption of completed dark adaption than white light of the same brightness but the saving in time is less than 5 minutes. Exploratory calculations suggest that blue rather than red light may in certain circumstances offer better ship concealments.

CP26/8 **Assessment of Red and White Illumination for Equal Legibility.** A.B.CHALONER.
AGARD Conference Proceedings CP 26, Reference 8, pp.8-1 to 8-13, 2 refs., 1967.
This study was undertaken to determine the amount of light needed to resolve test objects illuminated by red and white light. For the range of visual acuity investigated (0.1 to 0.4) it was found that approximately equal amounts of red and white light were required for resolution.

CP26/9 **The Effect of Red and White Instrument Lighting on the Dark Adaption Index.** T.C.D.WHITESIDE, A.MERCIER.
AGARD Conference Proceedings CP 26, Reference 9, pp.9-1 to 9-7, 2 refs. 1967.
A study has been made to determine whether there is any marked difference in the level of dark adaption when a pilot views an instrument panel by red or low temperature white light giving equal legibility. It is concluded that the use of red light has marginal advantages in reducing the time for adaption by approx 4 min.

CP26/10 **The Effect of Night Cockpit Luminance, Red and White, on Central and Peripheral Visual Performance.** B.KISLIN, R.H.DOHRN.
AGARD Conference Proceedings CP 26, Reference 10, pp.10-1 to 10-15, 7 refs., 1967.
Eighteen subjects were light adapted for 20 min. to an approximated cockpit luminance of 0.1 fort Lamberts red light and 0.1 fL incandescent white light. Thresholds for peripheral perception and central identification were taken. Statistically there appears to some advantage in peripheral retinal sensitivity after exposure to the red light but the foveal recognition threshold appears to be the same

CP26/11 **Luminance Measurements for Red and White-Lighted Aircraft Instruments.** R.H.DOHRN.
AGARD Conference Proceedings CP 26, Reference 11, pp.11-1 to 11-19, 4 refs., 1967.
A spectra brightness spot meter, Model U.B. 1/2 was used to measure the luminance level of flight instruments during sight flight. Measurements were taken in red and white-lighted cockpits of U.S. Airforce high-performance and cargo aircraft. Recordings were made of pilots adjustments for maximum, minimum and optimum instrument luminance levels used during night flights. These were approx 0.05-0.03, 0.0001-0.01 to 0.01-0.03 ft.L. respectively. Since a singie unnecessarily bright light may have the same detrimental effect as an entire instrument panel on the pilots' level of dark adaption it is important that the luminance of individual instruments be balanced and evenly distributed.

CP26/12 **The Effect of Red Versus White Lighting on Dark Adaption using a Simulated Instrument Panel for Preadaption.** W.F.GRETHER, H.N.REYNOLDS.
AGARD Conference Proceedings CP 26, Reference 12, pp.12-1 to 12-11, 2 refs., 1967.
This paper reports experiments in which a simulated instrument panel was used for preadaption, and luminance values corresponded to those used by pilots in aircraft. A comparison was made of red, white and blue-filtered white instrument lighting at several luminance levels. Dark adaption thresholds were measured as quickly as possible after subjects scanned the panel. The results show a relatively small superiority of red over white instrument lighting. An additional finding was that when adjusted for equal luminance, the red lighting gives somewhat better instrument legibility.

CP26/13 **Problems of the Illumination of Cockpits.** (in French). L.D.HEYNEMANN.
AGARD Conference Proceedings CP 26, Reference 13, pp.13-1 to 13-11, 1967.
In examining the problems, consideration is given to the choice of colour or colours, the mode of producing the illumination, the required level of luminance, and the evenness of lighting for each instrument, and for the interior of an instrument or a panel. For good legibility, design, dimension, and lighting, three inseparable parameters are considered. The use of electroluminescence is foreseen for lighting the instrument panels in the cockpits and for interior lighting of the instruments.

CP26/14 **Human Factor Aspects in Aircraft Interior Lighting.** J.LAZO.
AGARD Conference Proceedings CP 26, Reference 14, pp.14-1 to 14-12, 19 refs., 1967.
The development of current red and white lighting systems for U.S. Naval aircraft is presented. A systematic investigation is proposed.

CP26/15 **White Lighting of Instruments in USAF Aircraft.** C.J.JOLLEY, J.M.PLANET.
AGARD Conference Proceedings CP 26, Reference 15, pp.15-1 to 15-14, 1967.
Aircraft instrument lighting history is traced from 1917 to the present and is followed by predictions of future methods. Electroluminescent lamps are discussed together with such effects as cover glass reflections and anti-reflection coatings.

CP26/16 **Operational Evaluation of Filtered and Unfiltered White Aircraft Instrument Lighting.** C.J.MUICK.
AGARD Conference Proceedings CP 26, Reference 16, pp.16-1 to 16-10, 1967.
Describes a study on a T-38 trainer to determine the desirability of filtered white instrument lighting. Manufacturers supplied modified unfiltered instruments and the US Air Force supplied filtered white instruments. Nineteen pilots flew both filtered and unfiltered panels during scheduled night missions and the preference was significantly in favour of the filtered light system.

CP26/17 **Red Light for Cockpit Lighting – Results of an Inquiry and of some Investigations.** A.SCANO, C.TERRANA.
AGARD Conference Proceedings CP 26, Reference 17, pp.17-1 to 17-9, 11 refs., 1967.
An inquiry made among pilots of the Italian Air Force is described to find, on the basis of personal preference, the most suitable cockpit and flight instrument lighting for night flight. Indirect illumination by ultra-violet rays and red light were almost equally favoured but the vast majority voted for the combination of the two systems and/or adjustable white light. The results of questionnaires are listed and some tests are reported on pilots to determine the effect of red glasses on night adaptions

CP26/18 **Admissible White Preadaption Levels compared with Red Preadaption.** H.J.LEEBEEK.
AGARD Conference Proceedings CP 26, Reference 18, pp.18-1 to 18-9, 1967.
In the work described by the National Defence Research Organisation of the Netherlands general rules were found for the relations between recovery time after light exposure and the illumination levels and exposure times. The range of levels was 1-1000 lux and of time 1-30 minutes. Recommended levels can be read from the graphs both for red and white lighting.

CP27 **Integration of Propulsion Systems in Airframes.**
AD-672-073 AGARD Conference Proceedings CP 27, 235 pp., many refs., 1967.
N68-28850 Records the papers and the discussion on them at the 31st Meeting of the AGARD Flight Mechanics Panel, held in Gottingen, Germany, 13-15 September 1967. The meeting was devoted to problems of engine-airframe integration for both conventional and VTOL aircraft. The first five deal with integration effects of engine thrust, propulsive jet, engine control, nacelle interference and intake design of conventional aircraft. The remaining four discuss two important integration problems of VTOL aircraft: optimal lateral control, as a part of the overall design of VTOL control systems, and hot-gas ingestion. Results of simulator studies, wind-tunnel tests and flight-test programs are given. The nine papers are dealt with individually in the following abstracts.

CP27/1 **The Influence of Flight Speed on the Thrust Calibration of a Jet Engine.** J.P.K.VLEGHERT.
AGARD Conference Proceedings CP 27, Reference 1, pp.1-1 to 1-15, 4 refs., 1967.
Engine gross thrust is generally obtained from the pressures over the jet nozzle and its flow area, using a calibration factor derived from test bed comparison of weighed and calculated (Pearson) thrust, which is extrapolated for flight conditions. Flight test results show that the static pressure measured in the jet plane is considerable above the value expected from one-dimensional flow and is influenced by flight speed, especially at low nozzle pressure ratio. A method of correction is presented.

CP27/2 **Jet Influence on V/STOL-Aircraft in the Transitional and High Speed Flight Regime.** G.KRENZ, J.BARCHE.
AGARD Conference Proceedings CP 27, Reference 2, pp.2-1 to 2-25, 10 refs., 1967.
The paper summarizes some results of wind tunnel tests for a fighter type aircraft designed for a range of speeds from zero to supersonic. Special attention has been paid to the change of aerodynamic forces and moments during transition and in STOL with ground interference. Tests of up to transonic speeds are discussed. Finally a possible theoretical approach to jet influence on wings by means of a simple jet model is briefly discussed.

CP27/3 **Some Studies into Improvements in Automatic Throttle Control.** N.H.HUGHES.
AGARD Conference Proceedings CP 27, Reference 3, pp.3-1 to 3-14, 1967.
The characteristics of automatic throttle control systems are described with particular reference to speed holding, height holding, on the glidepath and throttle activity. The deficiencies of existing systems are examined and a modified form of control is presented which shows promise of avoiding most of these deficiences.

CP27/4 **Engine Airframe Integration Problems Peculiar to Aircraft Configurations with Nacelles Mounted above the Wing.** G.LOBERT, J.THOMAS.
AGARD Conference Proceedings CP 27, Reference 4, pp.4-1 to 4-23, 1967.
Discusses the advantages and disadvantages of the various possible locations of nacelles in relation to the wing. It is shown that advantages exist for nacelle location above the wing and the aerodynamic characteristics are discussed in the light of extensive wind tunnel tests.

CP27/5 **Aircraft and Propulsion Operational Considerations Related to Inlet Design.** F.T.RALL.
AGARD Conference Proceedings CP 27, Reference 5, pp.5-1 to 5-18, 1967.
Tests are described of an inlet mounted on the side of a fuselage and under a wing. The effects of inlet location and fuselage geometry are related to inlet pressure recovery, distortion and turbulence. The fuselage boundary layer was found to be of particular importance. Full scale engine tests are described on the effect of inlet turbulence on a turbojet. Wind tunnel tests of an underwing inlet show the effect of inlet unstart on the stability and control characteristics of a supersonic aircraft

CP27/6 **A Discussion of the Use of Thrust for Control of VTOL Aircraft.** S.B.ANDERSON.
AGARD Conference Proceedings CP 27, Reference 6, pp 6-1 to 6-17, 3 refs., 1967.
The use of engine thrust to control VTOL aircraft when hovering has been examined by simulator tests and the X-14A variability stability and control aircraft. The discussion includes consideration of the use of thrust vectoring and thrust modulation.

CP27/7 **Reaction Control System Preliminary Considerations for a Jet-Lift Research Aircraft.** D.L.HIRSH, W.W.STARK, W.B.MORRIS.
AGARD Conference Proceedings CP 27, Reference 7, pp.7-1 to 7-21, 9 refs., 1967.
Presents the results of a design study sponsored by NASA on a jet-lift aircraft reaction control system. The aircraft has a side by side arrangement of lift engines and two horizontal lift/cruise engines. Reaction control is provided by engine compressor bleed air. An engine compressor bleed rate variable up to 10 per cent was considered adequate. A system employing swivelling and differential discharge nozzles offered the most satisfactory design solution.

CP27/8 **Hot Gas Injection and Jet Interference Effects for Jet V/STOL Aircraft.** A.D.HAMMOND, H.C.McLEMORE.
AGARD Conference Proceedings CP 27, Reference 8, pp.8-1 to 8-27, 11 refs., 1967.
Reports tests in the NASA Langley full scale tunnel and the Langley 7 x 10 ft tunnels to investigate three problems unique to jet powered VTOL aircraft. These are. hot gas ingestion, aerodynamic suck-down, and jet interference in transition flight. Results are discussed and as some requirements are conflicting it is recommended that both aerodynamic interference effects and hot gas reingestion tests be made on identical configurations.

CP27/9 **Interaction between Airframe-Powerplant Integration and Hot Gas Ingestion for Jet-Lift V/STOL Transport Aircraft.** U.GITTNER, F.HOFFERT, M.LOTZ.
AGARD Conference Proceedings CP 27, Reference 9, pp.9-1 to 9-26, 3 refs., 1967.
Describes model tests confirmed by full scale tests, on the experimental V/STOL aircraft Do31 on hot gas reingestion. Model tests for a proposed operational jet lift transport have shown high temperature rises at the propulsion engine intakes. However unfavourable results can be overcome by fairly small changes of the engine positioning. It is therefore concluded that designs should not be fully integrated so that configuration modifications may be made without major structural changes, even at a late stage of development.

CP28 **Advanced Navigational Techniques.** Editor W.T.BLACKBAND.
AD-702-714 AGARD Conference Proceedings CP 28, 344 pp., many refs., 1970.
N70-24859 This volume contains the proceedings of the fourteenth symposium of the Avionics Panel held in Milan in September 1967. The 26 Chapters and discussions state the requirements for geodetic survey and navigation and supply information on the equipment, both existing and projected to meet the requirements. The 26 papers are treated separately in the following abstracts.

CP28/1 **Navigation Needs and Problems of Hydrographic and Oceanographic Vessels.** T.J.HICKLEY.
AGARD Conference Proceedings CP 28, Chapter 1, pp.3-9, 1 ref., 1970.
The navigation accuracy required by survey and oceanographic vessels is discussed in terms of "time-dependent" and "time-independent" variables. The first include water temperature, wind and wave characteristics, ocean currents and distribution of marine life. They vary so much with time that the accuracy of location of any single observation becomes less important as the rate of variation increases. At the present position accuracy within two nautical miles is satisfactory although higher accuracy is required for fine structure studies. For "time-independent" variable such as bottom topography a much higher accuracy is required and present systems largely fail. The paper sets down the characteristics of positioning systems required for open ocean and near-shore surveys.

CP28/2 **An International Airline Views Navigation Satellites.** B.F.McLEOD.
AGARD Conference Proceedings CP 28, Chapter 2, pp.11-15, 1970.
Within the next five to ten years, traffic increases and introduction of new aircraft types will demand an improved air traffic control system in areas such as the heavily travelled North Atlantic. Satellite navigation tests are planned and it is pointed out that major decisions are required now in order to avoid excessive delays in implementation.

CP28/3 **A View of Airline Requirements for Aids to long-Distance Navigation.** S.G.PORITZKY.
AGARD Conference Proceedings CP 28, Chapter 3, pp.17-22, 1 ref., 1970
The paper discusses the aids which may be required to supplement the self-contained navigational systems, particularly inertial. It is stated that such systems appear to meet present and possibly future requirements If they do not a separate system might be necessary but this is doubtful A brighter prospect immediately, is the use of satellites to improve communications with a possible later prospect of "space radar" surveillance for traffic control and blunder-detection.

CP28/4 **The Future Development of Long Range Navigation at Sea.** H.C.FREIESLEBEN.
AGARD Conference Proceedings CP 28, Chapter 4, pp.23-30, 30 refs., 1970.
After reviewing present systems it is suggested that in addition to radio systems, Omega in particular, navigation by satellites has most promise for the future. Naval and research ships will be satisfied by the passive Navy Satellite system while in merchant shipping an active system including communications will be preferred.

CP28/5 **The Supersonic Transport Navigation System.** A.F.NORWOOD, D.MANIS.
AGARD Conference Proceedings CP 28, Chapter 5, pp.31-46, 1970.
Describes the design process for the primary long-range navigation system for the U.S. Supersonic Transport. After an examination of requirements and of available systems an inertial navigation system was chosen. The design of this is discussed.

CP28/6 **The Omega System of Navigation.** C.C.STOUT.
AGARD Conference Proceedings CP 28, Chapter 6, pp.47-61, 27 refs., 1970.
The Omega Navigation System and its uses are described. Research and development of the System is almost complete. Operational experience has been obtained since 1966 and charts and other software have been prepared and tested.

CP28/7 **The Relay of Omega Navigation Signals by Satellite to a Central Processing Facility.** C.R.LAUGHLIN.
AGARD Conference Proceedings CP 28, Chapter 7, pp.62-76, 8 refs., 1970.
The N.A.S.A. is developing a system known as "Omega Position Location Equipment" (O.P.L.E.) to commence with the launch of the Application Technology Sateilite in mid-November 1967. The OMEGA signals, received at remote locations are relayed through the satellite to a central processing centre and the position of the remote receivers automatically determined by computer. While designed for balloon-borne meteorological systems, other potential applications include oceanographic exploration, marine and air traffic control and space vehicle recovery.

CP28/8 **On the Signal Format for the OMEGA System.** C.POWELL.
AGARD Conference Proceedings CP 28, Chapter 8, pp.77-85, 1 ref., 1970.
The present OMEGA signal format for 8 stations is discussed and an equi-period format and the use of side frequencies for hyperbolic patterns . suggested. A simple integrating receiver is then described.

CP28/9 **The Extension of the Long Range Aircraft Navigation System to the Short Range Role.** F.S.STRINGER.
AGARD Conference Proceedings CP 28, Chapter 9, pp.87-90.
Discusses the possibility of using long range navigation systems which could also be designed to meet short range requirements. Trials with OMEGA have been started and in discussion it is stated that results are encouraging.

CP28/10 **TELEVOR – A New Principle for Producing Radial Radio Coordinates in the Low and High Frequency Bands.** A.PRICHODJKO, A.SIMIANER.
AGARD Conference Proceedings CP 28, Chapter 10, pp.91-104, 1970.
The problems of producing radial radio coordinates at low radio frequencies are considered. It is shown that a J-ring antenna system can be fed so as to meet the requirements of a navigational system. The radiated field is very little affected by propagation conditions and as a result beaming errors at long range are likely to be small.

CP28/11 **Measurement of Trajectory by High Stability Clocks.** (in French). R.MOREAU.
AGARD Conference Proceedings CP 28, Chapter 11, pp.105-115, 2 refs., 1970.
Describes work by O.N.E.R.A. on the measurement of missile trajectories by means of an atomic clock. The characteristics of a rubidium vapour clock are discussed and it is suggested that its use would give considerable simplification in position finding.

CP28/12 **Ocean Platforms for Civil Aircraft Operations over the North Atlantic.** L.J.BRAYBROOK.
AGARD Conference Proceedings CP 28, Chapter 12, pp.117-127, 3 refs., 1970.
Suggests the use of stable moored ocean platforms to provide a reliable V.H.F. Communications Service and secondary surveiliance radar facilities to civil aircraft on the main routes across the North Atlantic. Three to four manned platforms are proposed with submarine cable links to the control centres. The possibility of the alternative of satellite communications is also discussed.

CP28/13 **The Doppler V.O.R. – Its Foundation and Results.** E.L.KRAMAR.
AGARD Conference Proceedings CP 28, Chapter 13, pp.128-142, 11 refs., 1970.
Work on Doppler V.O.R. was started some years ago and the paper discusses the advantages and presents results which substantiate the claims to considerable improvement of the accuracy of

course indication even during flights over very unfavourable country. Tests also show a considerable reduction in the present severe conditions for siting V.O.R. stations.

CP28/14 **A World-Wide Lunar Radar Time Synchronization System.** W.S.BAUMGARTNER, M.F.EASTERLING.
AGARD Conference Proceedings CP 28, Chapter 14, pp.143-162, 2 refs., 1970.
A system is described which is capable of synchronising clocks at remote locations with a master clock within a few microseconds by means of radar reflections from the moon. The system was devised to meet the needs of the N.A.S.A./J.P.L. Deep Space Network and results of tests indicate that the required accuracy can be obtained.

CP28/15 **A Method for Precision Measurement of Synchronization Errors in Tracking-Station Clocks.**
W.MARTIN, F.BORNCAMP, E.BRUMMER.
AGARD Conference Proceedings CP 28, Chapter 15, pp.163-183, 13 refs., 1970.
Early in the U.S. Lunar Orbiter program it was realised that the selenodetic objectives could not be improved unless the clock synchronization could be improved from ±5 milliseconds to ±10 microseconds. The paper discusses the problem and presents a solution, the Deep Space Network's Mark I ranging system which has provided an increase in accuracy of approximately 1,000 times.

CP28/16 **The United States Navy Navigation Satellite System.** R.B.KERSHNER.
AGARD Conference Proceedings CP 28, Chapter 16, pp.184-194, 1970.
This paper describes the operational experience and the problems encountered in the development of the satellite design since the first publication of plans in 1960 for the Navy Navigation Satellite System. The connection between system accuracy and geodesy is stressed and the level of accuracy now achieved is given. Finally possible future advances are discussed.

CP28/17 **An Aeronautical Satellite System Covering the North Atlantic Area.** H.G.LEYSIEFFER.
AGARD Conference Proceedings CP 28, Chapter 17, pp.195-203, 2 refs., 1970.
Increasing speeds and ever growing traffic density call for more accurate position monitoring methods for the air traffic area of the North Atlantic. To increase the reliability of such a method two independent radio location systems are proposed which allow the simultaneous position display of up to 300 aircraft and the silent control of the entire air situation. The first method is a 300 channel system by which position data from airborne equipment is transmitted via a satellite to a ground station. The second method determines the positions in succession from the ground by the propagation difference in time of signals transmitted via two satellites to the aircraft and via a transponder back to the ground.

CP28/18 **The S.P.O.T. Navigation Satellite System.** J.BRECKMAN, J.D.BARNLA.
AGARD Conference Proceedings CP 28, Chapter 18, pp.204-219, 1970.
Describes the S.P.O.T., a global all weather navigation system which gives near-instantaneous fixes or continuous tracks where desired. This phase navigation system can provide height, velocity and automatic guidance and control signals as well as position. It is stated that all of the art needed to implement S.P.O.T. exists now.

CP28/19 **Preliminary Investigation of Navigation Satellite Techniques for Achieving Accuracies in Position of the Order of Ten Metres.** E.S.KEATS.
AGARD Conference Proceedings CP 28, Chapter 19, pp.221-229, 1970.
A navigation satellite system with 10 metre accuracy is described in which satellites in 24-hour orbit employ passive interferometric or hyperbolic techniques.

CP28/20 **Independent Surveillance and Communication Using Satellites.** R.E.ANDERSON.
AGARD Conference Proceedings CP 28, Chapter 20, pp.231-255, 1970.
A suggested system uses satellites and cooperating ground stations to provide independent surveillance of the positions of aircraft and ships, and also undelayed voice and digital communications. The system employs a low energy speech transmission technique (L.E.S.T.). Position fixes are made by pulse train ranging from pairs of satellites. It is said that the techniques are proved and that a system could be operational before 1970.

CP28/21 **Hyperbolic Position Finding with Synchronous Satellites.** G.W.CASSERLY, E.D.McCONKEY.
AGARD Conference Proceedings CP 28, Chapter 21, pp.256-260, 1970.
It is suggested that present position finding equipment used in hyperbolic systems might be made to operate from higher frequency satellite signals by using a frequency conversion unit. This chapter presents the characteristics of several hyperbolic configurations in which one or more of the stations are on stationary satellites. Sources of error are discussed.

CP28/22 **A Unified Approach to the Error Analysis of Position Finding.** G.W.CASSERLY, E.D.McCONKEY.
AGARD Conference Proceedings CP 28, Chapter 22, pp.261-269, 2 refs., 1970.
It is shown that a large class of position finding configurations can be error-analyzed by the use of a single analytical model. A specific example is presented and equations are presented to indicate how individual measurement functions may be applied to the model. It is stated that the three dimensional matrix operations are best carried out on a digital computer.

CP28/23 **Error Sensitivity Associated with Orbital Hyperbolic-Navigation Schemes and a Suggested Approach for Improvement.** J.H.HUTCHINSON.
AGARD Conference Proceedings CP 28, Chapter 23, pp.271-289, 10 refs., 1970.
This chapter deals with the fundamental mathematical relationship applicable to satellite-linked hyperbolic systems. Error expressions are developed and the resultant second-order equations are solved by computer by iteration. It is recommended that further study be directed to multisatellite, multielement fix-determination processing using range-rate Doppler.

CP28/24 **Geodetic SE.CO.R.** J.E.HOWELL.
AGARD Conference Proceedings CP 28, Chapter 24, pp.291-303, 2 refs., 1970.
SE.CO.R. (SEquential COllation of Range) sponsored by the U.S. Army and developed by Cubic Corporation is described with operational experience since early 1964. Extensive tests have shown accuracy of satellite determination within 3 metres.

CP28/25 **N.A.S.A. Geodetic Satellite Program Contributions to Long Range Navigation.** R.D.BROWN, R.L.TAYLOR.
AGARD Conference Proceedings CP 28, Chapter 25, pp.304-317, 16 refs., 1970.
Presents the scope and objectives of the N.A.S.A. Geodetic and describes the satellites and tracking systems. A primary contribution to the problem of long range navigation is stated to be the more accurate positioning of new and existing navigation and tracking stations such as LORAN and STADAN relative to one another and to the earth's centre of mass.

CP28/26 **The French Geodetic Satellites DIADEME I and II, a Contribution to Navigation by Satellite.** (In French). J.C.HUSSON, A.BANCHEREAU.
AGARD Conference Proceedings CP 28, Chapter 26, pp.318-337, 5 refs., 1970.
The second and third satellites launched by France (DIADEME I and II) are described together with the preliminary results of observations.

CP29 **Advanced Techniques for Aerospace Surveillance.** Edited by W.T.BLACKBAND.
AD-673-887 AGARD Conference Proceedings CP 29, 404 pp., many refs., 1968.
N68-33392 This paper records the papers and discussions at the thirteenth Symposium of the Avionics Panel of AGARD held in Milan, Italy, 4-7 September 1967. It deals with the techniques for surveillance by photography or television in the ultra-violet, visible or infra-red portions of the spectrum, by millimetric sideways looking radar or by infra-red or millimetric radiometry. Five papers discuss the physical principles, five discuss passive infra-red and microwave sensing and others discuss active systems. A survey is given of recent developments in the techniques of recording and display. Three papers analyse image structure and the related problems of interpretation. Of the 23 papers 6 are in French. The individual papers are dealt with in the following abstracts.

CP29/1 **Measurement of Visible Luminance on Rustic Terrain.** (in French). J.P.LOISEL.
AGARD Conference Proceedings CP 29, Paper 1, 11 pp., 1968.
To assess the physical factors affecting surveillance, airborne photographic and photometric measurements were made of atmospheric transmission and luminance interference. Vertical observations of both level and natural terrain were made at altitudes of 15,000 and 30,000 metres.

CP29/2 **Effects of Atmospheric Turbulence on the Polarisation of a Laser Beam at 6328Å.** D.H.HÖHN.
AGARD Conference Proceedings CP 29, Paper 2, 12 pp., 9 refs., 1968.
The turbulence-induced depolarisation of a linearly polarised laser beam was investigated experimentally mainly with an optical path of 4.5 km. A He-Ne gas laser at 6328Å was used with an additional polariser at the output and with a rotating polarisation assembly in front of the receiver. The results were compared and agreed with the theoretical work of Hodara. The depolarisation was so small that the polarisation of the laser without polariser was not degraded up to path lengths of 30 km.

CP29/3 **Control of Lenses by Measurement of Their Modulation Factor and Comparison with a Theoretical Study.** (in French). J.POULEAU.
AGARD Conference Proceedings CP 29, Paper 3, 14 pp., 1968.
A method of determining the modulation transfer function is described for use in the quality control of photographic lenses. It can also be used to describe numerically the quality of the lens system.

CP29/4 **Passive Microwave Sensing of the Atmosphere and Earth Surface Environments.** C.V.FALCO, W.J.JOHNSON.
AGARD Conference Proceedings CP 29, Paper 4, 19 pp., 31 refs., 1968.
The purpose of this paper is to examine the potential utility of microwave radiometry for satellite surveillance of the atmosphere and earth environments. The basic principles and possible applications such as cloud structure, sea state and ground temperature are discussed.

CP29/5 **Spectral Characteristics of Ground Objects and Backgrounds with Reference to Ground Surveillance.** B.K.WERNICKE.
AGARD Conference Proceedings CP 29, Paper 5, 19 pp., 5 refs., 1968.
Deals with some of the characteristics of ground objects and their possible backgrounds which can be measured from airborne platforms. The discussion is limited to the "optical zone" of the magnetic spectrum and is pointed out that the applications are manifold, from peacetime uses such as aerial surveys to a variety of military uses.

CP29/6 **Fundamental Aspects of the Observation of the Earth's Surface by Infra-Red Passive Television from a Satellite.** (in French). F.DESVIGNES.
AGARD Conference Proceedings CP 29, Paper 6, 32 pp., 9 refs., 1968.
It is stated that day and night observation of the Earth's surface requires the use of infra-red passive cameras able to detect radiation temperature differences of 1°C in the range -20 to +40°C with a ground resolution of a few tens of metres. The paper deals with the fundamental requirements, surveys the emissive properties of earth objects and discusses the problems. Finally problems yet to be solved are listed.

CP29/7 **Ground Mapping by an Airborne Hertzian Radiometer.** (in French). B.RICHARD, J.P.PELTIER.
AGARD Conference Proceedings CP 29, Paper 7, 15 pp., 3 refs., 1968.
The effect of atmospheric attenuation at different wavelengths is discussed. A radiometer is described which works at a wavelength of 8 mm, resolution in 1 degree and the observed field ±25 degrees. This was installed in a B26 aircraft and the initial records are described and compared with other optical and infra-red maps.

CP29/8 **Some Results of Passive Microwave Groundmapping.** F.SCHLUDE.
AGARD Conference Proceedings CP 29, Paper 8, 16 pp., 3 refs., 1968.
A 35GHz radiometer has been used for mapping areas with characteristic water-land contrasts of line-scanning the antenna and flying a parallel strip flight programme. As a result of the flight experiments four thermal maps are shown of different targets.

CP29/9 **Next Generation Digitally Controlled Microwave Surveillance Receiver Systems.** R.H.RECTOR, A.D.MAREZ.
AGARD Conference Proceedings CP 29, Paper 6, 16 pp., 1968.
A next generation microwave digitally tuned scanning superheterodyne receiver is described which is stated to be fully developed to replace all military surveillance systems. The receiver has been developed around a Yttrium Iron Garnet (Y.I.G.) used as a wideband, high selectivity pre-selector and local oscillator tracking filter.

CP29/10 **A Continuously Calibrated Microwave Radiometer.** J.P.HACH.
AGARD Conference Proceedings CP 29, Paper 10, 19 pp., 4 refs., 1968.
The radiometer described in this paper, in contrast to the Dicke technique, uses a second reference temperature to eliminate the effect of receiver noise temperature fluctuations and receiver gain fluctuations. The reference is a series connection of a gas discharge noise tube and a sensitive attenuator. The receiver input is periodically switched between the reference temperatures and the modulated signal input processed by two synchronous detectors to make the constant of proportionality independent of time and environmental conditions. In most cases the minimum detectable signal is approximately the same as a Dicke radiometer.

CP29/11 **Receiving and Recording the Wide Dynamic Range of Signals of a Side-Looking Radar System.** E.M.ARNOLD.
AGARD Conference Proceedings CP 29, Paper 11, 10 pp., 1968.
This paper describes a mechanization technique for recording the wide dynamic range of received signals of a side-looking radar on photographic film.

CP29/12 **A Tradeoff between Range and Azimuth Performance in Side-Looking Radar.** M.S.WHEELER.
AGARD Conference Proceedings CP 29, Paper 12, 18 pp., 9 refs., 1968.
It is shown that the development of long and narrow antennae to improve azimuth performance and the use of shorter pulse widths to increase range resolution can result in serious degradation in radar performance. It is found that the less the receiver bandwidth the less the transient losses, but, with usual bandwidths the antenna length should be no more than half the pulse length as it travels on the transmission line following the aperture.

CP29/13 **Side-Looking Radar Using a Synthetic Antenna.** (in French). G.REVILLON.
AGARD Conference Proceedings CP 29, Paper 14, 22 pp., 2 refs., 1968.
Methods of using side-looking radar with synthetic antennae are discussed and methods used to improve resolution are described. Technical problems are assessed.

CP29/14 **Low Light Level Aerial Reconnaissance Using Television Techniques.** P.R.GROVES, J.E.ROWNTREE.
AGARD Conference Proceedings CP 29, Paper 14, 18 pp., 1968.
The characteristics and use of the Image Isocon for night reconnaissance are described. An electronic method of compensating for the image movement due to aircraft speed has been developed and the results presented demonstrate the performance of the system down to starlight conditions.

CP29/15 **Advanced Wideband Recording and Readout Techniques.** A.A.JAMBERDINO.
AGARD Conference Proceedings CP 29, Paper 15, 21 pp., 1968.
The report discusses the magnetic recording of data from electronic equipment and concludes that it is unlikely to be able to deal with present demands for higher storage densities and wider bandwidths. Electron and laser beam techniques are described in conjunction with thermoplastics, silver halides and photoplastics as recording media. Experimental models have demonstrated an order of magnitude improvement in packing densities over magnetic methods with bandwidths of 10 and 50 MHz.

CP29/16 **Electronography.** L.S.ALLARD, C.J.EMBERSON.
AGARD Conference Proceedings CP 29, Paper 16, 11 pp., 2 refs., 1968.
Electronography is the recording of information by the direct impingement of an electron beam on a recording media. The report discusses the problems in relation to an electron optical gun, points out the difficulties of placing the recording medium in the vacuum chamber and proposes a mica window. Experimental equipment is described which has demonstrated improved resolution over normal C.R.T. trace recording due to the elimination of phosphor noise.

CP29/17 **Recent Developments in Cathode Ray Tube Recorders and Displays.** W.A.WOODLEY.
AGARD Conference Proceedings CP 29, Paper 17, 9 pp., 1968.
Developments are reviewed in both C.R.T. film recording and direct view display fields. Modern high resolution fibre of the C.R.T.s make use of black clad fibre optic faceplates to solve film transport problems. Narrow angle black clad fibre optics are also used to give a high contrast screen for viewing in high ambient light conditions.

CP29/18 **Electroluminescence Display Devices.** W.BERTHOLD.
AGARD Conference Proceedings CP 29, Paper 18, 13 pp., 1968.
A number of electroluminescence devices are described which appear attractive for the display of data. Their application is particularly attractive where small depth, low power consumption and reliability under mechanical vibration is required. Typical applications are described.

CP29/19 **A Laser Display System.** G.G.FULLER.
AGARD Conference Proceedings CP 29, Paper 19, 11 pp., 4 refs., 1968.
A display system is described in which a laser beam is deflected to form a master scan and information impressed by a brightness modulator. The beam can then be used on a rear projection screen or to write information on a photochromic slide. Although designed for the British 405 line television standards the system is capable of modification to random scan for use with computer generated alphanumeric and graphic displays.

CP29/20 **Statistical Analysis of Photographic Images.** (in French). D.ESTOURNET, P.Y.SCHWARTZ.
AGARD Conference Proceedings CP 29, Expose No. 20, 24 pp., 1968.
Statistical data are presented on various methods for assessing photographic analyses. Preliminary results are given on aerial photography and on other photographic techniques. Further refinements are seen as image transmission with compressed data forms of signal analysis, and analysis of fine quasi-periodic signals.

CP29/21 **Interpretation Experience with Satellite Colour Photographs, Side-Looking Radar Pictures, and Infra-Red Scanning Records.** S.A.HEMPENIUS, H.M.MOHR, J.VERMEER.
AGARD Conference Proceedings CP 29, Paper 21, 16 pp., 8 refs., 1968.
This paper records the experience and suggestions of professional photo-interpreters working in the fields of geology, geography, hydrology and soil survey. Some conclusions are that satellite colour pictures of arid regions are of practical use, large scale IR scans will find applications in hydrology, side-looking radar may prove useful for small-scale regional studies and all-weather disaster surveys.

CP29/22 **Discrimination and Identification in Noisy Line-Scan Pictures.** W.A.WAGENAAR, A.MEETEREN.
AGARD Conference Proceedings CP 29, Paper 22, 18 pp., 6 refs., 1968.
The interpretation of line-scan pictures was examined as a function of image degradation. Pictures were produced with a flying-spot scanner and degradation was introduced by varying the line frequency and introducing noise. Eight photo-interpreters were asked to decide what object the various pictures represented. Maximum scores were reached for line frequencies between 3 and 5 lines per mm for each of the noise contents.

CP29/23 **Synthesis of Covert-Radiated High-Resolution T.V. Systems for Night-Time Reconnaissance and Surveillance.** T.B.KENT, P.F.SARGENT.
AGARD Conference Proceedings CP 29, Paper 23, 17 pp., 10 refs., 1968.
Recent developments of high efficiency light sources, improved photoemissive surfaces, wideband amplifiers, image compensation techniques and high resolution image orthicon carrier tubes are discussed in relation to the use of active T.V. in future night airborne reconnaissance missions.

CP30 **Hypersonic Boundary Layers and Flow Fields.**
AD-677-103 AGARD Conference Proceedings CP 30, 568 pp., many refs., 1968.
N69-10186 Records 26 papers presented at the AGARD Fluid Dynamics Panel Meeting on May 1-3, 1968 at the Royal Aeronautical Society in London, where particular attention was given to three-dimensional problems of hypersonic flow. The programme was broken down into three sessions which were boundary layer oriented, with special emphasis on turbulent results: one session on inlets and wave riders, one session on specific problems of bodies at angle of attack, and a special session covering some interesting problems of free flight and wind tunnel simulation which had not been recognised in previous work. A few papers on some special problems of controls, mass injection, and low density effects were included although the schedule did not permit any extensive review in these areas. The individual papers are dealt with in the following abstracts.

CP30/1 **Experiments with Hypersonic Turbulent Boundary Layers on Flat Plates and Delta Wings.** M.B.BERTRAM, A.M.CARY, A.H.WHITEHEAD.
AGARD Conference Proceedings CP 30, Paper 1, pp.1-1 to 1-21, 41 refs., 1968.
Considers recent experiments and proposed prediction methods on the problems of the effect of wall temperature on skin friction and heat transfer, the transformation of the compressible boundary layer to the constant density type, and the heat transfer to delta wings. Ability to predict the heat transfer to delta wings appears to be contingent upon the ability to predict the flow field.

CP30/2 **Experimental Measurements of Cold Wall Turbulent Hypersonic Boundary Layers.** J.H.PERRY, R.A.EAST.
AGARD Conference Proceedings CP 30, Paper 2, pp.2-1 to 2-19, 33 refs., 1968.
Measurements of cold wall turbulent hypersonic boundary layer stagnation pressure and stagnation temperature profiles made on the wall of a conical nozzle in a hypersonic gun tunnel are described. The data was obtained for Mach Number range of 8 to 11.5, a Reynolds Number range of 5×10^6 to 2.7×10^7 and wall to freestream stagnation temperature ratios of 0.26 to 0.36. Comparison with present methods of prediction did not give satisfactory correlation in all respects.

CP30/3 **Theory and Experiment for the Structure of Some Hypersonic Boundary Layers.** E.J.SOFTLEY, R.J.SULLIVAN.
AGARD Conference Proceedings CP 30, Paper 3, pp.3-1 to 3-18, 15 refs., 1968.
Recent tests of hypersonic boundary layer transition on a 5° cone are used to examine the structure of both laminar and turbulent boundary layers on sharp and blunt cones at edge Mach Numbers of 10. The laminar results are compared with a non-similar boundary layer theory calculated by computer. An interesting result for the turbulent layer is that the total temperature is far removed from the Crocco relationship.

CP30/4 **The Interaction of a Turbulent Boundary Layer and a Shock at Hypersonic Mach Numbers.** D.F.MYRING.
AGARD Conference Proceedings CP 30, Paper 4, pp.4-1 to 4-19, 20 refs., 1968.
Equations describing turbulent shock wave boundary layer interaction are described. The basic model used is the conventional one and on integration of the final set of simultaneous equations three solutions are identified. One of these is shown to correspond to shock wave interaction and comparisons with experiment are given.

CP30/5 **Laminar and Turbulent Flow Past Axisymmetric Convex Corners at Hypersonic Mach Numbers.** K.J.TOURYAN, T.J.TYSON.
AGARD Conference Proceedings CP 30, Paper 5, pp.5-1 to 5-16, 17 refs., 1968.
Calculations were made by several aerospace companies to calculate the pressure distribution on several cone-cylinder configurations. These configurations were then tested both in a rocket shed and hypersonic tunnel. The paper discusses the analytic techniques used, compares the results with the experimental ones and analyses the discrepancies. Finally an exact theoretical method is described in some detail.

CP30/6 **Orderly Three-Dimensional Processes in Turbulent Boundary Layers on Ablating Bodies.** T.N.CANNING, M.E.TAUBER, M.E.WILKINS, G.T.CHAPMAN.
AGARD Conference Proceedings CP 30, Paper 6, pp.6-1 to 6-14, 12 refs., 1968.
Contrary to previous assumptions of random behaviour experimental studies reported in the literature have shown a remarkable degree of order in transitional and turbulent boundary layers. This paper describes experiments made with biconic, concave and convex ablating Plexiglass models in a Mach 7 airstream at local Reynolds numbers approaching 10^7. In addition to the well known markings many parts of the models showed a "cross-hatch" pattern in which the spiral angle is close to the Mach angle and the spacing is a few boundary layer thicknesses. A physical flow model is suggested to explain these patterns.

CP30/8 **Reynolds and Mach Number Simulation of Apollo and Gemini Re-Entry and Comparison with Flight.** B.J.GRIFFITH, D.E.BOYLAN.
AGARD Conference Proceedings CP 30, Paper 8, pp.8-1 to 8-21, 12 refs., 1968.
Describes comprehensive tests on the Apollo and Gemini configurations to resolve several anomalies between preflight predictions and flight data. Tests were made at Mach Numbers from 3 to 20 at the Arnold Engineering Development Center (AEDC). The anomalies are explained and wind tunnel data is shown to be in excellent agreement with existing flight data.

CP30/9 **Modular Hypersonic Inlets with Conical Flow.** S.MÖLDER, J.M.ROMESKIE.
AGARD Conference Proceedings CP 30, Paper 9, pp.9-1 to 9-22, 16 refs., 1968.
The paper lists a series of requirements for the design of high performance hypersonic air intakes and presents a method of design. Experimental results are given for an axi-symmetric Busemann and a modular inlet design.

CP30/10 **The Use of Known Flow Fields as an Approach to the Design of High Speed Aircraft.** J.SEDDON, A.SPENCE.
AGARD Conference Proceedings CP 30, Paper 10, pp.10-1 to 10-21, 14 refs., 1968.
The paper gives an account of the beginning and some of the subsequent progress in the flow field approach to design resulting in the design of lifting shapes termed waveriders. It is in the nature of a survey and connected account of progress over the past few years.

CP30/11 **Calculation of the Pressure Distribution on Lifting Conical Wings with Applications to the Off-Design Behaviour of Waveriders.** L.C.SQUIRE.
AGARD Conference Proceedings CP 30, Paper 11, pp.11-1 to 11-21, 11 refs., 1968.
Charts are presented for the calculation of pressure distributions and shock shapes on conical wings with diamond and carei (Nonweiler) cross sections. Comparisons of measured and calculated pressure distributions show good agreement and it is considered that the theory may be used to predict off-design performance of waverider wings.

CP30/12 **Experimental Results from Three Cone-Flow Waveriders.** J.PIKE.
AGARD Conference Proceedings CP 30, Paper 12, pp.12-1 to 12-11, 3 refs., 1968.
Tests are described of three models, two with sharp and one with rounded leading edges. At a Mach Number of 4 the flow can be predicted and is shown to agree closely with experimental results. At other Mach Numbers the flow cannot be predicted but the experimental results show only smooth changes. Leading edge rounding affects pressure only close to the leading edge.

CP30/13 **Experimental Investigations of Waveriders in the Mach Number Range from 8 to 15.** K.KIPKE.
AGARD Conference Proceedings CP 30, Paper 13, pp.13-1 to 13-17, 10 refs., 1968.
Tests have been made on 6 waverider (caret) models in the DFL hypersonic gun tunnel. These include three component force tests, pressure distribution and shock wave angle determination by flow visualisation. It is shown that large viscous interaction effects have considerable influence on pressure distribution and shock wave angle.

CP30/14 **Hypersonic Viscous – Inviscid Interactions by a New Type of Analysis.** S.G.RUBIN, S.RUDMAN, T.C.LIN, M.PIEROCCI.
AGARD Conference Proceedings CP 30, Paper 14, pp.14-1 to 14-16, 14 refs., 1968.
Hypersonic viscous-inviscid interactions are treated by a finite-difference solution of a single set of equations valid throughout the boundary layer and shock wave structure. Cases treated are, axisymmetric flow over sharp cones, two-dimensional channel flow with interior shock wave reaction, and the three-dimensional geometry of a flat plate with sharp leading edge.

CP30/16 **An Investigation of Three-Dimensional Jet Control Interaction on a Conical Body.** V.ZAKKAY, J.ERDOS, W.CALARESE.
AGARD Conference Proceedings CP 30, Paper 16, pp.16-1 to 16-22, 35 refs., 1968.
Tests are described on a finite-span jet issuing normal to the surface of a 7° semi-vertex angle sharp cone at Mach Number 6. The results show that the total normal force coefficient is not degraded by three-dimensional effects. A new theoretical model is proposed to describe the structure of the jet interaction flow field.

CP30/17 **Hypersonic Interactions About a Slender Cone Induced by Radial Mass Injection.** P.G.SIMPKINS.
AGARD Conference Proceedings CP 30, Paper 17, pp.17-1 to 17-14, 24 refs., 1968.
Tests are reported on cones of 5° semi-angle with jets emerging radially from a slot. Film cooling effects are demonstrated.

CP30/18 **Hypersonic Flow in Rectangular and Non-Rectangular Corners.** R.J.CRESCI, S.G.RUBIN, C.T.NARDO.
AGARD Conference Proceedings CP 30, Paper 18, pp.18-1 to 18-16, 14 refs., 1968.
Experiments included the measurement of surface pressures and heat flow rates in the vicinity of corners with various included angles. Results are compared with theory where possible.

CP30/19 **The External Flow Field about Yawed Circular Cones.** W.J.RAINBIRD.
AGARD Conference Proceedings CP 30, Paper 19, pp.19-1 to 19-18, 33 refs., 1968.
Pressure distributions, surface shear stresses and the external flow field are measured on a 5° semi-angle cone at Mach Numbers of 1.80 and 4.25 and up to large incidences. Similar measurements on 12½° semi-angle cone are also presented.

CP30/20 **Theoretical and Experimental Study of the Boundary Layer on a Circular Cone at Incidence to a Hypersonic Stream.** (in French). D.GUFFROY, B.ROUX, J.MARCILLAT, R.BRUN, J.VALENSI.
AGARD Conference Proceedings CP 30, Paper 20, pp.20-1 to 20-18, 14 refs., 1968.
Theoretical and experimental results are reported at Mach 7 and Mach 9 on the flow around a cone of 9° half-angle. Surface flow was explored by flow visualisation while pilot probe observations defined the shock wave and showed the location of two open eddies.

CP30/21 **Displacement Interaction and Flow Separation on Cones at Incidence to a Hypersonic Stream.** T.K.FANNELOP, G.D.WALDMAN.
AGARD Conference Proceedings CP 30, Paper 21, pp.21-1 to 21-20, 17 refs., 1968.
A theoretical analysis is presented for the boundary-layer flow about a blunted cone at incidence to a hypersonic stream.

CP30/22 **Theoretical and Experimental Study of Hypersonic Flow around a Blunt Body at Incidence.** (in French). R.CERESUELA, G.KRETZSCHMAR, C.REHBACK.
AGARD Conference Proceedings CP 30, Paper 22, pp.22-1 to 22-14, 8 refs., 1968.
The aerodynamic field at Mach 10 around a very blunt cone of low apex angle was calculated by Babenko's method for angles of incidence of 5, 10 and 20 degrees, in the latter case the calculations diverged and gave negative pressures. Comparison with wind-tunnel results agreed well for shock wave position and local pressure except for the high incidence case where a boundary layer separation produced a horse-shoe vortex. The conclusion is that Babenko's method gives acceptable results at fairly high angles of incidence for the thermal and aerodynamic loads on similar bodies.

CP30/23 **Study of Supersonic and Hypersonic Flow around a Slender Wing at Incidence.** (in French). B.MONNERIE, H.WERLE.
AGARD Conference Proceedings CP 30, Paper 23, pp.23-1 to 23-19, 21 refs., 1968.
The aerodynamic field around a 75° delta wing with sharp leading edge was studied at Mach Numbers of 1, 9, 4 and 7 which correspond to cases for subsonic, sonic and supersonic flow normal to the leading edge. Flow visualisation and pressure measurements give a clear description of the flow on the upper surface of the wing, particularly of the separated regions.

CP30/24 **Hypersonic Laminar Boundary Layer Growth in an Adverse Pressure Gradient.** H.A.FITZHUGH.
AGARD Conference Proceedings CP 30, Paper 24, pp.24-1 to 24-16, 14 refs., 1968.
A number of boundary layer theories are tested against each other and against experiment. The conclusion is that no theory has been tested sufficiently to warrant its acceptance as a prediction method.

CP30/25 **Viscous Hypersonic Flow Past Slender Bodies at Incidence.** R.VAGLIO-LAURIN.
AGARD Conference Proceedings CP 30, Paper 25, pp.25-1 to 25-13, 13 refs., 1968.
The paper presents a physical model and a simplified analysis of three-dimensional hypersonic laminar boundary layers with large cross-flows. A preliminary assessment shows good agreement with experiment.

CP30/26 **Vortical Layers in Supersonic Conical Flow.** R.E.MELNIK.
AGARD Conference Proceedings CP 30, Paper 26, pp.26-1 to 26-20, 20 refs., 1968.
A theoretical analysis of supersonic flow over slightly yawed conical surfaces is presented. Analytic results are given for a yawed circular cone and for the entropy distribution on an elliptic cone.

CP30/27 **Study of Flow at Mach 18 around a Flat Plate at Incidence and with a Varied Leading Edge.** (in French). J.ALLEGRE, C.BISCH.
AGARD Conference Proceedings CP 30, Paper 27, pp.27-1 to 27-8, 21 refs., 1968.
Describes pressure measurements on a flat plate at incidences from -6 to +9 degrees and with leading edge thicknesses between 0.07 and 1.5 mm. Flow visualisation by electric spark pulses allowed the position and form of the shock wave to be determined.

CP30/28 **Studies of Three-Dimensional, Compressible Boundary Layers on Blunt Lifting Entry Bodies.** SAN-WOOK KANG, W.J.RAE, M.G.DUNN.
AGARD Conference Proceedings CP 30, Paper 28, pp.28-1 to 28-27, 62 refs., 1968.
Theoretical studies of the three-dimensional, laminar, compressible boundary layer with mass injection. Applications are given to cases typical of the heat shield of the Apollo vehicle during lifting re-entry.

CP30S **Supplement to Conference Proceedings CP 30.** Edited by R.BARTH.
AD-685-581 AGARD Conference Proceedings CP 30, Supplement, 48 pp., 3 refs., 1968.
N69-22550 Contains the discussions which followed the presentation of the papers of the Fluid Dynamics Specialists Meeting "Hypersonic Boundary Layers and Flow Fields" held in London 1-3 May 1968. It should be read in conjunction with AGARD Conference Proceedings No. 30 of which a summary is given under the numbers CP30 and CP30/1 to CP30/28.

CP31 **Helicopter Propulsion Systems.**
AD-850-115 AGARD Conference Proceedings CP 31, pp. 491, many refs., 1968.
N69-23976 Records 26 papers and the discussion on selected topics at 31st Meeting of the AGARD Propulsion and Energetics Panel held in Ottawa, Canada 10-14 June 1968. The seminar of lectures covered current problems and future expectations of the helicopter engine and engine component research and development, various rotor drive systems including mechanical and gas driven, future rotary wing aircraft concepts, and operational environment considerations. The purpose of the meeting was to familiarize NATO scientists and engineers, both military and civilian, with the future expected needs of advanced rotary wing aircraft, primarily from the propulsion standpoint; to exchange information on advanced propulsion system research and development, and to enable NATO countries to plan their future helicopter programmes with greater understanding of the overall propulsion system technologies. The individual papers are dealt with in the following abstracts.

CP31/1 **Future Requirements for Military Helicopters and their Propulsion Systems.** P.V.BROWN.
AGARD Conference Proceedings CP 31, Paper 1, pp.1-1 to 1-7, 1968.
This introductory paper points out that present helicopters have been conditioned largely by the state of power plant development and suggests that in spite of the many configurations proposed, future helicopters will be similarly influenced.

CP31/II **Helicopter Propulsion System State of the Art and its Implications to Engine Technology.** H.N.SHOHET.
AGARD Conference Proceedings CP 31, Paper II, pp.II-1 to II-12, 1968.
This paper reviews the effect the introduction of the gas turbine engine has had on helicopter design, the gas turbine engine itself and its accessories.

CP31/III **Helicopter Propulsion Trends.** C.W.ELLIS, J.ACURIO, J.J SCHNEIDER.
AGARD Conference Proceedings CP 31, Paper III, pp.III-1 to III-25, 1968.
The purpose of this paper is to trace the development of helicopter propulsion systems and identify areas where further improvement will be essential. In addition, projected requirements for future aircraft are defined.

CP31/1 **Advanced Engine Design Point Considerations.** C.H.CARPER.
AGARD Conference Proceedings CP 31, Paper 1, pp.1-1 to 1-15, 2 refs., 1968.
This paper investigates advanced gas turbine engine design and performance. Engines covering the range of from 500 to 10,000 shaft horsepower are considered.

CP31/2 **Turbine Engines for Helicopters.** (in French). H.C.DABBADIE.
AGARD Conference Proceedings CP 31, Paper 2, pp.2-1 to 2-8, 1968.
The considerable improvement in helicopter design is said to be largely due to the new gas turbines. With the use of mechanical transmissions several projects based on the new engines, show that less expensive designs are possible which will nevertheless offer greater safety, increased speed and greater comfort. Design features, number of engines and shafting arrangements are discussed.

CP31/3 **Helicopter Gas Turbines. Control of Quality Establishment of Reliability.** F.W.MORLEY.
AGARD Conference Proceedings CP 31, Paper 3, pp.3-1 to 3-7, 1968.
This paper sets down the basic principles by which an engine is judged by the customer. The action required of the designer and manufacturer of the present gas turbine is then discussed.

CP31/4 **Allison T63 Regenerative Engine Program.** E.J.PRIVOZNIK.
AGARD Conference Proceedings CP 31, Paper 4, pp.4-1 to 4-12, 1968.
This paper briefly summarises the results of the development of the Allison T63 regenerative engine. The flight test programme is stated to demonstrate the feasibility of the regenerative engine and it is claimed that regeneration increases the maximum specific range by 25.7%.

CP31/5 **Helicopter Turbine Engine Components.** (in French). H.C.DABBADIE.
AGARD Conference Proceedings CP 31, Paper 5, pp.5-1 to 5-5, 1968.
The use of gas turbines for helicopters is discussed in three generations of development. Improvements in specific power, fuel consumption and weight are described. The possible future developments, improvement of thermodynamic cycle, better component characteristics and the use of new materials are discussed.

CP31/6 **High Pressure Ratio Centrifugal Compressors for Small Gas Turbine Engines.** R.E.MORRIS, D.P.KENNY.
AGARD Conference Proceedings CP 31, Paper 6, pp.6-1 to 6-23, 10 refs., 1968.
This paper describes the problems and shows some data on the performance of single stage centrifugal compressors with pressure ratios of 10:1 to 15:1. A novel diffuser capable of accepting the non uniform supersonic flow from the impeller with low loss and good operating range is described. Test results are given for experimental compressors with overall pressure ratios of 12:1 after diffusion to a Mach Number of 0.15. The paper concludes with a discussion of future problems and prospects for this type of high pressure ratio compressors.

CP31/7 **Reaction Drive Systems for Helicopters.** C.L.WILDE.
AGARD Conference Proceedings CP 31, Paper 7, pp.7-1 to 7-15, 9 refs., 1968.
This paper discusses reaction drive systems and new possibilities. They eliminate the reduction gear to the rotor and the normal tail rotor but have usually been less efficient in terms of the fuel used per ton of lift. However there is expected to be a revival of interest for the very large weight lifting helicopters of the future.

CP31/8 **Hot Cycle Rotor Propulsion.** R.J.SULLIVAN.
AGARD Conference Proceeding CP 31, Paper 8, pp.8-1 to 8-17, 11 refs., 1968.
The XV-9A hot-cycle research helicopter developed by the Hughes Tool Company is described and its performance characteristics are shown to be close to predictions. It is predicted that hot cycle helicopters can have a better payload/empty weight ratio than conventional shaft driven helicopters and can attain high speeds of the order of 450 knots.

CP31/9 **Propulsion of Helicopter Rotors and Composite Aircraft by a Cold Jet.** (in French). F.MAILLARD.
AGARD Conference Proceedings CP 31, Paper 9, pp. 9-1 to 9-10, 1968.
The paper examines the optimum pressure for helicopter propulsion by jet thrust. The cold jet is said to provide a better solution than hot jets. The pressure required is dictated by unit conditions, the case being different for tip jets and normal propulsion. Two possible designs are described, one applicable to pure helicopters and the other to composite aircraft such as the Rotojet.

CP31/10 **Low Pressure Reaction Drive Systems for Large Helicopter Rotors.** G.REICHERT, E.F.WEILAND.
AGARD Conference Proceedings CP 31, Paper 10, pp.10-1 to 10-11, 6 refs., 1968.
This paper describes a reaction drive system using fuselage installed by-pass engines as gas generators and a gas duct system inside the rotorblade. The problems and possible gas generators are described and it is concluded that reaction systems, because of the empty weight advantage, can have advantages in the upper payload range of future helicopters.

CP31/11 **Efficiency Improvement of Helicopter Tip-Drive Systems.** G.KANNAMÜLLER.
AGARD Conference Proceedings CP 31, Paper 11, pp.11-1 to 11-30, 8 refs., 1968.
Results of comprehensive research on the efficiency of tip-drive systems are described. The programme led to an experimental hot gas rotor system 10 m in diameter now being tested. This is a scaled model for heavy lift helicopters leading to the Do132 helicopter.

CP31/12 **The Integration of Turbine Engines in the Design of a Helicopter with Mechanical Transmission.** (in French). R.MOUILLE.
AGARD Conference Proceedings CP 31, Paper 12, pp.12-1 to 12-17, 1968.
The paper examines, with examples, the various layouts proposed by designers of helicopters with jet engines and mechanical transmission. The choice is discussed for several helicopters on which flight experience is available.

CP31/13 **Mechanical Transmission Systems for Turbine Powered Helicopters.** J.N.DANIEL.
AGARD Conference Proceedings CP 31, Paper 13, pp.13-1 to 13-11, 10 refs., 1968.
Investigations on power transmission systems are described and have led to favourable consideration of high speed shafting, run at supercritical speeds and high ratio speed reduction units. The effects on helicopter design are discussed.

CP31/14 **Power and Speed Control for Parallel Operation of Two Single-Shaft Gas Turbines in a Helicopter Application.** F.WATZELT, A.STEPAN, C.GREUNE.
AGARD Conference Proceedings CP 31, Paper 14, pp.14-1 to 14-18, 8 refs., 1968.
Control problems in the parallel operation of two or more engines are discussed. Transient engine performance under operating conditions is demonstrated by oscillograms recorded on the gas turbines in the Bo105 helicopter.

CP31/15 **Compound Helicopters.** R.G.AUSTIN.
AGARD Conference Proceedings CP 31, Paper 15, pp.15-1 to 15-21, 2 refs., 1968.
An attempt is made to show the effectiveness of various degrees of lift and/or thrust compounding on helicopters. Though particular attention is paid to large transport type aircraft the results are considered to be generally applicable. Within the assumptions it is concluded the most productive aircraft will cruise at about 200 Knots, will use about 50% lift compounding but no thrust compounding. If higher speeds of say 250 Knots are required more lift and considerable thrust compounding will be needed but overall efficiency will drop.

CP31/16 **Propulsion for Composite Aircraft.** J.B.WHEATLEY, D.T.SASAKI.
AGARD Conference Proceedings CP 31, Paper 16, pp.16-1 to 16-23, 1968.
The paper describes a design with a folding and stowing rotor and discusses the problems and advantages. It is claimed that the provision of means for two independent modes of flight, as a helicopter or an aeroplane, results in an acceptable empty weight and a satisfactory payload.

CP31/17 **The Effect of Advanced Propulsion on Future Rotary-Wing-Type Aircraft.** L.M.GRAHAM, A.W.SHULTZ, H.C.SMITH.
AGARD Conference Proceedings CP 31, Paper 17, pp.17-1 to 17-14, 1968.
The effects of the use of advanced-technology turbine engines are discussed in relation to three types of design, a pure helicopter, a slowed-rotor compound helicopter and a tilting proprotor composite aircraft. It is concluded that using the new engine designs will result in much smaller and lighter aircraft for the same customer requirements.

CP31/18 **New Trends for High Speed Helicopter Propulsion.** C.CASCI, E.BIANCI.
AGARD Conference Proceedings CP 31, Paper 18, pp.18-1 to 18-14, 13 refs., 1968.
This paper reviews four configurations of pure helicopters suitable for high speed operation and lists the basic features of compound helicopters. The propeller is considered to be the most suitable means of propulsion for compound helicopters cruising at 200-250 Knots.

CP31/19 **Simple Solutions of the Helicopter Propulsion System Made Possible Using Closed Cycle for the Working Fluid.** D.DINI.
AGARD Conference Proceedings CP 31, Paper 19, pp.19-1 to 19-30, 9 refs., 1968.
The paper proposes a multiple expansion engine directly coupled to the rotor for helicopters. Several arrangements for small helicopters are discussed in detail. Steam engines and those using other working fluids are discussed together with compact heat sources.

CP31/20 **Helicopter Noise.** J.W.LEVERTON.
AGARD Conference Proceedings CP 31, Paper 20, pp.20-1 to 20-13, 15 refs., 1968.
The relative importance of the noise sources of a helicopter are discussed with particular reference to external noise generation. Rotational noise, vortex noise and blade shape are reviewed in the light of recent experimental and theoretical investigations. The problems of measuring and analysing helicopter rotor noise are briefly outlined.

CP31/22 **Icing and the Helicopter Powerplant.** J.R.STALLABRASS, R.D.PRICE.
AGARD Conference Proceedings CP 31, Paper 22, pp.22-1 to 22-12, 7 refs., 1968.
This paper briefly examines the effects of icing on both reciprocating and turbine engines and the standard methods of combating them. Some of the specific icing problems associated with turbine engines in helicopters are discussed with suggested methods of alleviation.

CP31/23 **Microscopic Particle Separation and Application.** R.POPLAWSKI, R.A.MILLER.
AGARD Conference Proceedings CP 31, Paper 23, pp.23-1 to 23-30, 27 refs., 1968.
The paper reviews filtration techniques and their applications in relation to helicopters from protection from dust or sea spray to applications in the field of air pollution. Theoretical and experimental results are presented.

CP32 **Flight Test Instrumentation.** Edited by M.A.PERRY.
AD-677-104 AGARD Conference Proceedings CP 32, 448 pp., many refs., 1967.
N69-10532 Papers presented at the 30th Meeting of the AGARD Flight Mechanics Panel held in Montreal, Canada, 30 May to 1 June, 1967. Eighteen papers, classified under four headings, User Requirements, Instrumentation Systems, Data Reduction, Sensing and Transcribing, with detailed discussions on each section. The aim of the Conference was to cover the whole user field (rather than to concentrate on specialist studies) and to survey existing methods, identify deficiencies and discuss possible developments. The need for complete multi-channel data handling systems with good reliability, accuracy and stability demands, integrated training, close collaboration, and mutual understanding between aerodynamicist and instrumentation engineer. Emphasis was placed also on the need for rationalisation and standardisation – in terminology as well as hardware – and it is suggested that AGARD might initiate action in this field. The individual papers are dealt with in the following abstracts.

CP32/1 **Flight Test Instrumentation – The User's Requirements.** M.L.HENNEY.
AGARD Conference Proceedings CP 32, Paper 1, pp.1-18, 3 refs., 1967.
The flight test engineer requires a comprehensive integrated airborne data-gathering, ground replay and analysis system, use of which will improve the efficiency of flight testing, both by reducing the amount of flying and time required and by providing a rapid feedback of digested data to assist in control of the flight test process. The paper offers a broad specification which is consistent with the current state of the art and suggests that standardisation is to be encouraged.

CP32/2 **The Flight Performance Tests of Supersonic Airplanes.** (in French). J.F.RENAUDIE.
AGARD Conference Proceedings CP 32, Paper 11, pp.19-41, 1967.
How supersonic flights and aircraft differ in their properties from their subsonic counterparts are discussed. New methods for measuring the flight performance of supersonic craft are evolved. The flight pattern of a Concorde craft is depicted and its performance characteristics are charted

CP32/3 **Test Objectives and Applications of Flight Test Data by the Structures Engineer.** S.L.GUGLETA.
AGARD Conference Proceedings CP 32, Paper 3, pp.43-61, 1967.
The type of instrumentation required in four types of structural test is discussed. Tests for Acoustical Environmental Survey, Vibration Environmental Survey, Flight flutter tests and Flight load tests are discussed and data pertinent to the B-52 heavy bomber is presented.

CP32/4 **Stability and Control Flight Testing – Some of the Test Instrumentation Requirements.** R.ROSE.
AGARD Conference Proceedings CP 32, Paper 4, pp.65-75, 1967.
The purpose of the paper is to present the view of the flight test engineer on the instrumentation requirements for stability and control flight testing and to consider some possible developments in the future. Typical ranges of the quantities required are listed and the view expressed that further development is required on magnetic tape recording systems and on telemetry.

CP32/5 **Some Problems of Data Acquisition for VTOL Flight-Test Data Analysis.** J.SCHÄFFLER, H.ALSCHER.
AGARD Conference Proceedings CP 32, Paper 5, pp.77-91, 2 refs., 1967.
The main problems are stated to be, the measurement of the direction and magnitude of airspeed over a wider range, measurement of engine dynamics, flow field conditions in inlets and on propellers over a wide range of incidence conditions, the effects of recirculation and jet induced aerodynamics and measurements of temperature and acoustic fields over large areas of the airframe and landing site. Many of the new problems have been tackled but it is yet too early to assess the success.

CP32/6 **IRIG Telemetry Standards.** R.S.REYNOLDS.
AGARD Conference Proceedings CP 32, Paper 6, pp.97-117, 1967.
The history of the Inter-Range Instrumentation Group (IRIG) is described and the present organisation and working group is presented. The main portion of the paper is devoted to a description of the telemetry standards developed and adopted for range use.

CP32/7 **Signal Conditioning in Flight-Test Instrumentation.** A.J.L.WILLEKENS, A.POOL.
AGARD Conference Proceedings CP 32, Paper 7, pp.119-131, 6 refs., 1967.
Signal conditioning, the conversion of an input signal in an aircraft in various stages for ray computer input The various operations that are required for typical applications are discussed and examples given.

CP32/8 **A Comparison of Systems.** A.BECKER, B.GARTUNG, H.MEYER.
AGARD Conference Proceedings CP 32, Paper 8, pp.133-160, 4 refs., 1967.
In this paper two different comparisons are made of systems used in flight-test techniques, on-board data recording and telemetry. In the second part the different IRIG-standardised telemetry techniques are discussed and compared. It is concluded that each of the systems, for definite applications, has advantages.

CP32/9 **Economics of Flight-Test Data Systems.** H.L.TOLLISEN.
AGARD Conference Proceedings CP 32, Paper 9, pp.163-171, 1967.
This paper is based on the Boeing Company's experience in certifying its commercial transports. The data volume required is high and the time available is short and has resulted in the development of a highly automated data system.

CP32/10 **The Application of Regression Analysis to the Evaluation of Instrument Calibration.** O.H.GERLACH.
AGARD Conference Proceedings CP 32, Paper 10, pp.175-209, 7 refs., 1967.
This paper deals with the expression of an instrument's calibration characteristics in a form suitable for the analysis of flight-test data by a digital computer. Typical examples are discussed and it is concluded that the method of regression analysis is applicable.

CP32/11 **Some Considerations of the "Philosophy" of the Utilization of Flight Test Measurements.** (in French). J.F.RENAUDIE.
AGARD Conference Proceedings CP 32, Paper 11, pp.211-242, 1967.
The problems posed by handling, analyzing, and utilizing the myriad of data collected by satellites and supersonic and experimental aircraft are discussed. A technique is proposed for rapid and automatic exploitation of the collected measurements. Flow charts of the various steps involved in the information retrieval are depicted.

CP32/12 **A Data Processing Facility for the XB-70 Flight Test Program.** E.L.EDWARDS.
AGARD Conference Proceedings CP 32, Paper 12, pp.243-258, 1967.
This paper describes the ground system used in the data processing of the XB-70 flight-test programme. Both analog and digital systems are employed.

CP32/13 **Statistical Methods for the Reduction of Dynamic Flight Data.** G.J.BORN, E.J.DURBIN.
AGARD Conference Proceedings CP 32, Paper 13, pp.259-295, 5 refs., 1967.
Much of the flight-test data required to be reduced for analysis contains an element of chance or randomness where it may not be defined precisely but only by certain probability distributions and average values. In this paper it is shown how the description of the data may be described as time averages, as frequency averages and probabilities.

CP32/14 **Force Feedback Inertial Instruments.** I.McLAREN.
AGARD Conference Proceedings CP 32, Paper 14, pp.299-312, 1967.
The paper deals with force feedback accelerometers and single axis gyroscopes and considers the sensors required. It is concluded that although force feedback transducers are potentially capable of high accuracies they may not do so if high-frequency underdeveloped systems are subjected to oscillatory signals or unwanted noise.

CP32/15 **Developments in Rate Gyroscopes.** R.P.G.COLLINSON, A.R.ESSEX.
AGARD Conference Proceedings CP 32, Paper 15, pp.313-334, 1967.
Gyroscopes for the measurement of angular rates of rotation are described and recent developments are discussed with particular attention to the spring-restrained and electrical force-balancing types. Typical performance figures are quoted.

CP32/16 **Temperature-Sensing Techniques.** F.TRENKLE, M.REINHARDT.
AGARD Conference Proceedings CP 32, Paper 16, pp.325-371, 31 refs., 1967.
This paper gives some essential data on the ranges and trends of the most interesting parameters in temperature-sensing devices in aircraft. It is concluded that some effects such as the recovery error and the effect of shock wages near the orifice of the probe, are not known with accuracy and that further work should be done.

CP32/17 **Measurement of Flow Speed and Flow Direction by Aerodynamic Probes and Vanes.** W.WUEST.
AGARD Conference Proceedings CP 32, Paper 17, pp.373-423, 113 refs., 1967.
This paper reviews the methods available for the measurement of speed and flow direction in aircraft and model testing and presents an extensive bibliography.

CP32/18 **An Airspeed Measuring System for Helicopters.** D.F.DAW.
AGARD Conference Proceedings CP 32, Paper 18, pp.427-443, 5 refs., 1967.
The paper describes an airspeed system which uses pitot probes mounted at the tips of both main rotors. The helicopter airspeed is derived from the nearly sinusoidal pressure fluctuations by an electronic package. Development is said to be proceeding.

CP33 **Phase and Frequency Instability in Electromagnetic Wave Propagation.**
AGARD Conference Proceedings CP 33, July 1970.
This publication reports the results of the 13th Symposium of the Electromagnetic Wave Propagation Committee on Phase and Frequency Instability in Electromagnetic Wave Propagation held in Ankara, Turkey, 9-12 October 1967.

During the past ten years great advances have been made in the development of precision oscillators which have excellent frequency and phase stability. This opens the door to the possibility of utilizing electromagnetic wave propagation for many applications which would have been beyond the state-of-the-art a short time ago, that is: (1) time and frequency broadcast for long range clock synchronization, (2) world wide navigation systems, (3) precision distance measurement, (4) communication (especially sophisticated modulation systems for communication with deep space probes), and also (5) the observation of the phase variations of electromagnetic wave propagation for geophysical research.

The stability of the propagation medium is being extensively studied, for example the realization that much greater phase stabilities are found at the very low frequencies, several orders of magnitude better than possible at high frequencies. More detailed attention now needs to be given to the instability of the propagation medium, since this is the basic limitation to any system which utilizes or requires phase and frequency stability in electromagnetic propagation.

CP34 **Advanced Components for Turbojet Engines.** Parts 1 and 2.
Part 1 AGARD Conference Proceedings CP 34, Parts 1 and 2, 620 pp., 1968.
AD-687-857 Records in two parts the papers presented at the 32nd Meeting of the AGARD Propulsion and
N69-28601 Energetics Panel held in Toulouse, France, 9-13 September, 1968. The papers fall under the following main headings:– Aircraft/Engine Systems, Compressors, Combustors, Turbines, Nozzles and
Part 2 After-Burners, Jet Mixing and Dynamic characteristics of Engines. The individual papers are dealt
AD-687-774 with in the following abstracts.
N69-26526

CP34/1/1 **Interactions between Air Intakes and Engines on Supersonic Aircraft.** (in French). A.GOZLAN.
AGARD Conference Proceedings CP 34, Part 1, Paper 1, pp.1-1 to 1-15, 18 refs., 1968.
The paper describes the interactions that may take place, reviews the principal problems including intake buzz and engine surge and presents some test results.

CP34/1/2 **Choice of Engine Cycle for High Performance Military Aircraft.** R.J.LANE.
AGARD Conference Proceedings CP 34, Part 1, Paper 2, pp.2-1 to 2-23, 1968.
The effects are discussed of the main engine parameters on the design of advanced military aircraft such as the variable geometry strike/interceptor aircraft. The report comments that installational effects raise perhaps the most important problems.

CP34/1/3 **Variable Geometry Intakes at Supersonic Speeds – Some Techniques and Some Test Results.** E.L.GOLDSMITH.
AGARD Conference Proceedings CP 34, Part 1, Paper 3, pp.3-1 to 3-31, 14 refs., 1968.
Equipment and models used for measuring the internal flow characteristics and the external drag of air intakes are described. Some illustrative results are given from both pressure recovery and drag results.

CP34/1/4 **Effect of High-Frequency Fluctuations of Inlet Flow on Compressor Stall.** B.H GOETHERT, W.F.KIMSEY.
AGARD Conference Proceedings CP 34, Part 1, Paper 4, pp.4-1 to 4-16, 8 refs., 1968.
Off-design operation of propulsion systems can result in oscillatory and distorted inlet flow conditions which often cause compressor stall. In this paper the effects are studied using an analytical model which represents the axial flow compressor as consisting of multiple parallel compressors formed by sectoring. Preliminary results are reported.

CP34/1/5 **Perspectives and Problems of Transonic and Supersonic Compressors.** F.A.E.BREUGELMANS.
AGARD Conference Proceedings CP 34, Part 1, Paper 5, pp.5-1 to 5-20, 25 refs., 1968.
The problems of high speed compressors are discussed and the paper concentrates on those of transonic-supersonic compressors, especially the shock in the rotor stage. Means of overcoming the difficulties in the stator and motor systems are discussed and comments are made on the radial equilibrium equation and the supersonic axial component cascade.

CP34/1/6 **Methods of Flow Calculation for Axial Flow Compressors.** D.G.GREGORY-SMITH, H.MARSH.
AGARD Conference Proceedings CP 34, Part 1, Paper 6, pp.6-1 to 6-8, 15 refs., 1968.
Methods of calculation for turbomachines are described and compared with experimental results. Lack of agreement is greatest close to the walls and further work is said to be required. Some preliminary experiments are described which show fair agreement for the predicted development of the wall boundary layer.

CP34/1/7 **Improved Techniques for Compressor Loss Calculation.** D.L.TIPTON.
AGARD Conference Proceedings CP 34, Part 1, Paper 7, pp.7-1 to 7-23, 13 refs., 1968.
Because of the complexity of flow approximations are used for the estimation of losses. The approximations are largely developed empirically from existing data and are subject to question when extended to advanced concepts. The report suggests that the conventional methods of loss prediction are not directly applicable to the blade elements used in supersonic compressors. Improved agreements for loss prediction with experimental data have been developed and the results have been employed for the determination of some optimum design criteria for high pressure ratio compressors.

CP34/1/8 **Study by Hydraulic Analogy of Wave Configurations in Supersonic Compressors.** (in French). R.SOVRANO, Y. LE BOT.
AGARD Conference Proceedings CP 34, Part 1, Paper 8, pp.8-1 to 8-10, 12 refs., 1968.
The report describes hydraulic analogy tests in which an experimental arrangement of a rotating annular cascade in a free surface water tank where the shock wave and the expansion line pattern are visualised.

CP34/1/9 **Aeroelasticity of Fans and Compressors.** F.SISTO.
AGARD Conference Proceedings CP 34, Part 1, Paper 9, pp.9-1 to 9-9, 13 refs., 1968.
Aeroelastic problems in axial-flow fans and compressors are defined and the characteristics of the major categories of phenomena observable in turbomachines are described. A diagnostic procedure for "acoustic resonance" is proposed and its application explained. Suggestions are made for future investigations.

CP34/1/10 **Considerations in the Design of Variable-Geometry Blading for Axial-Flow Compressor Stages.** G.K.SEROVY, P.KAVANAGH.
AGARD Conference Proceedings CP 34, Part 1, Paper 10, pp.10-1 to 10-10, 28 refs., 1968.
Requirements for advanced axial-flow compressors generally indicate the need for some form of variable-geometry flow control. A review of typical blade-element performance curves is used to demonstrate the need in recent designs and the limitations of control by blade rotation is shown. Other methods are discussed.

CP34/1/11 **A Semi-Empirical Approach of the Transonic Flow Past Cascades Including Shock and Viscous Effects.** L.FOTTNER.
AGARD Conference Proceedings CP 34, Part 1, Paper 11, pp.11-1 to 11-18, 17 refs., 1968.
The paper presents a complete method, partly empirical for calculating the viscous transonic flow past cascades including the local supersonic field and the terminal compression shock. A practical example of calculation is given.

CP34/1/12 **Cascade Wing Tunnel Tests on Blades Designed for Transonic and Supersonic Compressors.** W.HEILMANN, H.STARKEN, H.WEYER.
AGARD Conference Proceedings CP 34, Part 1, Paper 12, pp.12-1 to 12-16, 12 refs., 1968.
Presents a survey of research work at DVL on two dimensional cascades. Double circular and circular wedge cascades have been tested and the results agree with those measured in rotors. Finally a short note describes an investigation on the influence of the axial velocity density ratio on the performance of high turning blades at subsonic inlet Mach numbers.

CP34/1/13 **Steps in the Development of a Supersonic Compressor Stage.** W.DETTMERING, B.BECKER.
AGARD Conference Proceedings CP 34, Part 1, Paper 13, pp.13-1 to 13-13, 4 refs., 1968.
To increase the efficiency and pressure ratio of a supersonic compressor, a plane supersonic tandem cascade was designed to produce both deceleration and turning. Experimental results are presented and a schlieren rig for the optical observation of the three dimensional is described. The consequences are then discussed.

CP34/1/14 **Experimentally Determined Shock Configurations in a High-Solidity Supersonic Rotor.** A.J WENNERSTROM, E.G.JOHNSON, C.T.CARMAN.
AGARD Conference Proceedings CP 34, Part 1, Paper 14, pp.14-1 to 14-10, 6 refs., 1968.
The paper describes an experiment intended to determine the shock-wave structure in a supersonic compressor rotor at design speed. Pressure measurements were used to determine the shock conditions and conventional probe instrumentation to measure the compressor performance. Shock wave patterns are presented and these are stated to resemble pseudoshock patterns. The mediocre efficiency is believed not to be due to a misconception concerning the shock structure but to other properties of the design.

CP34/1/15 **Study of Supersonic Compressors.** (in French). O.CONRAD, J.PLEISS, T.WEBER.
AGARD Conference Proceedings CP 34, Part 1, Paper 15, pp.15-1 to 15-22, 12 refs., 1968.
Stage efficiencies and stage pressure ratios were calculated, from experimental data on cascades, for shock-in-rotors, impulse rotors and guide vanes. The results indicate that the impulse compressors are better for the smaller ratios while the shock-in-compressors are better for high pressure ratios.

CP34/1/16 **Analysis and Demonstration Techniques for Installation Aerodynamics Effects on High Bypass Turbofans.** J.S.HOLDHUSAN.
AGARD Conference Proceedings CP 34, Part 1, Paper 16, pp.16-1 to 16-14, 9 refs., 1968.
Methods of conducting engine tests, wind tunnel tests and flight tests are reviewed and an analytical framework suggested for the following quantities required for predicting net cruise thrust: inlet internal recovery, inlet internal distortion, exhaust system thrust coefficient, inlet external drag, aft surface external drag, and mutual interactions between the engine and aircraft flow fields.

CP34/2/17 **Development of High Intensity Combustion Chambers.** A.QUILLEVERE.
AGARD Conference Proceedings CP 34, Part 2, Paper 17, pp.17-1 to 17-24, 15 refs., 1968.
The chemical kinetics of homogeneous and heterogeneous combustion are reviewed for a primary combustion zone from the viewpoint of efficiency and intensity. Experimental studies were carried out on spherical inlets, a maximum extinction charge and a nearly homogeneous combustion were attained for a given carburized mixture. Extending the results to the primary zone of a turboreactor was not successful because of the geometry of the inlet and the limiting factor of admissible charge loss. Further research was recommended to develop a turboreactor chamber of high combustion intensity.

CP34/2/18 **High Intensity combustion – Some Thoughts on its Attainment within Aircraft Gas Turbine Combustion Chambers.** J.ODGERS.
AGARD Conference Proceedings CP 34, Part 2, Paper 18, pp.18-1 to 18-15, 6 refs., 1968.
Short-length combustion chambers require very high release rates and in this paper the performance of aircraft combustors is analysed in terms of the release characteristics of a spherical combustor, assumed to be the maximum possible. The major problems are discussed, in particular, flame tube life.

CP34/2/19 **Measurements of Ignition Delays of Hydrogen – Air Mixtures under Simulated Conditions of Supersonic Combustion Chambers.** T.JUST, F.SCHMALZ.
AGARD Conference Proceedings CP 34, Part 2, Paper 19, pp.19-1 to 19-13, 13 refs., 1968.
The ignition time delay of several hydrogen-air mixtures has been measured in a large shock tube behind reflected shocks. As the ignition delay near the second explosion limit depends critically on temperature, an attempt was made to measure the temperature history behind the reflected shock. A simplified kinetic theory is presented and it is claimed that practical agreement with experiment is obtained.

CP34/2/21 **Some Aerodynamic Aspects of Turbine Design.** J.DUNHAM, D.J.L.SMITH.
AGARD Conference Proceedings CP 34, Part 2, Paper 21, pp.21-1 to 21-15, 10 refs., 1968.
Two experiments in turbine design are described. In the first a turbine was designed for optimum efficiency and achieved on test its predicted performance. The peak efficiency was 92½%. In the second, another turbine fitted with variable nozzle guide vanes was tested. It was less efficient than predicted because the nozzle clearances needed to permit their movement caused greater losses than expected.

CP34/2/22 **Aerodynamic Problems in Cooled Turbine Blading Design for Small Gas Turbine.** J.CHAUVIN, K.PAPALIOU, L.BURROWS.
AGARD Conference Proceedings CP 34, Part 2, Paper 22, pp.22-1 to 22-19, 22 refs., 1968.
The next generation of small gas turbines in the 500-1,000 s.h.p. range require turbine inlet temperatures of the order of 1,200°C to obtain fuel consumption and power better than those of piston engines. The paper discusses the problems involved including the cooling of the nozzle and blades of the compressor turbine and describes work done on blade optimisation and secondary flow and losses.

CP34/2/23 **Transonic Turbine Blading.** C.SIEVERDING.
AGARD Conference Proceedings CP 34, Part 2, Paper 23, pp.23-1 to 23-20, 20 refs., 1968.
The report states that knowledge is at present insufficient to allow design of the transonic stages in gas and steam turbines and that cascade tests are essential. Tests are described on a transonic cascade of a pitch chord ratio of 1.3 and a stagger angle of 65°. A second design was also tested to determ ' the effect of a change in L.E. and T.E. profile.

CP34/2/24 **The Problems of Nozzle Optimisation.** (in French). P.CARRIERE, M.SIRIEIX.
AGARD Conference Proceedings CP 34, Part 2, Paper 24, pp.24-1 to 24-20, 19 refs., 1968.
The optimisation of a nozzle is a compromise between various constraints. This paper discusses the problems and compares recent experimental work with theory. The conditions at the off-design flight of a supersonic aircraft are considered and the constraints imposed by the need for thrust reversal and silencing are surveyed.

CP34/2/26 **Supersonic Nozzles.** J.J.HORGAN, D.B.WARING.
AGARD Conference Proceedings CP 34, Part 2, Paper 26, pp.26-1 to 26-11, 8 refs., 1968.
The paper discusses the design of exhaust nozzles for supersonic aircraft. The nozzle flow is influenced by the external flow which is itself, affected by the exhaust jet and the task of reducing the external drag is therefore complicated. The paper reviews the development of supersonic exhaust systems and discusses several attractive nozzles.

CP34/2/27 **The Effect on Output of Reheating Turboreactors intended for Supersonic Planes.** L.BAUGER.
AGARD Conference Proceedings CP 34, Part 2, Paper 27, pp.27-1 to 27-15, 1968.
The importance of reheating on the propulsion efficiency of supersonic civilian transports is discussed. The reheating apparatus and an analysis of the output of reheated propulsion are considered. Propulsive yield is the product of three specific elementary efficiencies of reheating: isentropic yield of the cycle; combustion efficiency in the combustor; and isentropic efficiency of expansion in the ejection nozzle. Also indicated is the effect of stator blades in the reheating duct on increasing the output of the expansion gas cycle in an adapted convergent-divergent nozzle.

CP34/2/28 **On the Burning Limits of Flame-Holder – Stabilized Flames in Supersonic Flow.** G.WINTERFELD.
AGARD Conference Proceedings CP 34, Part 2, Paper 28, pp.28-1 to 28-12 (bound in front of pp.19-1 to 19-13), 9 refs., 1968.
Experimental work is described on the effect of different types of fuel injection on the burning limits of flames stabilized by flame holders in supersonic flow. It is shown that there is little effect. It is then shown that the interaction of a shock wave with a flame in the wake of a flame holder can generate a second recirculation zone which can combine with that due to the flame-holder and considerably increase the burning limits.

CP34/2/29 **A Contribution to the Turbulent Mixing of Two Parallel Streams inside a Mixing Chamber.** A.HOMBURG.
AGARD Conference Proceedings CP 34, Part 2, Paper 29, pp.29-1 to 29-11, 5 refs., 1968.
In order to account for two-dimensional effects and to analyse the mixing process integral relations for the equations of motion are used similar to the method applied to the problem of turbulent mixing of unbounded coaxial streams. Results of calculations for incompressible and compressible flow of streams with equal total enthalpy at the mixing chamber entry are compared with experimental data.

CP34/2/30 **Mixing of Two Streams with Different Total Enthalpies.** (in French). E. LE GRIVES.
AGARD Conference Proceedings CP 34, Part 2, Paper 30, pp.30-1 to 30-10, 11 refs., 1968.
It is stated that one dimensional analysis leads to a satisfactory description of the supersonic regime when the primary stream expansion controls the mass flow ratio of a subsonic secondary stream, or of the mixed flow with or without downstream choking. A test rig has been used for research on downstream choking and theoretical predictions are compared with the results for long mixing. tubes.

CP34/2/31 **The Dynamic Behaviour of Jet Engines under External and Internal Action.** F.FETT.
AGARD Conference Proceedings CP 34, Part 2, Paper 31, pp.31-1 to 31-11, 6 refs., 1968.
To deal with off-design conditions such as the use of compressed air for control changes of inlet temperature due to re-circulation or other similar cases and the taking of mechanical energy from the jet engine a method of calculation has been devised to investigate the transient characteristics. Examples are given and theory is compared with experiment for the case of heavy air bleeding.

CP34/2/32 **A New Method for the Determination of Transient Jet Engine Performance Based on the Non-stationary Characteristics of the Components.** K.BAUFERFEIND.
AGARD Conference Proceedings CP 34, Part 2, Paper 32, pp.32-1 to 32-23, 5 refs., 1968.
The transient effects of the heat exchange between gas and metal, packing logs due to the filling up of volumes and combustion variations are three important factors. In this paper a computer program is described and a comparison between calculated and tested transient performance shows good agreement. A parametric study has been carried out to highlight the most important components and their effect on transient performance. It is concluded that certain aspects of present control systems should be improved.

CP35 **Transonic Aerodynamics.**
AD-685-270 AGARD Conference Proceedings CP 35, 404 pp., many refs., 1968.
N69-28694 A Specialists Meeting of the Fluid Dynamics Panel of AGARD was held in Paris 18-20 September, 1968. These proceedings contain a collection of the papers presented at this meeting, the purpose of which was to review and discuss the practical methods available for the study of flows around airplanes flying at subsonic speeds at which local supersonic regions appear. The collection of papers emphasizes various calculation methods, experimental studies on profiles, viscosity effects, and wing-body interference, to present a good cross-section of the state-of-the-art and to provide guidance for further research and development in this field. The individual papers are dealt with in the following abstracts.

CP35/1 **Transonic Shock-Free Flow, Fact or Fiction?** G.Y.NIEUWLAND, B.M.SPEE.
AGARD Conference Proceedings CP 35, Paper 1, pp.1-1 to 1-14, 12 refs., 1968.
The paper presents the evidence for shock-free transonic flow and concludes that although in any real transonic flow shock waves can be detected, the engineer, the mathematician and the physicist can be satisfied with the assumption of shock-free flow.

CP35/2 **Lax-Wendroff Scheme Applied to the Transonic Airfoil Problem.** R.E.SINGLETON.
AGARD Conference Proceedings CP 35, Paper 2, pp.2-1 to 2-9, 11 refs., 1968.
A numerical method is developed for solving the unsteady flow equations for the flow of a non-conducting inviscid gas around an arbitrary profile. The method gave results for transonic flow with a shock wave for the one case considered and is being further investigated with a more accurately given airfoil. The operation requires large computer memory and long runs.

CP35/3 **Inviscid Supercritical Airfoil Theory.** R.MAGNUS, W.GALLAHER, H.YOSHIHARA.
AGARD Conference Proceedings CP 35, Paper 3, pp.3-1 to 3-5, 6 refs., 1968
A procedure is presented to calculate the steady planar flow over a prescribed lifting profile. Two examples are computed, first the flow at a Mach Number of 0.85 over a biconvex airfoil 8.4% thick and second that over a blunt nosed profile.

CP35/4 **Application of the Method of Unstationary Characteristics to the Numerical Computation of a Steady Compressible Flow.** (in French). P.CARRIERE, C.CAPELIER.
AGARD Conference Proceedings CP 35, Paper 4, pp.4-1 to 4-9, 4 refs., 1968.
The two-dimensional flow around an airfoil is computed as an asymptotic limit to an unstationary flow. As initial data it is possible to use a known solution and modify as a continuous function of time the limiting conditions, or impose the desired limiting conditions to an arbitrary flow The evolution of the flow can be determined by the method characteristics A change of coordinates, such that the current lines and their orthogonal trajectories are represented by lines parallel to the axes, simplify the relations of the characteristics as well as the organization of the numerical computation

CP35/5 **Time Dependent Calculation of the Compressible Flow about Airfoils.** D.MacKENZIE, G.MORETTI.
AGARD Conference Proceedings CP 35, Paper 5, pp.5-1 to 5-15, 5 refs., 1968.
The paper offers computational programs which can be used with present generation computers for time dependent transonic flow. Results of several calculations are presented including the subsonic and supersonic flow about a 6% biconvex airfoil in a duct, the flow in a converging-diverging nozzle with supersonic exit conditions and the subsonic flow about a circular cylinder.

CP35/6 **Supercritical Transonic Airfoil Design from Prescribed Velocity Distribution.** M.S.CAHN, H.R.WASSON, J.R.GARCIA.
AGARD Conference Proceedings CP 35, Paper 6, pp.6-1 to 6-6, 1968.
A computer program recently developed by Northrop for designing an aerofoil to a prescribed velocity distribution is described. Application to several shapes with known solutions indicate that the method is a useful tool for studying transonic airfoil shapes.

CP35/7 **Analogue Calculation of Airfoil Profiles in the Transonic Regime.** (in French). F.RIGAUT.
AGARD Conference Proceedings CP 35, Paper 7, pp.7-1 to 7-20, 12 refs., 1968.
An analogue calculation method is presented based upon the finite differences representation of the hodograph equations of transonic flow. After a brief review of both analogue and hybrid methods, special emphasis is given to the study of profiles. The cases of symmetrical profiles, zero lift profiles, and lifting profiles are treated in succession. Examples and comparisons are submitted which illustrate the possibilities of the method. Finally, a calculation algorithm is presented for determining, by means of a hybrid technique, a flow with a shock wave. The method is also applicable to the calculation of cascades, and several examples are submitted.

CP35/8 **Digital Determination of Sub-Critical Wing Profiles by the Hodograph Method.** (in French). P.BEVIERRE.
AGARD Conference Proceedings CP 35, Paper 8, pp.8-1 to 8-11, 5 refs., 1968.
A hodograph is given for a lifting airfoil with a subsonic velocity at infinity. This hodograph includes a weakly supersonic region without shock. The first step in the computation involves the Chaplygin compressibility law. Such hodographs containing a large number of parameters are obtained analytically. The closure conditions of the corresponding airfoils and the location of I (image of the point at infinity) with respect to the hodograph boundary are obtained with accuracy. Starting from these results, the location of I is changed in order to find some airfoils corresponding to an exact compressibility law. A computational method is then described, involving the determination of a function which exhibits the singular behaviour of the point I.

CP35/9 **An Experimental Investigation of Unsteady Transonic Flow by High-Speed Interferometric Photography.** G.MEIER, W.HILLER.
AGARD Conference Proceedings CP 35, Paper 9, pp.9-1 to 9-9, 2 refs., 1968.
The paper presents photographs demonstrating the formation of unsteady motion in transonic channel flow. The starting point is a steady shock free transonic flow corresponding to an exact solution of the gas dynamic equations. Changes in flow parameters generate shock waves and the essential element of instability is said to be boundary layer separation coupled with shock formation.

CP35/10 **Theory of Viscous Transonic Flow – A Survey.** M.SICHEL.
AGARD Conference Proceedings CP 35, Paper 10, pp.10-1 to 10-15, 67 refs., 1968.
The paper discusses the present position of theory on viscous transonic flow confining attention to the description of viscous effects in the external flow. The author points out the need for more experimental data.

CP35/11 **The Interaction between Local Effects at the Shock and Rear Separation – A Source of Significant Scale Effect in Wing-Tunnel Tests on Aerofoils and Wings.** H.H.PEARCEY, J.OSBORNE, A.B.HAINES.
AGARD Conference Proceedings CP 35, Paper 11, pp.11-1 to 11-23, 14 refs., 1968.
The paper draws attention to important restrictions in the application of the flow model previously developed for shock-induced separation of turbulent boundary layers. It is suggested that these restrictions may introduce real difficulties in reproducing full-scale behaviour at low or moderate Reynolds Number.

CP35/12 **The Prediction of Aerofoil Pressure Distributions for Sub-Critical Viscous Flows.** R.C.LOCK, B.J.POWELL, C.C.L.SELLS, P.G.WILBY.
AGARD Conference Proceedings CP 35, Paper 12, pp.12-1 to 12-16, 12 refs., 1968.
The paper summarises recent advances in practical methods for predicting pressure distributions on aerofoils in two-dimensional sub-critical flows. Several comparisons are given with recent experimental results.

CP35/13 **Experimental Research on Supercritical Wing Profiles.** (in French). M.VINCENT DE PAUL.
AGARD Conference Proceedings CP 35, Paper 13, pp.13-1 to 13-21, 2 refs., 1968.
Some upper-surface velocity distributions having a peak near the profile leading-edge are studied. It is well known that this type of distribution always appears when profiles are at incidence but it can also be imposed at the design incidence. In the first case the peak governs the separation at the leading-edge, at low speed and high lift; in the second case, at the moderate lift encountered at high speed, this peak determines the mechanism of the shock formation. To examine these problems, a family of symmetrical profiles has been defined, starting from velocity distribution laws in incompressible flow, at zero angle of attack, as a function of the peak position and intensity and also of the following recompression gradient. The study of the evolution of the curvature in the leading-edge region of the calculated profiles, led to classify them into four main categories. The experimental analysis aims at criticizing the aerodynamic qualities of such profiles at low speed (maximum lift) as well as in the transonic range (drag and lift divergence Mach Number). The first experimental results presented concern tests in transonic flow.

CP35/14 **Leading-Edge Supersonic Velocity Peaks and the Determination of the Velocity Distribution on an Aerofoil in a Sonic Stream.** N.THOMPSON, P.G.WILBY.
AGARD Conference Proceedings CP 35, Paper 14, pp.14-1 to 14-20, 10 refs., 1968.
The geometric features of an aerofoil that are required to produce a supersonic velocity peak at the leading-edge are examined, and a rule is presented for relating the compressible velocity on a round leading-edge to the incompressible velocity. For a supersonic peak, the sonic point must lie on a region of sustained high curvature, and the dependence of the recompression on the way in which the curvature is reduced is indicated. An empirical method for determining velocity distribution is presented and several comparisons of predicted and measured velocity distributions are presented.

CP35/15 **An Approach to the Design of the Thickness Distribution Near the Centre of an Isolated Swept Wing at Subsonic Speed.** M.M.FREESTONE.
AGARD Conference Proceedings CP 35, Paper 15, pp.15-1 to 15-14, 6 refs., 1968.
An attempt has been made to design the centre of an isolated non-lifting swept wing on a simple basis. There are indications that improvements to the basic wing flow can be produced but further work is required.

CP35/16 **Factors Affecting the Choice of a Three-Dimensional Swept Wing Design for High Subsonic Speeds.** A.B.HAINES.
AGARD Conference Proceedings CP 35, Paper 16, pp.16-1 to 16-16, 20 refs., 1968.
The paper discusses the likely objectives for a sweptback wing design for operation at high subsonic speeds and the possible alternatives and results of two wings tested at ARA are used in illustration. Some of the compromises dictated by structural or engineering requirements are discussed and it is suggested that research is needed to establish the true exchange rates involved.

CP35/17 **An Approximate Method for the Determination of the Pressure Distribution on Wings in the Lower Critical Speed Range.** T.E.LABRUJERE, W.LOEVE, J.W.SLOOF.
AGARD Conference Proceedings CP 35, Paper 17, pp.17-1 to 17-10, 9 refs., 1968.
The paper presents an approximate method based on the assumption that the main characteristics of subsonic flow about wings are described sufficiently well by the linearised potential equation. The compressible flow is related to the incompressible flow round an analogous configuration which is obtained from the original one by an affine transformation. Viscous effects are then corrected for. Theoretical and experimental results are presented.

CP35/18 **The Aerodynamic Design and Testing of a Lifting Swept Wing Body Configuration with Shock Free Wing Flow at M = 1.20.** J BRIDGEWATER, S.O.T.HAN, H.KRAMER.
AGARD Conference Proceedings CP 35, Paper 18, pp.18-1 to 18-12, 6 refs., 1968.
A wing-body configuration has been designed to give economical cruise characteristics at low supersonic speeds by reducing wave drag as far as possible and by reducing boundary layer separation. Results of tunnel tests are presented and it is claimed that good lift/drag characteristics have been obtained.

CP35/19 **Wing-Body Interference at Supersonic Speeds.** K STEWARTSON, D.A.TREADGOLD.
AGARD Conference Proceedings CP 35, Paper 19, pp.19-1 to 19-9 11 refs., 1968.
The problem discussed is the interference between an infinitely long cylinder and a thin wing. Linearised solutions are discussed and attention is directed to the neighbourhood of the surface bounding the initial interaction region and the neighbourhood of the wing root. Finally a comparison is made with some experimental measurements.

CP35/20 **Experimental Investigation of Wing-Body Interferences in the Mach Number Range from 0.5 to 2.0.** W.SCHNEIDER.
AGARD Conference Proceedings CP 35, Paper 20, pp.20-1 to 20-23, 10 refs., 1968.
Transonic tunnel tests are described on three basic wings, a rectangular wing, a sweptback wing and a delta wing both alone and in combination with two pointed cylindrical bodies. Interference effects are presented.

CP35/21 **Effects of Reynolds Number and Boundary-Layer Transition on Location of Shock-Induced Separation.** J.A.BLACKWELL.
AGARD Conference Proceedings CP 35, Paper 21, pp.21-1 to 21-10, 9 refs., 1968.
A two-dimensional experimental and theoretical investigation is described on a NACA 65_1-213 airfoil to determine the effect of Reynolds number and transition location on shock-induced separation. It is claimed that, by properly locating the boundary-layer transition on the model, full scale results can be simulated at the usual wind tunnel Reynolds numbers and that the required transition point can be predicted with acceptable accuracy.

CP35/22 **Wind Tunnel Experiments on the Interference between a Jet and a Wing at Subsonic Speeds.** J.A.BAGLEY.
AGARD Conference Proceedings CP 35, Paper 22, pp.22-1 to 22-14, 3 refs., 1968.
A series of experiments are described in which the influence of a jet on the pressure distribution on an adjacent wing is measured. A brief survey is given of the effects of Mach number, jet pressure ratio and the spacing of the jet and the possibility of representing the blown jet by a solid body extending behind the nacelle is discussed.

CP35/23 **Some Problems of Transonic Flow for Engine Nacelles of Airbus Type Aircraft.** (in French). J.LEYNAERT, G.MEAUZE.
AGARD Conference Proceedings CP 35, Paper 23, pp.23-1 to 23-14, 17 refs., 1968.
High by pass ratio turbofans raise new aerodynamic problems due to the importance of the mass flow both at the intake and exhaust. These are discussed and electrical analogy and transonic tunnel measurements are presented.

CP35/24 **New Results on Steady, Two-Dimensional Transonic Flow.** K.OSWATITSCH.
AGARD Conference Proceedings CP 35, Paper 24, pp.24-1 to 24-11, 8 refs., 1968.
Research by two students is described. The first is work on the construction and discussion of two-dimensional transonic flow patterns and in the second the integral equation method is used to treat transonic flows past lifting aerofoils.

CP35S **Supplement to Conference Proceedings No. 35.**
AD-694-715 AGARD Conference Proceedings CP 35, Supplement, 38 pp., 3 refs., 1968.
N69-38630 A collection of edited discussions and additional submissions following the presentation of papers at the AGARD Fluid Dynamics Panel Specialist Meeting on "Transonic Aerodynamics". Also contains errata to the papers published in CP35.

CP36 **Symposium on Structural Optimization.**
N71-13125 AGARD Conference Proceedings CP 36, 446 pp. October 1970.
This publication contains the papers which have been presented at the Symposium on Structural Optimization by the Structures and Materials Panel on 8-10 October 1970, in Tarabya, Instanbul, Turkey.

The purpose of the Symposium was to bring together the work on optimization being conducted in the various NATO countries and to provide thereby a conspectus of the current advances in the state-of-the-art. The Symposium would then be a forum for the exchange of ideas among the participants from so many different countries and should be a stimulus for further research and development activities in structural optimization within NATO.

At the 26th Meeting of the Structures and Materials Panel a coordinating committee was delegated to organize the Symposium and invite experts from NATO countries to prepare contributions.

Four major topic areas were defined as follows:

1. Mathematical techniques in Optimization
2. Analytical and Idealization Models
3. Applications of Optimization
4. Man-Machine Interaction

The Symposium was arranged to consist of an Introductory Keynote session, one session for each of the above groups, and to close with a general discussion session.

CP37
Part 1
AD-685-665
N69-22576
Part 2
AD-685-666
N69-22605

Scatter Propagation of Radio Waves. Parts 1 and 2. E.THRANE (Editor).
AGARD Conference Proceedings CP 37, Parts 1 and 2, 740 pp., many refs., 1968.
These two volumes record the 50 papers and the discussion on them at the Fourteenth Symposium of the Avionics Panel of AGARD held at Sandefjord, Norway, 19-23 August, 1968. The papers deal with the importance of scatter propagation for communication purposes as well as the use of scattered radio waves as diagnostic tools for studying the scattering media. The individual papers are dealt with in the following abstracts.

CP37/1/1 **Ground Scatter in Review.** E.C.HAYDEN.
AGARD Conference Proceedings CP 37, Part 1, Paper 1, pp.1-1 to 1-26, 241 refs., 1968.
This introductory paper traces the history of the knowledge on High Frequency ground scatter from the late 1920s to the present time. It presents a bibliography arranged in chronological order and an author index. Applications and unsolved problems are discussed briefly and lists four avenues for future development.

CP37/1/2 **Surface Scattering in Ocean Roughness and Sea Ice Studies.** A.W.BIGGS.
AGARD Conference Proceedings CP 37, Part 1, Paper 2, pp.2-1 to 2-7, 11 refs., 1968.
The report reviews scattering from rough surfaces in terms of analytical and experimental results. Results of observations with a radar scatterometer with different sea states and with sea ice are described.

CP37/1/3 **A Study of the Process of Lateral Diffusion in a Bistatic Experiment Using Two Monostatic Decametric Radar Stations.** (in French). M.CROCHET.
AGARD Conference Proceedings CP 37, Part 1, Paper 3, pp.3-1 to 3-11, 5 refs., 1968.
An experiment between stations at Valensole (France) and Guadeloupe (West Indies) has made it possible to investigate side-scatter with the help of soundings by backscatter. The areas of scatter are determined by a time check of the signals, and different types of propagation are studied.

CP37/1/4 **Some Features of HF Back-Scatter Ionograms.** L.W.BARCLAY.
AGARD Conference Proceedings CP 37, Part 1, Paper 4, pp.4-1 to 4-8, 1 ref., 1968.
The report describes observations with a Granger 100 kW back-scatter sounder in which back-scattered returns from swept frequency, fixed azimuth HF pulse transmissions have been recorded on P'f ionograms at one minute intervals. The predominant feature is a return with a range which increases with increasing frequency an effect which is ascribed to focussing of the minimum time paths via the F-region. However other returns are observed at greater ranges which often have a range which is approximately independent of frequency. It is suggested that these are due to travelling disturbances in the ionosphere. It is concluded that for a path over land without outstanding profile features, the ionosphere variations are more important than ground scatter variations in determining the ranges at which returns are observed.

CP37/1/6 **The Reflection of Decametric Waves on the Earth's Surface by the Emission of Pulses and the Part this Plays in the Interpretation of Frequency Spectra of Echoes Obtained in Soundings by Back-Scatter.** (in French). C.GOUTELARD.
AGARD Conference Proceedings CP 37, Part 1, Paper 6, pp.6-1 to 6-22, 9 refs., 1968.
Two types of models have been used to demonstrate the reflection of signals over land and sea. Three effects may appear together diffusion, diffraction and interference. Energy is not transmitted solely as specular reflection and in every case a small part of the energy is diffused in other ways The quasi-isotropic property of the diffuse beams explains the formation of echoes in soundings by back-scatter.

CP37/1/7 **HF Ground Back-Scatter Analysis with the Aid of Computer Ray Tracing.** R.G.MALIPHANT.
AGARD Conference Proceedings CP 37, Part 1, Paper 7, pp.7-1 to 7-16, 8 refs., 1968.
This report describes a computer program which simulates the back-scatter process and produces synthetic back-scatter records directly on the computer output form at high speed. A description is given of some plots and the general features are discussed. The possibility of reversing the process is considered and finally the problems of translating experimental back-scatter records into synthetic oblique incidence ionograms for particular paths are discussed.

CP37/1/8 **Interference Patterns in HF Signals Back-Scattered from Ocean Waves.** D.B.MULDREW.
AGARD Conference Proceedings CP 37, Part 1, Paper 8, pp.8-1 to 8-11, 22 refs 1968.
The report describes certain back-scatter records which contain patterns of up to six parallel rids. It is thought that they are caused by interference of radio waves back-scattered from waves on the ocean surface at distances of a few thousand kilometers from the transmitter. It is suggested that a narrow beam back-scatter radar would be better than the oblique incidence sounder used if a study of the sea structure of the sea surface is required.

CP37/1/9 **Some Characteristics of Ground Side-Scatter at 20MHz.** D.W.RICE.
AGARD Conference Proceedings CP 37, Part 1, Paper 9, pp.9-1 to 9-10, 1968.
This report describes observations at Ottowa of the time delay and other characteristics of the 20MHz time standard transmissions from Washington. The observed signals arrive over an azimuthal range of 270° or more with transit times 10 to 20 milliseconds greater than that expected from great-circle propagation (3 milliseconds). They are interpreted in terms of two-hop propagation over a non-great-circle path with scatter occurring from the ground beyond the transmitter and receiver one-hop skip distances.

CP37/1/10 **Fading Amplitude Due to Interference from Forward Sea Scatter.** G.C.RIDER.
AGARD Conference Proceedings CP 37, Part 1, Paper 10, pp.10-1 to 10-10, 7 refs., 1968.
This paper deals with the prediction of fade depth for a ground to air propagation path with a view to plotting signal strength probability against range or time. A model is described and the results of some flight tests on three frequencies including the UHF and SHF bands are shown to be in acceptable agreement.

CP37/1/11 **Aperture Synthesis in Ground Back-Scatter Radar.** E.D.R.SHEARMAN, J.CLARKE.
AGARD Conference Proceedings CP 37, Part 1, Paper 11, pp.11-1 to 11-7, 7 refs., 1968.
The report proposes a method of improving the use of back-scatter radars for observing the properties of ionospheric layers over a large geographical area. The proposal is to use two aerials only, one fixed and one moving along a track, to record and then synthesise by computation the range/azimuth display which would have been obtained with a complete array the length of the track. Results obtained with an ultrasonic model using two separable transducers under water to detect targets illuminated by reflection at the rippled surface support the proposal and full scale radio experiments are in preparation.

CP37/1/12 **Short Note on the 2XF Diffuse Echoes Observed at Djibouti.** (in French). A.M.BOURDILA, J.ODOUX.
AGARD Conference Proceedings CP 37, Part 1, Paper 12, pp.12-1 to 12-5, 1 ref., 1968.
Daily records show diffuse tracings corresponding to echoes reflected twice by the F layer (2 x F) without the tracing 1 x F being affected. The records are studied statistically for the year 1964. In spring and summer two maxima appear; in autumn and winter three. This points to a marked influence of ionosphere while back-scatter on a rough sea may have some effect. The influence of magnetic activity appears to be small.

CP37/1/13 **Scattering of Electromagnetic Radiation by Particulate Suspension in the Atmosphere.** K.BULLRICH.
AGARD Conference Proceedings CP 37, Part 1, Paper 13, pp.13-1 to 13-18, 21 refs., 1968.
The paper, presented by a meteorologist, surveys the scattering parameters in the turbid atmosphere and describes the role of aerosol particles in terms of size, distribution, structure and refractive index. It states that the behaviour of the atmospheric aerosol and the scattering of higher orders must be included in the consideration of scattering processes in the atmosphere and records that knowledge is incomplete.

CP37/1/15 **Scattering of Radio Waves from Regular and Irregular Time Varying Refractive Index Structures in the Troposphere.** D.J.GJESSING.
AGARD Conference Proceedings CP 37, Part 1, Paper 15, 15-1 to 15-17, 24 refs., 1968.
The paper reviews the problems related to tropospheric radio scattering in a unified and simplified manner. Scattering from turbulent irregularities and scattering (reflection) from refractive index spectrum and the characteristic properties of the scattered radio wave are calculated in terms of the same general spectrum. The proposal is to treat the problems in such a way that a physical understanding of the phenomena is obtained by first order results.

CP37/1/16 **Theoretical Analysis of Medium-Dependent Fluctuations with Tropospheric Scatter Links, and Comparison with New Experimental Data, Including Side-Scatter Characteristics.** H.H.ALBRECHT.
AGARD Conference Proceedings CP 37, Part 1, Paper 16, pp.16-1 to 16-11, 23 refs., 1968.
This paper amplifies previous work by the same author and contains a theoretical treatment of the possible effects of frontal disturbances passing through a scatter volume as well as a general comparison of side-scatter data. New experimental data is shown to be in good agreement with theoretical values.

CP37/1/17 **Phase Quadrature Components of the Microwave Scattered Field in a Short Tropospheric Path as Related to the Meteorological Parameters.** G.I.BEARD, W.T.KREISS, W.F.TANK.
AGARD Conference Proceedings CP 37, Part 1, Paper 17, pp.17-1 to 17-10, 9 refs., 1968.
This report describes a microwave propagation experiment on an optical path with extensive meteorological instrumentation to show quantitively the effect of the atmospheric scatterers on the microwave statistics. A particular microwave technique is used at 10.4 GHz to resolve the received microwave field into its phase quadrature components to provide results directly.

CP37/1/18 **Phase and Amplitude Measurements of Transhorizon Microwaves with a Multi-Data-Gathering Antenna Array.** D.C.COX, A.T.WATERMAN.
AGARD Conference Proceedings CP 37, Part 1, Paper 18, pp.18-1 to 18-16, 6refs., 1968.
This paper describes a versatile vertical antenna array and receiving system which have been developed at Stanford University to operate at 3.2 GHz. The array consists of 12 parabolic antennae spaced on a tower to give a total vertical aperture of 15.24 m (162.5 wavelengths). The equipment samples phase difference between elements and amplitude at each element at rates up to 100 passes per second over the 12 elements. Data has been processed to produce a conventional array beam 0.3° wide scanned in elevation to produce angular response patterns.

CP37/1/19 **The Wavelength Dependence of Tropospheric Beyond-the-Horizon Propagation.** F.EKLUND.
AGARD Conference Proceedings CP 37, Part 1, Paper 19, pp.19-1 to 19-5, 1 ref., 1968.
This paper is a brief contribution summarising a paper to be published in "Radio Science". It deals with the wavelength dependence of received power in relation to free space power as measured over a 270 km tropospheric scatter path in Sweden. The frequencies were 1,000 and 3,000 MHz and the antennae both gave beam widths of 2.2°. The main findings are that wavelength dependence varies between λ^{-1} and λ^{+3} and the exponent is correlated with the level of received power. The results are discussed briefly.

CP37/1/20 **The Theory of Tropospheric Scattering in the Light of New Propagation Measurements.** L.FEHLHABER.
AGARD Conference Proceedings CP 37, Part 1, Paper 20, pp.20-1 to 20-5, 5 refs., 1968.
This report deals mainly with beyond-the-horizon propagation of frequencies from 1,000 MHz to 2,000 MHz. Theoretical investigations have shown that conclusions about the refractivity structure can be drawn from measurements of the electro-magnetic field at the receiving station. The wave spectrum of the refractivity, deduced in this way, is shown to agree with that deduced from turbulence theory. The dependence on height of the inhomogoneities of refractivity, needed to determine the transmission loss can usually be calculated from routine radiosonde data. A model of the troposphere is deduced and appears to explain most of the effects of tropospheric beyond-the-horizon propagation.

CP37/1/21 **Microwave Propagation Influenced by Internal Gravity Waves.** G.FENGLER, G.STILKE.
AGARD Conference Proceedings CP 37, Part 1, Paper 21, pp.21-1 to 21-10, 6 refs., 1968.
This paper deals with the influence of a moving rippled layer on the fading characteristics of VHF signals on transhorizon links. Measurements of micropressure variations on the ground are quoted and from these the existence of gravity waves in the lower troposphere is deduced. Corresponding variations in field strength on three 92.4 MHz radio paths show correlation. Thus the rippled layers are thought to influence the fading characteristics of transhorizon microwave links.

CP37/1/22 **Investigation of the Receiving Field for Scatter Propagation.** J.GROSSKOPF.
AGARD Conference Proceedings CP 37, Part 1, Paper 22, pp.22-1 to 22-11, 3 refs., 1968.
Many important parameters of tropospheric scatter propagation can be derived from the statistical structure of the electromagnetic field at the receiving site of a scatter link. This field structure is characterised by its space and time correlation functions. They are measured with a 418 km scatter link in 2,000 MHz frequency range, using an arrangement of three antennae. Analytical expressions for the correlation function and its scale length have been found.

CP37/1/23 **Electromagnetic Scattering from Air Currents.** H.N.KRITIKOS.
AGARD Conference Proceedings CP 37, Part 1, Paper 23, pp.23-1 to 23-6, 2 refs., 1968.
In this report the scattering of a plane monochromatic electromagnetic wave incident on an air current is studied by considering a jet stream in a homogeneous dielectric fluid to be its idealized model. The results show that first order reflections can only take place at forward scattering, large angles of incidence and transitions which are of the order of a wavelength. For wind shears of 0.1 sec^{-1} an angle of incidence of 85° and a frequency of 50 MHz the reflection coefficient is of the order of $R = 10^{-10}$.

CP37/1/24 **Tropospheric Scatter Propagation at 16 GHz Over a 500 km Path.** U.H W.LAMMERS, E.A.ALTSHULER, J.W.B.DAY.
AGARD Conference Proceedings CP 37, Part 1, Paper 24, pp.24-1 to 24-10, 1 ref., 1968.
This report describes the equipment being used in a troposcatter experiment. Synchronous, computer controlled beam-swinging techniques give two-dimensional cuts of the troposphere covering up to 2,000 km^2 in a 10 minute raster scale. High stability CW signals are used for Doppler and spectral studies within the 5 km^3 troposcatter volume. Some preliminary results are presented and it is hoped that by development more and useful information can be gathered from the troposphere than was hitherto possible.

CP37/1/25 **Using the Tropospheric Volume of a Quasi-Back-Scatter Link to Investigate the Scatter Mechanism.** R.MENZEL, Kh.ROSENBACH.
AGARD Conference Proceedings CP 37, Part 1, Paper 25, pp.25-1 to 25-8, 12 refs., 1968.
The first part of this paper refers to the effect of diffraction paths between transmitter and receiver and possibilities of accounting for these paths; it includes the comparison between values calculated theoretically and experimental determinations on selected paths over hilly terrain. The second part gives experimental data obtained with the quasi-back-scatter link and includes a detailed discussion on measured values in relation to theory. Results are interpreted in relation to data from other scatter links.

CP37/1/26 **Notes on the Theory of Troposcatter Modulation Distortion.** A.WASILJEFF.
AGARD Conference Proceedings CP 37, Part 1, Paper 26, pp.26-1 to 26-13, 9 refs., 1968.
The report discusses the theories used to calculate the intermodulation distortion caused by tropospheric effects and prefers Bremmer's "few echoes" theory. It gives a generalisation of the theory including autocorrelation functions of the Norton type. The frequency multiplex signal is represented by a pre-emphasised band-limited Gaussian noise. The aim of this paper is to calculate the intermodulation of such a signal caused by the tropospheric effects.

CP37/1/28 **Radio Wave Scattering from the Ionospheric D-Region.** J.B.GREGORY.
AGARD Conference Proceedings CP 37, Part 1, Paper 28, pp.28-1 to 28-15, 44 refs., 1968.
This review paper deals with partial reflections and scattering of radio waves vertically incident upon the lower ionosphere. Present knowledge is summarised and theoretical treatments of perturbations in electron density and collision frequency are examined. Applications of scattering to the determination of electron densities below 100 km, to the measurement of winds above 65 km, and to the detection of particle influx are discussed.

CP37/1/29 **Drift Measurements by Use of D-Region Partial Reflections.** A.HAUG, O.HOLT.
AGARD Conference Proceedings CP 37, Part 1, Paper 29, pp.29-1 to 29-8, 9 refs., 1968.
The report records preliminary results from an experiment where Mitra's method of drift measurement in the ionosphere is applied to D-region partial reflections. Partially reflected waves of frequency 2.75 MHz are received on four loop aerials with a spacing of the order of one wavelength. The fadings are recorded on four-channel magnetic tape and an analogue computer is used in the correlation analysis. Drift measurements have been made down to 60 km but normally the reflections come from 70-80 km. The report states that as observations have just begun it is impossible to draw any conclusions but the paper is presented to show the feasibility of the method.

CP37/1/31 **Thomson Scatter as a Communication Mode.** A.M.PETERSON.
AGARD Conference Proceedings CP 37, Part 1, Paper 31, pp.31-1 to 31-11, 26 refs., 1968.
The report suggests that scattering of radio waves by density fluctuations of free electrons (Thomas scatter) in the upper region of the ionosphere offers possibilities of long distance communication in the VHF and UHF bands. While high transmitter power and large a tennae would be required, the communication capacity of this propagation mode would decrease only slowly with path length up to about 4,000 km. A wide range of frequencies could be used, with the 100 to 1,000 MHz range being the most likely for practical applications

CP37/1/32 **Incoherent Scatter Observations of the E-Region.** G.N.TAYLOR.
AGARD Conference Proceedings CP 37, Part 1, Paper 32, pp.32-1 to 32-10, 8 refs., 1968.
This report describes a method of measuring profiles of electron concentration against height in the lower ionosphere with a pulsed incoherent scatter radar. Some typical mid-latitude summer profiles for both night time and daytime are presented. Plots of the heights of well-defined peaks against time illustrate the relative stability of the normal- and sporadic-E peaks, and the large number of abnormal propagation modes that can exist for short periods.

CP37/2/34 **Auroral Scatter.** P.A.FORSYTH.
AGARD Conference Proceedings CP 37, Part 2, Paper 34, pp.34-1 to 34-10, 26 refs., 1968.
This report reviews the evidence on the nature of radio aurora particularly that relating to the scattering mechanism. Much evidence is found to support the hypothesis that the radio waves are scattered from electron density gradients produced by propagating ion-acoustic waves and it is suggested such waves could be generated by the auroral electrojet. However there is considerable evidence which cannot be explained by the existence of ion-acoustic waves. It is concluded that this evidence relates to occasions in which radio waves are weakly scattered by electron density gradients randomly distributed.

CP37/2/35 **A Note on a Particular Type of Scattering Echoes Observed at High Altitudes.** K.FOLKESTAD.
AGARD Conference Proceedings CP 37, Part 2, Paper 35, pp.35-1 to 35-5, 3 refs., 1968.
This report deals with a particular type of back-scatter traces recorded in swept frequency oblique soundings at high altitudes. Results of attempts to interpret the measured returns are given and the explanation offered is in terms of aspect sensitive scattering from irregularities in limited regions of enhanced ionization density to the north of the sounding site.

CP37/2/36 **Field Aligned Ionization Scatter Geometry.** G.M.MILLMAN.
AGARD Conference Proceedings CP 37, Part 2, Paper 36, pp.36-1 to 36-13, 12 refs., 1968.
This paper evaluates the theoretical and graphical methods for calculation: (i) the orientation of the magnetic field for back-scatter reflections, and (ii) the locus of points on the earth's surface for the reception of the forward-scatter mode. Computations for both the back and forward-scatter are presented for two locations in the Northern hemisphere.

CP37/2/38 **Review of VHF Forward-Scatter.** R.C.KIRBY.
AGARD Conference Proceedings CP 37, Part 2, Paper 38, pp.38-1 to 38-12, 36 refs., 1968.
This report presents mainly a description of the continuous propagation observed at oblique incidence throughout the world in the frequency range of 25 to 110 MHz, scattered from irregularities in electron density from 70 to 90 km and from meteoric ionization. Observations have been largely over 1,000 to 2,000 km path lengths in the Northern and Southern hemispheres and near the equator using pulsed and continuous wave transmissions. Some attention is drawn to extra modes of propagation, primarily from the E-region at low altitudes and aurora at high altitudes and absorbtion effects are mentioned.

CP37/2/39 **Electromagnetic Scattering from a Plasma Slab Having Large Scale, Random Density Fluctuations.**
A.F.HOCHSTIM, C.P.MARTINS.
AGARD Conference Proceedings CP 37, Part 2, Paper 39, pp.39-1 to 39-8, 2 refs., 1968.
In this report calculations are made of the energy reflected from a parallel plasma slab having random amplitude step-function fluctuations of electron density when a plane electromagnetic is incident normally to it. Results are compared with exact calculations from a computer model. It is shown that the first Born approximation using the power spectrum method can deviate appreciably from an exact calculation. The statistical averaging method or the use of the corellation function gives improved results.

CP37/2/40 **Controllability Aspects of Scatter Propagation of Radio Waves.** M.Z von KRYWOBLOCKI.
AGARD Conference Proceedings CP 37, Part 2, Paper 40, pp.40-1 to 40-15, 58 refs., 1968.
The paper discusses whether it is possible to improve present methods of selecting the optimum frequencies for various types of scatter propagation. These are usually based on a statistical approach and the author discusses whether it is possible to use methods which are mathematically stronger. The paper presents the main equations used in scatter calculations and suggests that these may be used to give the optimum values of the parametric variables of the sending station.

CP37/2/41 **VHF Ionospheric Scatter Propagation Via the Equatorial Electrojet.** C.A.ROMERO, A.A.GIESECKE, E.P.O.PEREZ.
AGARD Conference Proceedings CP 37, Part 2, Paper 41, pp.41-1 to 41-30, 8 refs., 1968.
This report presents a statistical analysis of VHF ionospheric forward scatter signals propagated via the equatorial electrojet. Continuous data were obtained from November 1966 to June 1967. During this period, as during the International Geophysical year, the signal levels propagated by forward scatter at the magnetic equator were considerably higher than those for similar paths at temperate latitudes. A statistical study of the results provides the seasonal variation of the morning and evening reversal times. The results of magnetic storms, sudden ionospheric disturbances and the total eclipse of November 12, 1966 are studied.

CP37/2/42 **Microwave Scattering from Spherical Electron Clouds.** N.W.ROSENBERG, M.M.KLEIN, G.ANDERSON.
AGARD Conference Proceedings CP 37, Part 2, Paper 42, pp.42-1 to 42-10, 3 refs., 1968.
In the report the scattering of radio waves by a spherical electron cloud with a Gaussian distribution of electron density has been treated numerically by ray optics methods. In the case of no magnetic field, it is found that a hard or highly overdense sphere may be replaced by a conducting sphere of radius equal to the critical radius although this approximation is inaccurate for slightly overdense or softer spheres

CP37/2/43 **Stochastic Theory of the Scattering of Electromagnetic Waves from a Random Medium.**
AGARD Conferenee Proceedings CP 37, Part 2, Paper 43, pp.43-1 to 43-9, 6 refs., 1968.
This report studies wave propagation and scattering in a random medium by means of a wave equation which includes the effect of a random plasma motion as well as the presence of a random density. It presents the spectrum of the scattered power and the spectral functions of density and velocity.

CP37/2/45 **A Review of Transequatorial Propagation.** D.L.NIELSON.
AGARD Conference Proceedings CP 37, Part 2, Paper 45, pp.45-1 to 45-18, 40 refs., 1968.
The paper reviews published and unpublished literature concerning VHF propagation over transequatorial paths. At least two classes appear to exist. Propagation of one class uses refraction from the horizontal gradients of electron density that are regular diurnal characteristics of the equatorial ionosphere. A second class, the propagation of frequencies above about 60 MHz over 4,000 to 6,000 Km paths is due to both normal refraction . . a low-loss reflection mechanism that is not yet completely defined. Signal characteristics for this second class are documented and three possible mechanisms discussed.

CP37/2/46 **The Importance of Horizontal F-Region Drifts to Transequatorial VHF Propagation.** D.L.NIELSON.
AGARD Conference Proceedings CP 37, Part 2, Paper 46, pp.46-1 to 46-6, 2 refs., 1968.
This report offers evidence for oblique reflection from a moving F-region irregularity at frequencies as high as 90 MHz. The velocity of the irregularity is 150 m/sec in an east-west direction. Evidence is also presented of the relative sensitivity of VHF propagation on a 5,000 Km transequatorial path to magnetic latitudinal and longitudinal variations.

CP37/2/47 **Study of Transequatorial Propagation Outside the Great Circle Path in a Period of F-Region Drift.** (in French). M.CROCHET, P.BROCHE.
AGARD Conference Proceedings CP 37, Part 2, Paper 47, pp.47-1 to 47-9, 8 refs., 1968.
Describes a study of the propagation between France and the South Pacific between June 1965 and June 1968 on decametric wavelengths. A type of propagation was found outside the great circle which was very stable. Three possible explanations are discussed.

CP37/2/48 **Ray Tracing Over a Transequatorial Path.** N.C.GERSON.
AGARD Conference Proceedings CP 37, Part 2, Paper 48, pp.48-1 to 48-23. 10 refs., 1968.
In this report ray-tracing methods are employed to clarify the mechanism of transequatorial propagation. The basic data used were 41 MHz back-scatter soundings south Mayaguez, Puerto Rico, and vertical incidence observations converted into electron density v true height profiles. The results imply that more transequatorial signals would be observed at lower frequencies and with lower launch angles.

CP37/2/49 **Transequatorial Propagation Implications of Equatorial Vertical Drift Measurements.** R.COHEN, J.P.McCLURE.
AGARD Conference Proceedings CP 37, Part 2, Paper 49, pp.49-1 to 49-9, 34 refs., 1968.
This report suggests that in view of the successes of theoretical developments and the ability to measure vertical drifts of the F-region plasma at the magnetic equator it should be possible to clarify the transequatorial propagation phenomena. The status of theory and experiment is reviewed and a programme of investigation is recommended.

CP37/2/51 **F-Region Scatter.** R.COHEN.
AGARD Conference Proceedings CP 37, Part 2, Paper 51, pp.51-1 to 51-12, 37 refs., 1968.
The report reviews experience in F-region propagation attributable to scattering and the results of forward scatter and back-scatter studies are summarised. These results are related to their consequences and utility for F-region scatter propagation.

CP37/2/52 **Radio-Doppler Observations of the Ionosphere Near the Magnetic Equator.** K.DAVIES, N.J.F.CHANG.
AGARD Conference Proceedings CP 37, Part 2, Paper 52, pp.52-1 to 52-6, 4 refs., 1968.
A model is proposed to explain echoes with marked frequency scatter during evening hours which have been observed in radio observations of the ionosphere near the magnetic equator on 10 and 20 MHz frequencies. Statistical evidence is presented and the model is used to explain the observations in terms of asymmetric atmospheric waves propagating from West to East with velocities in the range of 100 to 150 m/sec.

CP37/2/53 **Joint Probability Density of Signal Fading at Spaced Receivers.** T.J.ELKINS.
AGARD Conference Proceedings CP 37, Part 2, Paper 53, pp.53-1 to 53-15, 2 refs., 1968.
An attempt is made to apply the technique of spaced receiver measurements of fading signal propagation to include cases in which the "drifting screen" analysis fails. A model is considered and a comparison using signals from a geo-stationary satellite on 136 MHz gives an indication that it may be of practical value.

CP37/2/55 **HF Radar Signatures of Travelling Ionospheric Irregularities – 3D Ray-Tracing Simulation.** T.M.GEORGES, J.D.STEPHENSON.
AGARD Conference Proceedings CP 37, Part 2 Paper 55, pp.55-1 to 55-15, 16 refs., 1968.
A technique is described for simulating a multitude of ground-back-scatter displays using information

supplied by three-dimensional computer ray tracing. Model ionospheres containing realistic wavelike travelling disturbances are used to produce representative displays and to correct some misconceptions about the interpretation of back-scatter signatures.

CP37/2/56 **Nature of F-Region Irregularities Inferred from Oblique Reflection Measurements.** L.C.HUMPHREY, C.R.ROBERTS, R.MATHER.
AGARD Conference Proceedings CP 37, Part 2, Paper 56, pp.56-1 to 56-7, 2 refs., 1968.
Data from two types of measurements are described which reveal the nature of both long-term and short-term irregularities, including travelling ionospheric disturbances. These measurements are the fading characteristics themselves and the apparent azimuth of arrival on the long distance path. The strength, curvature, and extent of the irregularities are deduced from the measurements.

CP37/2/58 **Back-Scatter Observations from Distant Field-Aligned Irregularities.** H.KOPKA, H.G.MÖLLER, W.STOFFREGEN.
AGARD Conference Proceedings CP 37, Part 2, Paper 58, pp.58-1 to 58-14, 10 refs., 1968.
Reflections from distant field-aligned irregularities have been observed by back-scatter observations and correlation with the occurence of spread-F in the region from Uppsala and Juliusruh has been established. The relative magnitude of back-scattered energy is calculated as a function of the relative electron density variation and the distance of the scattering irregularities.

CP37/2/59 **Research on Field-Aligned Propagation of HF Radiowaves using Alouette 2 Topside Sounder Data and Digital Ray-Tracing Techniques.** J.RAMASATRY, E.J. WALSH, J.R.HERMAN.
AGARD Conference Proceedings CP 37, Part 2, Paper 59, pp.59-1 to 59-22, 13 refs., 1968.
The first part of this paper covers the study of guidance of HF radiowaves along field-aligned paths using the topside sounder data from the Alouette 2 satellite. A self-consistent explanation based on the assumption of multiple reflections is offered for the observed characteristics. The second part gives the results of ray tracing studies of the guidance of HF radiowave along field-aligned ionization irregularities in the magnetosphere.

CP38 **New Experimental Techniques in Propulsion and Energetics Problems.**
AGARD Conference Proceedings CP 38, October 1970 - Technivision.
This contains the papers and discussions presented at the meeting held in September 1968 on the above subject. The 31 papers presented cover such areas as instrumentation and shock tube measurements, projectiles and gun tunnel techniques, mass spectrometry and other miscellaneous techniques.

CP39
AD-697-621
N70-12051 **Storage and Retrieval of Information – A User-Supplier Dialogue.** Edited by H.F.VESSEY, I.J.GABELMAN.
AGARD Conference Proceedings CP 39, 198 pp., many refs., 1968.
This volume records the proceedings of a symposium arranged jointly by the Avionics and Technical Information Panels and held at Munich 18-20 June 1968. The aim of the symposium was to bring together suppliers of information (information scientists, documentalists, etc.) and users of information (engineers and scientists), to discuss information storage and retrieval using computers. Texts of the 16 papers and discussions are given. Topics covered are the individual points of view of user and supplier, present operation manual and mechanical systems, mechanical reading, on-line storage and retrieval, user needs, selective dissemination of information, interactive information processing and education of user and supplier. The 16 papers are dealt with individually in the following abstracts.

CP39/1 **Communication and Secrecy in Science.** R.SCHRADER.
AGARD Conference Proceedings CP 39, Paper 1, pp.1-8, 1968.
The paper points out that, despite mechanical processing and dissemination, direct contact by discussion, correspondence and conferences will continue to play a major role in communication. Secrecy, whether military or commercial, is to be deprecated and should not be applied to pure research as it can only bring short term advantages. Finally, recommendations made by the NATO Science Committee on exchanges of scientific information, cooperation in publication and coordination of documentation centres are recalled.

CP39/2 **The Supplier's Point of View – Introductory Paper.** H.F.VESSEY.
AGARD Conference Proceedings CP 39, Paper 2, pp.11-19, 1968.
The tasks, problems and equipment available to the documentalist or information officer are outlined. The types of information agencies libraries, documentation centres, information analysis centres and referral centres, and the services each provides, are briefly described. The economic need to link information retrieval by computer with other activities such as preparation of abstract journals, indices, SDI, is stressed. Finally future developments in mechanisation and the need for education of documentation service users are discussed.

CP39/3 **The Problems Raised by the Documentary Vocabulary and the Preparation of Dictionaries and Thesauri.** (in French). F.LEVERY.
AGARD Conference Proceedings CP 39, Paper 3, pp.21-38, 1968.
The preparation of documentary card (or similar) indices implies that the information contained in a text can be represented by a certain number of signs. The signs used made up a documentary vocabulary serving two purposes, to describe the text and to allow search. To fulfil both tasks documentary vocabulary must be extensive and structural (to assist search). Structural documentary dictionaries or thesauri appear to be the indispensable link between authors and those requesting information. Some practical methods for preparing thesauri are described.

CP39/4 **Four "New" Sciences: An Approach to Complexity.** E.B.MONTGOMERY.
AGARD Conference Proceedings CP 39, pp.41-47, 1968.
Present-day discoveries are causing an exponential growth in information because a discovery in one field may very well lead to new discoveries and the generation of new information in other related fields and even in other disciplines. The problem is one of coping with complexity. Four "new" sciences, not new in themselves, but looked at from new points of view are suggested as solutions, namely Information science, Communication science, System science and Application science. Finally, it is suggested that the Science of science itself may provide answers to some of the problems.

CP39/5 **Trends and Developments in Character and Pattern Recognition.** L.A.FEIDELMAN.
AGARD Conference Proceedings CP 39, Paper 5, pp.49-60, 10 refs., 1968.
Up-to-date developments in the fields of pattern and character recognition are described, and technical and economic possibilities for the near future are forecast by surveying present technical principles, present and potential areas of application, and significant trends.

CP39/6 **Efficient Transfer of Textual Information.** J.W.ALTMAN.
AGARD Conference Proceedings CP 39, Paper 6, pp.63-75, 11 refs., 1968.
Three problems which arise in attempts to achieve efficient provision of textual information to scientists and engineers are discussed. (a) Text-sensitive tasks of scientists and engineers have not been delineated and analysed sufficiently to define clearly their requirements for textual information support. (b) Methods have not yet been established to permit characterisation of text in terms which support the development of a technology for efficient transfer of text to users. (c) Little effort has been devoted to establish lawful relationships between text-sensitive tasks and characteristics of text.

CP39/7 **On-Line Information Storage and Retrieval.** N.S.PRYWES.
AGARD Conference Proceedings CP 39, Paper 7, pp.77-87, 21 refs., 1968.
The components of an automatic storage and retrieval system are briefly reviewed. The storage, indexing and the generation of a library classification system are described. It is concluded that the interactive man-computer retrieval process which follows offers the best potential for improving retrieval effectiveness.

CP39/8 **Non-Numerical Mathematics and Data Processing.** F.KRÜCKEBERG.
AGARD Conference Proceedings CP 39, Paper 8, pp.89-96, 14 refs., 1968.
Several problems involving non-numerical mathematics are listed. In the field of non-numerical data processing, the following topics are discussed briefly: Group Theory, Games Theory, Translation, Graph Theory, Pattern recognition and enhancement.

CP39/9 **Manual Systems – TDCK Circular Thesaurus System.** J.A.SCHÜLLER.
AGARD Conference Proceedings CP 39, Paper 9, pp.99-110, 1968.
The organization, functions and systems, all manual, used at TDC are described. TDCK collects, evaluates, stores and disseminates information primarily for the Netherlands Armed Services. The retrieval systems mainly used are the Universal Decimal System and the TDCK Compact System. In the latter, which is described in some detail the terms in the Thesaurus are arranged on concentric circles and arrows radiating outwards display relationship

CP39/10 **Mechanical Systems.** N.E.C.ISOTTA.
AGARD Conference Proceedings CP 39, Paper 10, pp.111-115, 1968.
The view is put forward that the handling of large document files requires mechanization and that even indexing, question analysis and retrieval result evaluation must eventually be by machine. Key punching for computer input presents particular problems and the solution could be optical scanning if standardised print formats were used in document production. The direct interrogation of the machine file with remote visual display is an inevitable development and the ESRO/ELDO Documentation service hopes to have a network available in Europe in 1969.

CP39/11 **An Introduction to the Study of Cost Effectiveness in Information Services.** J.N.WOLFE.
AGARD Conference Proceedings CP 39, Paper 11, pp.117-121, 1968.
Observations on the nature of cost effectiveness studies in general are made as an introduction to the procedures being adopted in a study of information services commissioned by the Office of Scientific and Technical Information, UK. Cost determination for alternative types of service is the first step in the procedure.

CP39/12 **Technical Information Services and User Needs.** W.C.CHRISTENSEN.
AGARD Conference Proceedings CP 39, Paper 12, pp.123-130, 1968.
Three audiences for technical information are defined. the general audience, the mission audience, and the technical management audience. The information needs of these three groups are discussed. The provision of technical information by the US Department of Defense is outlined, and in particular, some of the functions of the Defense Documentation Center are described.

CP39/13 **Selective Dissemination of Information.** M.S.DAY.
AGARD Conference Proceedings CP 39, Paper 13, pp.133-148, 1968.
Selective Dissemination of Information (SDI) provides individual scientists and engineers with announcements of a limited number of documents specifically of interest to them. Selection is done by a computer process, which compares a file of bibliographic data with a customers interest profile, then prints out references to matching documents. Economical service to a large number of customers may be provided by the use of standard subject profiles, as typified by the NASA/SCAN (Selected Current Aerospace Notices) program which is described.

CP39/14 **Interactive Information Processing, Retrieval, and Transfer.** J.R.C.LICKLIDER.
AGARD Conference Proceedings CP 39, Paper 14, pp.151-166, 17 refs., 1968.
Describes the present status and trends of man-computer-interactive information processing, retrieval and transfer made possible by multi-access computers. Examples are drawn from three projects, MAC, TIP and Intrex at the Massachusetts Institute of Technology.

CP39/15 **Man-Machine Interface.** W.HÄNDLER.
AGARD Conference Proceedings CP 39, Paper 15, pp.169-178, 1968.
The problem of the man-machine interface is traced back to the time when the first computers were designed. In overcoming the problems of the interface the cathode-ray tube display is said to be of prime importance. Solution to many of the problems, however, still awaits better knowledge of how information processing takes place within the human nervous system.

CP39/16 **Education.** F.LIEBESNY.
AGARD Conference Proceedings CP 39, Paper 16, pp.179-185, 4 refs., 1968.
The educational requirements for users and suppliers of scientific and technical information and the steps taken to provide professional education for various levels of attainment are discussed. Mention is made of the specific efforts made in the UK to provide undergraduate and postgraduate training for users. The type of training courses available to suppliers – chartered librarians, library assistants and information scientists – are outlined.

CP40 **Aeromedical Aspects of Troop Transport and Combat Readiness.**
AD-687-775 AGARD Conference Proceedings CP 40, 84pp., many refs., 1968.
N69-26833 This volume contains the papers presented at the AGARD/NATO Study of Aeromedical Aspects of Troop Transport and Combat Readiness held in NATO headquarters at Brussels 10-11 October 1968. Nine papers were presented in the two day Meeting, the subjects covered ranging from logistics and organisational problems, to field and to laboratory studies, on for example, thermal comfort. Attention was drawn to the difference between the problems of long range transport with its conditions similar to those of commercial passenger flying, and medium range transport with its characteristic problems of noise and turbulence and thermal discomfort. Difficulties in language were particularly referred to in conjunction with multi-national air lifts and casualty evacuation. The nine papers are dealt with in the following abstracts.

CP40/1 **Troop Transport Operations.** G.H.DHENIN.
AGARD Conference Proceedings CP 40, Paper 1, pp.1-1 to 1-2, 1968.
This short paper describes the operational conditions from which the aeromedical aspects derive. It is based on British practice but this differs only in degree from that of most other countries. On long range flights the troops ride in comfort comparable to that of civil airlines and the only medical problems are fatigue, upset to circadian rhythms and lack of acclimatisation. On short and medium range flights comfort is less and the medical problems are airsickness and fatigue. Helicopters may accumulate toxic concentrations of carbon-monoxide if cabin guns are fired.

CP40/2 **Experience Gained from the Air Transport of the Medical Units AMF (L) During the Period 1965 Through 1967.** W.K.THIERSCHMANN.
AGARD Conference Proceedings CP 40, Paper 2, pp. 2-1 to 2-4, 1968.
A short paper based on the experience of the Medical Unit in the course of three years. In principle, each transport aircraft should carry one complete, fully operable surgical section. Transportation of the Medical Unit AMF (L) was by the following aircraft types C124, C130 model E, C133 and C141.

CP40/3 **Results of a Medical Enquiry on Air Transport of Italian Paratroops.** P.ROTA.
AGARD Conference Proceedings CP 40, Paper 3, pp. 3-1 to 3-5, 1968.
Presents the results of a questionnaire to Italian paratroops on a mission including flight, parachuting and ground tasks.

CP40/4 **Biological Rhythms.** C.H.KRATOCHVIL.
AGARD Conference Proceedings CP 40, Paper 4, pp. 4-1 to 4-9, 25 refs., 1968.
Reviews the pertinent literature and points out areas in which further research is required.

CP40/5 **The Physiological Basis of Artificial Acclimatization Techniques.** J.R.ALLAN.
AGARD Conference Proceedings CP 40, Paper 5, pp. 5-1 to 5-2, 12 refs., 1968.
The report states that although the value of heat acclimatization has been repeatedly demonstrated there is as yet no practical method for reserve forces based in temperate climates. Experimental results show promise and the need for further work.

CP40/6 **The Prevention of Motion Sickness During Troop Transport.** J.J.BRAND.
AGARD Conference Proceedings CP 40, Paper 6, pp. 6-1 to 6-2, 2 refs., 1968.
The paper states that with troop transportation motion sickness will occur in a significantly large proportion and may impair operational efficiency. Drugs may be used but may be potentially dangerous if not well controlled. Various prophylactic regimes are discussed.

CP40/7 **Medical Aspects of Combat Force Airlift Deployment.** F.BARNUM.
AGARD Conference Proceedings CP 40, Paper 7, pp. 7-1 to 7-10, 4 refs., 1968.
Pre-deployment briefing and the post-deployment comments of the Division Surgeon in the airlift of about 10,000 troops are discussed briefly. The larger portion of the report deals with a C-141 incident where rapid decompression occurred at 34,600 ft. Of the 96 troops one required hospital treatment while the others proceeded on after a delay of approximately 40 hours.

CP40/8 **Assessment of Thermal Comfort in Flight and Its Effects on Performance.** R.F.GOLDMAN.
AGARD Conference Proceedings CP 40, Paper 8, pp. 8-1 to 8-14, 19 refs., 1968.
The thermal environmental factors that affect man are reviewed briefly and levels at which troops might experience distress are discussed. The after effects of exposure are considered and residual dehydration is singled out as the most probable cause of subsequent problems.

CP40/9 **Military Medical Aspects of High Altitude.** R.P.CARSON.
AGARD Conference Proceedings CP 40, Paper 9, pp. 9-1 to 9-6, 9 refs., 1968.
The marked effects of high altitudes on the earth are stated to be accentuated by the rapidity of exposure made possible by air transport. The problems are discussed in relation to studies of healthy volunteers rapidly transferred from sea level to Pikes Peak, Colorado (14,000 ft.).

CP41
AD-691-092
N69-34751 **Pattern Recognition – Body Armour and Aircrew Equipment Assemblies – Current Space Medical Problems – Aeromedical Evacuation.**
AGARD Conference Proceedings CP 41, 308 pp., many refs., 1968.
Records the papers presented at the 25th Meeting of the Aerospace Medical Panel of AGARD held in London, England, 15-17 October, 1968. This volume contains the text of 29 papers covering the four main topics of the title. These papers are dealt with in the following abstracts.

CP41/A1 **Visual Theory in Target Acquisition.** E.B.DAVIES.
AGARD Conference Proceedings CP 41, Paper A1, pp. A1-1 to A1-13, 15 refs., 1968.
The theoretical approach to visual search for a target based on the target's contrast and size and the concept of visual-lobes is reviewed briefly. New flight data for foveal contrast size thresholds related to the maximum detection ranges of prominent terrain objects, are found to compare favourably with laboratory data from much simpler visual tasks.

CP41/A2 **Towards a Theory of Visual Search.** C.I.HOWARTH, J.R.BLOOMFIELD.
AGARD Conference Proceedings CP 41, Paper A2, pp. A2-1 to A2-12, 11 refs., 1968.
As part of a fuller programme of research into the nature of visual search a simple adaptable search has been devised in which subjects look for the odd disc in a display of larger or smaller discs. Extensive studies of well practised observers have produced much basic research data.

CP41/A3 **Variables Underlying the Recognition of Random Shapes.** H.J.CLARK, R L.KNOLL.
AGARD Conference Proceedings CP 41, Paper A3, pp. A3-1 to A3-9, 37 refs., 1968.
Previous studies have shown that shape association value is a strong determining factor in shape recognition. In this study, the physical characteristics of shapes of high and low association value are compared. Results are that none of the factors differentiated between the two classes of shapes.

CP41/A4 **Perception and Identification of Simple Images, Presented in Different Sequences, by Subjects Submitted to various Gravitational Fields.** A.SCANO, G.MEINERI, R.CAPORALE.
AGARD Conference Proceedings CP 41, Paper A4, pp.A4-1 to A4-9, 23 refs., 1968.
This paper describes the results of research on eleven reliable subjects. While fixing the centre of a perimeter with one eye they were required to identify simple images located at various angles from the centre and illuminated for a short time. The results were little affected by subjecting the observers to gravitational fields of up to + 2.4 g.

CP41/A6 **Information on Maps for Air and Ground Use.** V.D.HOPKIN.
AGARD Conference Proceedings CP 41, Paper A6, pp.A6-1 to A6-4, 1968.
A trial sheet of the Joint Operations Graphic intended for air and ground use, is discussed and some of the causes for the unfavourable comments of some potential users are indicated.

CP41/A7 **The Influence of Lighting for Reading Navigation Maps.** (in French). A.MERCIER, G.PERDRIEL, J.CHEVALERAUD.
AGARD Conference Proceedings CP 41, Paper A7, pp A7-1 to A7-11, 1968.
Questionnaire results from 163 navigators of military and civilian aircraft are addressed to the problem of the lighting mode preferred in the reading of navigational maps. Red or white or mixed light effects were evaluated. Both night-time and day-time considerations were involved. The majority of navigators preferred mixed lighting (during both rolling and take-off), and they abandoned red lighting to some degree during the cruising phase of flight when maximum use of map reading occurs. Questions regarding lighting intensity, the ease of adaption to exterior viewing needs, the fatigue produced by different lighting conditions, and the choice of French-type or American-type maps were also put to the navigators; responses were unanimous in favour of control of the red element in lighting conditions.

CP41/A8 **Philosophies of Voice Communication Systems Design.** R.T.CAMP.
AGARD Conference Proceedings CP 41, Paper A8, pp.A8-1 to A8-2, 1968.
Typical tape recordings were used to demonstrate the need for improved aircraft voice communication. It is suggested that the philosophy of systems design since World War II is responsible for the present low efficiency systems. A new philosophy of systems design is proposed and tape recordings were used to demonstrate the claim that high intelligibility under high ambient noise conditions is possible.

CP41/A9 **Research Findings on Target Detection that have Implications for Pattern Recognition.** H.C.SELF.
AGARD Conference Proceedings CP 41, Paper A9, pp.A9-1 to A9-4, 10 refs., 1968.
Describes a series of studies of the target-finding behaviour of observers. Some of the findings having implications for pattern recognition are discussed. Within wide limits contrast is said to influence reaction time more than it does probability of recognition and target finding is complicated by target-background interaction. Likely target locations reduce image quality requirements while unlikely ones increase them. It is concluded that a priori search patterns can be inefficient and that detection models must be very complex to be useful.

CP41/B1 **Aircrew Protective Systems.** T.E.SULLIVAN.
AGARD Conference Proceedings CP 41, Paper B1, pp.B1-1 to B1-12, 1968.
This paper covers the development of armour materials, especially reinforced plastic-ceramic composite armour for protection of men and equipment against small arms fire and shell fragments. Emphasis is placed on applications for aircraft particularly helicopters. The results of wound ballistic studies are reported from South East Asia and the psychological effects of the use of body armour are discussed.

CP41/B2 **Safety Implications of Aircrew Armour and Allied Personal Equipment.** K.G.GREGORY.
AGARD Conference Proceedings CP 41, Paper B2, pp.B2-1 to B2-3, 1968.
Aircrew armour used in the United States services are described and safety implications and misadventures are reported. Suggestions for improvements are made.

CP41/B4 **A New Aircrew Armour Vest Developed for Protection of the Neck and other Peripheral Regions.** J.E MURPHY, B.H.WARREN.
AGARD Conference Proceedings CP 41, Paper B4, pp.B4-1 to B4-11, 19 refs., 1968.
The armour described was developed quickly to meet the problems of low level defoliation missions flown by UC-123 aircraft. Crews were wearing flak vests of various types but there was clear need for additional protection especially in the neck area. A study of crews attitudes and experience, based on a total of 13,660 combat hours, was made. Primary criticisms were restriction of body movements, lack of protection from small arms fire, and the incompatibility of the present armour with other personal and aircraft equipment.

CP41/B5 **Protective Bullet Proof Vest.** (in French). G.C.LEOMAND.
AGARD Conference Proceedings CP 41, Paper B5, pp.B5-1 to B5-8, 1968.
Background to the development of the modern protective buliet-proof vest is given and the final choice of the military, the chasuble form, is described. Shoulder straps of 14 cm thick, layered nylon fabric join the front and back sections covering the superior portions of the body. Details of the unique construction include analysis of the plaquettes which are alveolar in type, of polyester fiber glass, and the basic units which block penetration of a projectile. A general performance record from field experience of service men is provided to demonstrate protection against grenades, various flying fragments and direct impact. The psychological advantages and problems of adjustment to any long period of use are also discussed.

CP41/B6 **Development of an Aircrew Safety Harness with Special Reference to F111 Aircraft.** D.C.READER.
AGARD Conference Proceedings CP 41, Paper B6, pp.B6-1 to B6-4, 2 refs., 1968.
The principles of safety harness design are discussed and a method of assessment of an alternative British harness for the F111 is described. The British harness was compared with the American harness and was accepted as a replacement due to its improved restraint and operational advantages.

CP41/B7 **Physiological Assessment of Aircrew Protective Suit Systems under Different Environmental Conditions.** L.J.SANTAMARIA.
AGARD Conference Proceedings CP 41, Paper B7, pp.B7-1 to B7-7, 15 refs., 1968.
The paper surveys different protective suit systems designed to provide a tolerable level of heat equilibrium during flight and in emergencies. Among those considered are the USN Mk5A suit assembly, the diver's wet suit (WS) and a polyvinylchloride suit (PVC).

CP41/B8 **The Water Cooled Suit.** D.F.INGRAM.
AGARD Conference Proceedings CP 41, Paper B8, pp.B8-1 to B8-4, 16 refs., 1968.
Literature on water cooled garments is reviewed and it is stated that several problems still await solution. Of these the ability of skin sensation to guide the correct selection of inlet temperature to maintain thermal balance, and the effect of vasoconstriction on the performance of the suit are discussed in detail.

CP41/B9 **Flashblindness Protection System.** G.T.CHISUM.
AGARD Conference Proceedings CP 41, Paper B9, pp.B9-1 to B9-7, 1968.
The paper reviews the problems of protection from flashblindness and states that fixed density goggles are unsuitable due to the severe reduction of light for normal use. The ideal system is described and several methods of quickly obtaining a dense filter are discussed and it is concluded that a complete solution is not yet foreseeable. The characteristics of the most recent development, the US Navy Photometric System are discussed.

CP41/C1 **Cardiovascular Aspects of Hypodynamics.** M.C.LANCASTER.
AGARD Conference Proceedings CP 41, Paper C1, pp.C1-1 to C1-7, 25 refs., 1968.
Bed rest has been accepted as an acceptable experimental model for the study of weightlessness. The paper reviews the cardiovascular effects of bed rest.

CP41/C2 **The Metabolic and Hematologic Aspects of Hypodynamics.** J.H.TRIEBWASSER
AGARD Conference Proceedings CP 41, Paper C2, pp.C2-1 to C2-14, 39 refs., 1968.
The paper is a summary of the literature and ground-based experiments made within the United States Air Force School of Aerospace Medicine. The metabolic and hematologic consequences of prolonged bed rest have been correlated to those observed and postulated in weightlessness. Some are a result of a change in level of activity and others are secondary to a change in posture.

CP41/C3 **Observations on the Gas Tensions of Mixed Venous Blood in Man.** D.M.DENISON.
AGARD Conference Proceedings CP 41, Paper C3, pp.C3-1 to C3-4, 7 refs., 1968.
This short paper records some observations on mixed venous gas tensions and states that, in the past, such pressures were not measured frequently but that modern instruments have made it easier to do so. It is claimed that a rebreathing technique can measure them and can be used for the study of exercise during *total* water immersion.

CP41/C4 **The Effects of Prolonged Exposure to High Oxygen Tension.** G.H.KYDD.
AGARD Conference Proceedings CP 41, Paper C4, pp.C4-1 to C4-6, 20 refs., 1968.
The expected use of 100% oxygen at low pressure as the respiratory gas for astronauts makes it desirable to determine the effects of long-term breathing of oxygen. The evidence is reviewed and experiments with rats at periods of 30 to 47 days are described.

CP41/C5 **Fire Prevention and Protection in Oxygen Enriched Atmospheres.** D.I.CARTER.
AGARD Conference Proceedings CP 41, Paper C5, pp.C5-1 to C5-8, 4 refs., 1968.
The United States Air Force has devoted considerable effort in fire prevention for ground based simulators using oxygen enriched atmospheres for research, testing and hyperbaric therapy. This paper describes recent work in removing combustible material and ignition sources and in improving fire extinguisher systems.

CP41/C6 **Influence of Magnetic Field Variations on the Growth of Certain Microorganisms.** (in French). L.MIRE, G.DELTOUR, A.PFISTER.
AGARD Conference Proceedings CP 41, Paper C6, pp.C6-1 to C6-6, 1968.
Three series of experiments placing growing *Escherischia coli* cultures in the presence of varying levels of magnetic field influence are reported. In a magnetic field of 42,000 gauss, no appreciable change in growth rate was determined, however, differences of metabolic output were provoked after each variation, and sudden increases in growth rates according to the number of viable cells counted. Daughter cells produced during this period were considered to be polynuclear and to have inferior nuclear structures to the mother bacteria.

CP41/D1 **Aeromedical Evacuation.** D.W.ATKINSON.
AGARD Conference Proceedings CP 41, Paper D1, pp.D1-1 to D1-8, 1968.
The purpose of the paper is to outline the arrangements in the Royal Air Force for strategic and tactical aeromedical evacuation and to describe some of the equipment which has been developed. Aircraft used on scheduled aeromedical flights from Singapore, Bahrein and Germany as well as those used for the UK internal flights are described. Equipment is briefly described and some of the problems are discussed. Equipment used in units for tactical operational use is described. These units are self-contained and their role is to evacuate, not to treat, casualties.

CP41/D2 **Experiences of Air Transport of Patients in Peace Time.** R.NEY.
AGARD Conference Proceedings CP 41, Paper D2, pp.D2-1 to D2-3, 1968.
In this short paper experience obtained on 35 helicopter missions in the area of the University Hospitals, Düsseldorf, Germany is described. Autobahn victims were initially transported by police helicopters, Alouette II, but subsequently higher capacity helicopters of the German or Allied forces were used to allow treatment during flight. Conditions for the use of helicopters are discussed.

CP41/D3 **Aeromedical Problems in the Rescue of Downed Airmen.** R.A.BOSEE, J.F.PARKER.
AGARD Conference Proceedings CP 41, Paper D3, pp.D3-1 to D3-6, 1968.
Reviews aeromedical problems in the rescue of downed airmen under combat conditions and assesses the need for new or improved equipment and techniques. 42 rescues are studied in some detail.

CP41/D4 **Recent Advances and New Concepts in the Air Evacuation of Patients in Cargo Type Aircraft.** J.E.MURPHY.
AGARD Conference Proceedings CP 41, Paper D4, pp.D4-1 to D4-9, 16 refs., 1968.
Equipment is described which has been developed to allow the rapid conversion (less than 1 hour) of cargo aircraft so that casualties may be evacuated by the same aircraft that delivers supplies to forward areas. Special medical equipment is described for multi-mission aircraft C7, C123, C130 and C141 that have short range (250 Km) tactical missions. It is stated that a special care unit is now being developed to allow seriously ill patients to be moved over large distances.

CP41/D5 **Medical Considerations Affecting Early Air Evacuation of the Seriously Ill Patient.** R.C.McIVER, J.E.MURPHY.
AGARD Conference Proceedings CP 41, Paper D5, pp.D5-1 to D5-3, 1968.
The paper considers the problems involved in transporting seriously ill patients by air. It is concluded that a severely injured patient can be transported by air but that the greatest success will be obtained if patients are stabilised before transport. Nevertheless these individuals can be flown satisfactorily if proper precautions are taken.

CP41/D6 **Research and Development in Support of Aeromedical Evacuation.** F.M.G.HOLMSTROM, V.M.ALENA, L.B.ROWE.
AGARD Conference Proceedings CP 41, Paper D6, pp.D6-1 to D6-11, 1968.
Describes the primary objectives of the USAF programme to improve inflight patient care and discusses the problems involved.

CP41/D7 **A Lightweight Plastic Litter.** I.C.PERRY.
AGARD Conference Proceedings CP 41, Paper D7, pp.D7-1 to D7-2, 1968.
This paper presents the case for a plastic litter which it is claimed could be lighter, and smaller than present ones. A casualty could be put into such a litter on the battle field and would not need to be

removed from it until he reached his hospital bed, the litter acting if needed, as stretcher, plaster cast, X-ray couch and operating table. It could considerably increase the capability of existing aircraft, mainly by its reduced length.

CP42 **Aircraft Engine Noise and Sonic Boom.**
AD-697-190 AGARD Conference Proceedings CP 42, 588 pp., many refs., 1969.
N70-13137 Papers presented at the Fluid Dynamics Panel and Propulsion and Energetics Panel (33rd) Joint Meeting held at the Institut Franco-Allemand de Recherches, Saint-Louis, France, 27-30 May 1969.
The noise of modern aircraft and the sonic boom of future supersonic carriers pose important problems. Considerable effort has been devoted in recent years to studying the generation, propagation and effects of aircraft engine noise and sonic boom, with the final aim of developing means to minimise them. Of the thirty-four programmed papers, two were withdrawn, five were review papers devoted respectively to the physics of noise, some legal problems relating to sonic boom, airport design and operation for minimising exposure to noise, the effects of aircraft noise and sonic boom on ground structures, and human response to sonic booms. The remaining papers dealt with specialised aspects, theoretical and experimental, of aircraft engine noise or sonic boom, and were grouped appropriately in the meeting programme. Papers from six NATO countries were included in the programme. The 32 papers published in this volume are dealt with individually in the following abstracts.

CP42/1 **Physics of Noise.** G.M.LILLEY.
AGARD Conference Proceedings CP 42, Reference 1, pp.1-1 to 1-12, 5 refs., 1969.
The paper not only sets out the unified theory of aerodynamic noise involving random disturbances in the flow, but also shows how the theory can include the analysis of the pressure fields from bodies travelling through otherwise undisturbed air at subsonic and supersonic speeds and therefore includes the theoretical background for the treatment of the sonic boom problem for generalised aircraft motions.

CP42/2 **A Brief Legal History of the Sonic Boom in America.** J.P. and E.R.TAYLOR.
AGARD Conference Proceedings CP 42, Reference 2, pp.2-1 to 2-11, 1969.
Legal precedents already established in USA on damage claims for military supersonic flight operations are surveyed. Sonic booms and their effects on man and his structures are examined through material available from administrative claims and court cases. It is stated that the legal consequences of commercial SST may well turn out to be as complex as the development of the aircraft itself.

CP42/3 **Airport Design and Operation for Minimum Noise Exposure.** I.H.HOOVER, D.G.COCHRAN.
AGARD Conference Proceedings CP 42, Reference 3, pp.3-1 to 3-20, 6 refs., 1969.
Alleviation of the aircraft noise problem requires that new airport designs and modifications to existing airports take maximum advantage of the potential noise reductions soon to become available by aircraft design. This paper examines the expected noise exposures to be generated by commercial aircraft operating in the next decade and reviews significant considerations in the location of new airports, the land requirements of existing and new airports. The forecasting of aircraft noise exposure near airports and its relationship to the development of compatible land use programs and public relations/education programs are discussed.

CP42/4 **Probability of Aircraft Noise and Sonic Boom Induced Building Damages.** G.WEBER.
AGARD Conference Proceedings CP 42, Reference 4, pp.4-1 to 4-6, 1969.
The scope of this paper is the calculation of the ratio of calculated static main stresses in buildings to the dynamic supplementary stresses induced by aircraft noise and sonic booms. The type of damage to be expected is listed in order of probability.

CP42/5 **Human Response to Sonic Boom.** H.E.Von GIERKE, C.W.NIXON.
AGARD Conference Proceedings CP 42, Reference 5, pp.5-1 to 5-15, 20 refs., 1969.
Reviews the results of the various observations made in USA, UK and France which form the basis for present day estimates regarding the acceptance of sonic boom. The loudness and annoyance and the complex reaction of individuals exposed to sonic booms are discussed. The few experiments available proving that even the highest present sonic boom cannot produce any direct medical injury are described. The acceptability of regular supersonic services is discussed.

CP42/6 **Turbofan Engine Noise – Mechanism and Control.** C.G.GORDON.
AGARD Conference Proceedings CP 42, Reference 6, pp.6-1 to 6-11, 14 refs., 1969.
The sources of noise within the engine and in the jet are listed, discussed, and data from laboratory studies presented. It is stated that there is much to be learned about these sources before their significance in current and projected engine designs can be properly understood.

CP42/7 **Noise Associated with Shock Waves in Supersonic Jets.** D.L.MARTLEW.
AGARD Conference Proceedings CP 42, Reference 7, pp.7-1 to 7-10, 5 refs., 1969.
Current methods for predicting the field of noise around a jet are not adequate to explain observations of high noise levels in directions at large angles to supercritical jets in motion. Experiments on static jets at NGTE suggest that the "forward throw" may be due to the presence of a regular shock cell structure in the jet. It is concluded that the elimination of the shock cell pattern could reduce jet noise forward of the nozzle by 10 dB.

CP42/8 **Jet Noise from Moving Aircraft.** J.E.FFOWES-WILLIAMS.
AGARD Conference Proceedings CP 42, Reference 8, pp.8-1 to 8-7, 3 refs., 1969.
A short theoretical paper extending the treatment of jet noise in a previous paper by the same author.

CP42/9 **Determination of the Noise Field Produced by Manoeuvring Aircraft.** (in French). M.KOBRYNSKI.
AGARD Conference Proceedings CP 42, Reference 9, pp.9-1 to 9-11, 8 refs., 1969.
The noise field produced at the ground is calculated from the thermodynamical characteristics of the jet, the exhaust velocity, and the generalized acoustical spectrum in the directions considered. The analytical results are shown to agree well with experimental results.

CP42/10 **A Study of Acoustical Interference by Reflection. Application to the Acoustical Pressure Spectrum of Jets.** (in French). P.THOMAS.
AGARD Conference Proceedings CP 42, Reference 10, pp.10-1 to 10-17, 4 refs., 1969.
The measurement of noise fields of turbojets is usually made at the ground when the acoustical pressure spectrum measurements are then disturbed by complex reflection phenomena which complicate measurements. A theoretical and experimental study has been made of reflection problems at SNECMA.

CP42/11 **Sonic Boom of Bodies of Revolution.** K.OSWATITSCH.
AGARD Conference Proceedings CP 42, Reference 11, pp.11-1 to 11-9, 19 refs., 1969.
This paper outlines recent work on the sonic boom problem. The problems treated with the aid of an analytic method of characteristics are: sonic boom from bodies of revolution at constant supersonic speed, sonic boom from one moving at varying transonic speed and the influence of the isothermal stratification of the atmosphere on the sonic boom. It appears that the widely used asymptotic formulae are unsatisfactory at altitudes of practical importance.

CP42/12 **Focussing Effects in Non-Linear Short Waves – Application to the Focussing Supersonic Boom.** (in French). J.P.GUIRAUD.
AGARD Conference Proceedings CP 42, Reference 12, pp.12-1 to 12-11, 17 refs., 1969.
The supersonic boom theory is considered as an application of the non-linear theory of short waves, and in the same way the focussing boom theory appears to be an application of the general phenomena in short waves.

CP42/13 **Atmospheric Refraction and Reflection of Bangs at the Ground.** (in French). C.THERY.
AGARD Conference Proceedings CP 42, Reference 13, pp.13-1 to 13-14, 9 refs., 1969.
An analysis of the behaviour of a sonic wave in the vicinity of a totally reflecting surface is presented, as applicable to sonic booms. A properties method allows wave refraction to be followed as long as flow behind the wave remains supersonic.

CP42/14 **Mirage IV Trials.** (in French). M.I.C.WANNER.
AGARD Conference Proceedings CP 42, Reference 14, pp.14-1 to 14-18, 10 refs., 1969.
Following ONERA theoretical studies on the propagation and amplitude of sonic bangs, CEV have made some flight studies of the phenomena using Mirage IV. From five case studies, the minimum distance between theoretical and experimental positions is 200 m, and the maximum distance 2,400 m. This confirms difficulties experienced in measuring the focal position.

CP42/15 **Survey of United States Sonic Boom Overflight Experimentation.** J.O.POWERS, D.J.MAGLERI.
AGARD Conference Proceedings CP 42, Reference 15, pp.15-1 to 15-35, 20 refs., 1969.
The report reviews published material and adds new material resulting from recent experimental flights. Some recent damage claims and legal activity in relation to the boom are discussed and recent developments in instrumentation and theoretical methods are outlined.

CP42/16 **An Analysis of Devices for Reducing Sonic Boom.** S.I.CHENG, A.GOLDBURG.
AGARD Conference Proceedings CP 42, Reference 16, pp.16-1 to 16-12, 21 refs., 1969.
Techniques for applying electro-kinetic forces or adding thermal energy to the flow field around a supersonic transport have been proposed to alter the shock pattern and thereby reducing sonic boom. These proposals are analyzed and stated to be conceptually deficient. It is concluded that efforts for the reduction of boom intensity should concentrate on the development of detailed optimization of the aerodynamic design of the airplane.

CP42/17 **The Development of Acoustic Absorbers for Turbofan Engines.** C.J.WEBBER.
AGARD Conference Proceedings CP 42, Reference 17, pp.17-1 to 17-11, 1969.
High bypass ratio engine noise is dominated by the fan and turbine sources. Noise from these components may be reduced by the application of absorbent liners to the engine ducts. Experimental data is required and a description is given of a Rolls-Royce acoustic test rig. Some results for typical liner designs are presented and discussed.

CP42/18 **Aircraft Engine Noise Measurement Techniques, Facilities, and Test Results.** W.R.MORGAN, S.N.SUCIU.
AGARD Conference Proceedings CP 42, Reference 18, pp.18-1 to 18-14, 1969.
This paper describes three basic phases of acoustic testing and analysis necessary to advance the state of the art of quiet engine development. A description is given of the types of laboratory test equipment and some important early results that may be obtained from it. Far field acoustic ground test facilities and flight tests are also discussed.

CP42/19 **Generation and Suppression of Combination Tone Noise from Turbofan Engines.** J.D.KESTER.
AGARD Conference Proceedings CP 42, Reference 19, pp.19-1 to 19-12, 2 refs., 1969.
Advanced acoustical design has resulted in the elimination of several noise sources from the JT9D high bypass ratio turbofan engine. With reductions in pure tone noise levels combination tone noise is the principal remaining noise source at high powers where the fan blade tips are supersonic. Studies have been made and noise mapping has given a basic understanding. Substantial reductions have been obtained by sound absorbing linings and the results are described.

CP42/21 **Method for Estimating the Noise of a Turbojet in Relation to its Thermopropulsion Output.** (in French). R.HOCH, J.P.DUPONCHEL.
AGARD Conference Proceedings CP 42, Reference 21, pp.21-1 to 21-20, 9 refs., 1969.
A method is proposed for estimating the maximum noise produced by a turbojet by use of simple monographic charts which are based on the total thermopropulsion magnitudes. These are generally published in descriptive notices, or in the handbook on installation and properties of the turbojet.

CP42/22 **Methods of Examination and Treatment of Acoustical Information for the Study of Aircraft Noise.** (in French). J.HAY.
AGARD Conference Proceedings CP 42, Reference 22, pp.22-1 to 22-12, 6 refs., 1969.
After briefly recalling the principle of real time analysers of studying acoustical signals, the ONERA techniques of measurement and examination are shown which at present comply with the automatic analysis of a test.

CP42/23 **The Near Field Sound Pressures of a Choked Jet During a Screech Cycle.** R.WESTLEY, J.H.WOOLEY.
AGARD Conference Proceedings CP 42, Reference 23, pp.23-1 to 23-13, 12 refs., 1969.
Describes an experimental investigation of the near field sound pressures during the axisymmetric screech mode of a choked air jet. The data and a previous paper by the same authors clarifies certain aspects and provides data for predicting structural response in the near field.

CP42/24 **Study of Aircraft Noise at Take-Off.** I.P.A.PIANKO MARC.
AGARD Conference Proceedings CP 42, Reference 24, pp.24-1 to 24-28, 6 refs., 1969.
First the optimal trajectories to minimise aircraft noise at take-off are studied. The measurement of these trajectories point to the aircraft parameters (particularly the noise of the engine) which determine noise at take-off. The relative influence of each parameter is calculated. Similarly, cases are examined in which measurement of the results are modified by the introduction of actual PNdB (with a correction for duration). Lastly, the influence of engine technology is studied, constraining and limiting the future progress in the subject of noise at take-off.

CP42/25 **Ground Configuration Effects on Sonic Boom.** D.DINI, R.LAZZERETTI.
AGARD Conference Proceedings CP 42, Reference 25, pp.25-1 to 25-29, 28 refs., 1969.
The propagation of a sonic boom is affected by ground configuration by reflection and refraction. The paper analyses the possible effects for different ground geometries and possible overpressure values. More than twice and up to eight times overpressure is possible. The results of calculations are compared with known results.

CP42/26 **A Preliminary Study of Atmospheric Effects on the Sonic Boom.** G.A.HERBERT, W.A.HASS, J.K.ANGELL.
AGARD Conference Proceedings CP 42, Reference 26, pp.26-1 to 26-11, 10 refs., 1969.
More than 4,000 sonic boom pressure traces have been compared with a computer program which generates maximum overpressure values for a horizontally stratified atmosphere. The program is shown to be in error by about 10% when the maximum observed overpressure is derived from the positive impulse area. It is suggested that turbulence in the planetary boundary layer is the main cause of the large variation in maximum overpressure.

CP42/28 **The Simulation of Sonic Bangs.** C.H.E.WARREN.
AGARD Conference Proceedings CP 42, Reference 28, pp.28-1 to 28-13, 7 refs., 1969.
The various methods developed in the UK to simulate sonic bangs are described. The application of each type is discussed and some of the results obtained are referred to briefly.

CP42/29 **Sonic Boom Simulation Facilities.** I.R.SCHWARTZ.
AGARD Conference Proceedings CP 42, Reference 29, pp.29-1 to 29-18, 16 refs., 1969.
The paper discusses a broad spectrum of sonic boom simulators. The paper shows that substantial progress has been made recently in simulation.

CP42/30 **Sonic Boom Considerations in Aircraft Design.** C.S.HOWELL, A.SIGALLA, E.J.KANE.
AGARD Conference Proceedings CP 42, Reference 30, pp.30-1 to 30-7, 16 refs., 1969.
The techniques for estimating sonic boom pressure signatures are reviewed and the effects of different configuration variables are shown. In particular configuration variables and novel concepts that could lead to potentially favourable sonic boom characteristics are examined.

CP42/31 **An Application of Quadrupole Theory to Correlate the Directivity and Spectra of High Speed Jet Noise.** J.D.VOCE, P.A.LUSH.
AGARD Conference Proceedings CP 42, Reference 31, pp.31-1 to 31-10, 4 refs., 1969.
A considerable amount of experimental data has been obtained from model jets at Rolls-Royce Ltd. This paper outlines efforts to correlate this data using Lighthill's quadrupole theory of jet noise with modifications due to FFOWCS WILLIAMS for high speed flow.

CP42/33 **Engine Quieting – Engine Designs.** N.F.REKOS.
AGARD Conference Proceedings CP 42, Reference 33, pp.33-1 to 33-9, 1969.
This paper describes a major program called by the NASA the "Quiet Engine Program". This is aimed at the development of the technology required for the design of a subsonic engine which produces a minimum amount of noise. Preliminary results indicate that noise reductions of about 20 PNdB below the noise levels of current commercial subsonic turbofan engines, are feasible.

CP42/34 **Noise Characteristics of the C-5A Heavy Logistics Transport.** J.A.BAIR.
AGARD Conference Proceedings CP 42, Reference 34, pp.34-1 to 34-8, 6 refs., 1969.
The latest available community noise data from the C-5A noise measurements program are represented. Noise measurement at ground stations during take-off and landing is presented and compared to predictions. Limited comparison of measured and predicted noise levels to community standards is included and the remaining portions of the C-5A noise program are outlined.

CP42/35 **Engine Quieting – Nacelle Acoustic Treatment.** N.F.REKOS.
AGARD Conference Proceedings CP 42, Reference 35, pp.35-1 to 35-10, 1969.
This paper describes a major program for reducing the fan noise radiated from the turbofan engines used in current Boeing and McDonnell-Douglas four engine commercial transports. Reductions of the order of 12 to 15 PNdB are expected by acoustic treatment in the fan inlet and discharge jets.

CP43 **Inertial Navigation – Systems and Components.** Edited by C.T.LEONDES.
AD-692-540 AGARD Conference Proceedings CP 43, 584 pp., 1968.
N69-36851 The thirty papers published in this volume are those resulting from two Symposia arranged by the Guidance and Control Panel of AGARD. The first, held in Oxford, England, in September 1967, was concerned with "Inertial Navigation: Systems and Applications" and the second, held in Braunschweig, Germany in May 1968, covered "Inertial Navigation: Components". An additional paper "Inertial Principles in Navigation and Guidance" introduces the main papers.

CP43/1 **Inertial Principles in Navigation and Guidance.** C.S.DRAPER.
AGARD Conference Proceedings CP 43, Paper 1, pp.vii to xvi, 1968.
An introductory paper dealing with complete navigation and guidance systems and the components used for sensing and control. It is concluded that inertial equipment although not yet perfect will continue to be used and that the false claims made for particular mechanisms will in time be replaced by true engineering information and sound technology.

CP43/2 **Technique and Philosophy of Mixing or Aiding Inertial Navigation with Other Navigation Aids.** G.F.ROBERTS.
AGARD Conference Proceedings CP 43, Paper 2, pp.1-13, 1968.
A broad treatment is given of the requirement for the use of hybrid Inertial Navigation systems in the light of continual development in the capability of pure inertial systems, and the availability of new navigation aids and computing techniques. Future trends in hybrid systems are discussed, emphasising the importance of modern digital computing techniques.

CP43/3 Inertial Navigation for Long Ranges (in French). B. de CREMIERS.
AGARD Conference Proceedings CP 43, Paper 3, pp.15-29, 1968.
Describes the principles of the inertial navigation system used in CONCORD and developed by collaboration between the French Societé SAGEM and the British firm Ferranti.

CP43/4 Cost-of-Ownership Philosophy Applied to Inertial Navigation Systems. W.J.LAUBENDORFER, R.V.PLANK. E.J. De NEZZA.
AGARD Conference Proceedings CP 43, Paper 4, pp.31-47, 4 refs., 1968.
The paper makes a case for complete costing of systems being considered for operational use. Rather than an assessment of technical acceptability and first cost it is argued that funding to be expected in support of operational use and in maintenance should also be included. A concept titled COPE (cost-of-ownership performance) is presented, defined and applied to inertial navigation system design and selection.

CP43/5 A Study of Strapdown Inertial Navigation at the MARSHALL Space Flight Center. F.P.DANIEL, G.B.DOANE, R.R.KISSEL.
AGARD Conference Proceedings CP 43, Paper 5, pp.49-70, 17 refs., 1968.
The trend to simplification in mechanical components and to more complex electronics is explained and examined with particular emphasis on large rocket boosters. Performance specifications are discussed and that chosen at the Marshall Space Flight Center is explained. Methods of statistical data reduction and some comparison between testing components for a platform and for a strapdown system are presented.

CP43/6 Description of a Strapdown Inertial Measurement Unit. J.YAMRON.
AGARD Conference Proceedings CP 43, Paper 6, pp.71-95, 7 refs., 1968.
A strapdown inertial reference package developed for the Lunar Module's About Guidance System is described. Test data are reviewed and error sources are examined for boost operation. Development problems are highlighted and an assessment made of strapdown applications.

CP43/7 Field Test, Alignment and Trimming of the ELDO-A Platform. M.PÜTZ.
AGARD Conference Proceedings CP 43, Paper 7, pp.97-108, 1968.
The equipment used for pre-flight testing of the inertial platform used in the ELDO-A programme is described. The Field Test Unit performs all the necessary switching between the platform system and the measuring and recording instruments. For easier operation and for the purpose of documentation all data are delivered digitally and printed.

CP43/8 Error Prediction for an Inertial Navigation System. (in French). M. da SILVEIRA.
AGARD Conference Proceedings CP 43, Paper 8, pp.109-118, 5 refs., 1968.
An error model for the maximum efficiency optimization of an inertial navigation system is explained in its derivation from Doob's general stochastic process theory, the integration of differential equations systems with Lagrange equations, and the final expression which is the singular model. Errors which result from simplification of the model are plotted to demonstrate that for long-distance flight. the model is uniquely applicable as it stands. Analytical solution requires matrix and scalar methods to achieve coefficients of correction and measurement of error variance Additionally, the model can be applied to error variance of rectilinear and near uniform flight, and to the correction of vehicle positioning in acceleration. Evidence gained from application of the model to real flight data demonstrates a consistent residual error accumulated in vehicle acceleration contributing to both vertical gyroscope imbalance and the derivation of azimuth data.

CP43/9 Factors Influencing the Choice of Computer for an Inertial Navigation System. P.WILSON.
AGARD Conference Proceedings CP 43, Paper 9, pp.119-126, 1968.
The paper deals exclusively with digital computing techniques. The dominance of digital computing techniques in the inertial field is now almost complete and a resumé is made of the reasons leading to this situation. The paper then discusses the various types of digital computers used, surveys some typical systems and attempts to forecast the future trend.

CP43/10 Optimum Use of Redundant Data in Inertial Navigation Systems. F.G.UNGER.
AGARD Conference Proceedings CP 43, Paper 10, pp.127-146, 6 refs., 1968.
The performance of inertial navigation systems can be improved by using additional or redundant data from various sensors. Several methods are available for corrections ranging from pure resetting to optimal filtering. These methods, their possible implementation, their different influences on the behaviour of the system, and the resulting errors are described.

CP43/11 The Impact of Statistical Estimation on Inertial Navigation. L.D.BROCK.
AGARD Conference Proceedings CP 43, Paper 11, pp.147-166, 4 refs., 1968.
The application of statistical estimation techniques is one of the more important new developments in inertial navigation. These techniques make possible significant improvement in the performance of

a navigation system even with no change in the quality of the instruments, by allowing the system to continuously calibrate itself. The purpose of this paper is to describe the operation of an inboard statistical filter and to discuss some of the practical consequences and problems.

CP43/12 **Application of Inertial Technology to Airborne Gravimetry.** E.J.FREY, R.B.HARLAN.
AGARD Conference Proceedings CP 43, Paper 12, pp.167-190, 20 refs., 1968.
Describes work in relation to the application of the techniques of inertial guidance to airborne gravimetry. The results of an error analysis of the stabilization and navigation requirements are presented and the design of the experimental gravimetric system discussed. Some results of the flight tests are presented in the form of raw data and reduced observations. Incidental data involving air turbulence and aircraft motion are included.

CP43/13 **Present-Day North-Finding Systems and Their Fundamental Limitations.** B.T.TRAYNER.
AGARD Conference Proceedings CP 43, Paper 13, pp.191-205, 4 refs., 1968.
Three basically different types of gyroscopic north-finding systems are described and the principles and method of use discussed. The sources of error, including those which arise from the environment, are outlined. It is indicated that present day systems are limited in accuracy by the environment in which they are used and by the time available as well as by the usual gyro errors. They are limited in application by their cost and this is the field where most development is likely in the immediate future.

CP43/14 **System Parameters as Considered in the Design of a Small Inertial Navigation Computer.** J.KYDD.
AGARD Conference Proceedings CP 43, Paper 14, pp.207-230, 11 refs., 1968.
The system design of a small digital inertial navigation computer is discussed and the layout of the computer briefly described. The computer operates with whole binary numbers with a fixed binary point and uses the CORDIC algorithms for trigonometric computation.

CP43/15 **The Application of Statistical Estimation Techniques to Inertial Component Calibration.** G.T.SCHMIDT.
AGARD Conference Proceedings CP 43, Paper 15, pp.231-249, 20 refs., 1968.
The calibration of inertial instruments in component, system and vehicle level tests is shown to be amenable to modern statistical filtering techniques and two examples are discussed. In the second the design and test experience is given for a calibration filter used to align and calibrate the Apollo Guidance, Navigation and Control System inertial platform while it is in a launch vehicle that is subjected to wind sway.

CP43/16 **Euler Angle Strapped-Down Computer.** A. van BRONKHORST.
AGARD Conference Proceedings CP 43, Paper 16, pp.251-280, 8 refs., 1968.
A particular type of whole-number high speed computer, solving a three-parameter Euler angle transformation, has been investigated as a component of a strapped-down mid-course inertial guidance system for a short range missile. This paper presents the results of this investigation.

CP43/17 **A Concept of Digital Avionics.** J.F.BUSSELL.
AGARD Conference Proceedings CP 43, Paper 17, pp.281-295, 1968.
This paper is concerned with the results of studies of the application to Avionics of whole-number general purpose, digitial techniques. The following applications are discussed – Inertial platform computations, Navigation, Automatic flight control, Power-plant control, Head-up display and Air data.

CP43/18 **Microplasticity in Metals for Precision Instruments.** O.H.WYATT.
AGARD Conference Proceedings CP 43, Paper 18, pp.297-311, 17 refs., 1968.
The microplasticity of metals is discussed and work on materials used in precision instruments is reviewed. Some new data are presented for beryllium obtained from ROF Cardiff, which closely agree with results from the Brush Beryllium Corp. Variable drift in a precision gyroscope has been traced to ligament creep and steps to reduce the effect are described.

CP43/19 **Gyro Ball Bearings – Technology Today.** A.P.FREEMAN.
AGARD Conference Proceedings CP 43, Paper 19, pp.313-356, 48 refs., 1968.
This paper reviews current ball bearing technology. The spin axis bearing is a major unit in determining gyro reliability for which microinch position stability is required for tens of thousands of running hours. Developments leading to the present performances are discussed and it is shown that application of the available knowledge can yield the required thousands of hours of reliable operation. Possible future improvements are outlined.

CP43/20 **Conical Gas Bearings for Gyroscope Spin Axis Support.** D.FADDY, T.L.ELLIS.
AGARD Conference Proceedings CP 43, Paper 20, pp.357-374, 2 refs., 1968.
The problems of the manufacture of three types of self-pressurised gas bearings are compared and the manufacture and inspection on an experimental conical bearing is described. A proposed design for a miniature gyroscope is included.

CP43/21 **Strapdown Guidance Component Research.** R.J.HAYES.
AGARD Conference Proceedings CP 43, Paper 21, pp.375-400, 8 refs., 1968.
The major potential advantages of strapdown systems over gimbaled systems include weight, volume, power, cost together with increased packaging, flexibility, reliability and ease of maintenance. The major limitations are associated with the fact that high angular velocities produce performance errors and the system requires a faster computer. This paper discusses the reasons for the preponderance of gimbaled systems, describes work now in hand on the components for strapdown systems and suggests that many technical problems remain to be solved.

CP43/22 **The Gyroflex Gyroscope.** R.F.CIMERA, M.NAPOLITANO.
AGARD Conference Proceedings CP 43, Paper 22, pp.401-409, 1968.
This paper presents a general description of the design and construction of the Gyroflex gyro and some of the highlights and results of Kearfott's evaluation testing of units. In the discussion of component evaluation, both beach and test results and environmental test results are presented.

CP43/23 **The Rotor-Vibragyro.** E.MÜHLENFELD.
AGARD Conference Proceedings CP 43, Paper 23, pp.411-418, 1968.
The Rotor-Vibragyro is another word for the rotating, two axis vibragyro under development elsewhere under the trademarks "Vibratotor-Gyroscope", or "Oscillogyro". The principle of operation is described and some experimental results described.

CP43/24 **The Oscillogyro.** R.WHALLEY, D.W.ALFORD.
AGARD Conference Proceedings CP 43, Paper 24, pp.419-427, 2 refs., 1968.
This paper describes the operation of the oscillogyro using simplified mechanical concepts. The main feature is its inherent simplicity, which promises low cost manufacture with high reliability.

CP43/25 **The PIPA (Pulsed Integrating Pendulous Accelerometer).** G.J.BUKOW.
AGARD Conference Proceedings CP 43, Paper 25, pp.429-458, 4 refs., 1968.
The PIPA used in the Apollo Inertial Measurement Unit is a moderate cost, high performance single-degree-of-freedom, specific force integrating receiver, operating closed loop as a torque restrained pendulum. The paper examines the theory and operation and concludes with a summary of present performance capabilities and makes recommendations for improvement.

CP43/26 **The High Sensitivity ONERA Accelerometer.** (in French). M.DELATTRE.
AGARD Conference Proceedings CP 43, Paper 26, pp.459-474, 6 refs., 1968.
Describes the state of development of the high sensitivity accelerometer being made by ONERA. After a short description of the principles the present position on construction and testing is reviewed.

CP43/27 **The Vibrating String Accelerometer.** R.O BOCK.
AGARD Conference Proceedings CP 43, Paper 27, pp.475-486, 6 refs., 1968.
The report describes the principle of the vibrating string accelerometer and concludes that it offers high precision performance with great simplicity and reliability.

CP43/28 **Technical Report on the Quartz Resonator Digital Accelerometer.** N.S.SERRA.
AGARD Conference Proceedings CP 43, Paper 28, pp.487-516, 4 refs., 1968.
The Quartz Resonator Digital Accelerometer is the result of an extensive program of work in developing an accelerometer with digital output using direct conversion from force to frequency. The report describes the design, construction and testing of an instrument, the accuracy of which was 0.02% linearity in the range of 0 to 20 g.

CP43/29 **An Optically Pumped Nuclear Magnetic Resonance Gyroscope.** J.H.SIMPSON, I.E.GREENWOOD.
AGARD Conference Proceedings CP 43, Paper 29, pp.517-524, 3 refs., 1968.
The nuclear magnetic resonance gyroscope described is a rate integrating single input axis instrument. It has no moving parts; many of its advantages, such as extreme acceleration tolerance and lack of reaction torques arise primarily from this feature. The instrumentation of a recently tested experimental model is described and design factors affecting random drift rates and application ranges are discussed.

CP43/30 **Laser Gyrometers and Applications.** (in French). J.M.CATHERIN, B.DESSUS.
AGARD Conference Proceedings CP 43, Paper 30, pp.525-536, 11 refs., 1968.
The gyrometer is composed of a tube in which thin plasma material is susceptible to light amplification. The tube is placed on a close optic cavity. With this design, the uses and applications of the gyrometer are investigated. Results indicate the system may be used for engine stabilization, inertial navigation and guidance, brief angle measurements, and the direction of the axes in earth rotation measurements. Various other uses are mentioned. Also included are some of the advantages and disadvantages of this system.

CP43/31 **Status and Future of Liquid Components.** D.L.WRIGHT, W.G.WING.
AGARD Conference Proceedings CP 43, Paper 31, pp.537-579, 1968.
Particular examples of fluid gyros and accelerometers are described and their performance analysed. The information on the range of sensors described has been collected from some five commercial firms and from various patents and publications.

CP44 **Principle and Practice of Bionics.** H.E. von GIERKE, W.D.KEIDEL, H.L.OESTREICHER.
AGARD Conference Proceedings CP 44, Technivision, October 1970.
The growing practical importance and potential contributions of Bionics principles to aerospace research and operations stimulated the interest within NATO nations for a closer information exchange and a joint evaluation of the present status of this broad, interdisciplinary field. After first having sponsored a very successful Lecture Series on Bionics in 1965, AGARD decided to hold a Bionics symposium in 1968. This meeting took place 18-20 September 1968 at the Institut de Physiology Solvay, Université Libre de Bruxelles, Belgium. This volume contains the 28 invited papers delivered at the conference by selected scientists from six NATO nations.

CP45 **Ground Effect Machines and their Military Applications.** NATO Restricted.
AD-399-003 AGARD Conference Proceedings CP 45, 141 pp., 140 refs., 1968. (circulation restricted).
This document is a collection of the papers presented at the AGARD Meeting on the above subject held at the NATO Headquarters on the 26-27 November 1968. This meeting was a follow up to the publication of AGARD Advisory Report 15 on "The ACV Concept and its Military Application" and the most significant parts of the session devoted to the discussion of this Report are also recorded in this document. Four papers deal with the different technical potentialities of ACV, three with operational problems and three with future national requirements of three countries – US, UK, and France – in the field of GEM. Recommendations to NATO Authorities regarding the furtherance of this new concept are expressed in various places and especially in the Foreword. The eleven papers delivered are dealt with in the following abstracts.

CP45/1 **Large Hovercraft Vehicles.** P.R.CREWE.
AGARD Conference Proceedings CP 45, Paper 1, pp.1-20, 1968.
Describes the family of Hovercraft vehicles developed by the British Hovercraft Corporation leading up to the Mountbatten Class SRN4, a 170 ton vehicle now operating on cross-channel services. A "1½ and 5 rule" is suggested: a design can be stretched 50% in weight by modifications and by five times by going to a new and larger type within a family. Such growth rates are considered to be the largest to be safe within present knowledge. The paper then considers the development potential of the N4 type up to displacements of 1,000 tons and refers to alternative cushion containments and propulsion,

CP45/2 **Development of Air Cushion Vehicles.** (in French). C.MARCHETTI, P.F.GUIENNE.
AGARD Conference Proceedings CP 45, Paper 2, pp.21-30, 1968.
French work includes the Naviplane, the Terraplane and the Aerotrain all of which are air cushion vehicles. The problems presented by each design case are discussed. These include the vehicle configuration, the choice of operating conditions, methods of simulation and the civil and military requirements.

CP45/3 **On the Improvement of Cruise Efficiency and Manoeuverability of Ground Effect Machines.** W.B.NIXON.
AGARD Conference Proceedings CP 45, Paper 3, pp.31-40, 1968.
The report considers two extremes in design, the "barge like" type dictated by operational requirements and the type in which the designer has great freedom in the external shape. In the latter type the possible gains by using aerodynamic lift are discussed. In both cases it is predicted that performance gains are possible and the arguments lead to the advantages of a type of hybrid aircraft offering considerably increased cruise efficiency. Some experimental flight tests are described.

CP45/4 **Hovercraft Propulsion Problems.** J.G.RUSSELL.
AGARD Conference Proceedings CP 45, Paper 4, pp.41-60, 1968.
This paper deals with the use of air propellers and water jets for the propulsion of air cushion vehicles. The advantages and disadvantages are discussed.

CP45/5 **The Inter Service Hovercraft Unit.** P.BEACON. NATO Restricted.
AGARD Conference Proceedings CP 45, Paper 5, pp.61-72, 1968. (circulation restricted).
This short paper followed a film on the work of the Inter Service Hovercraft Unit during the last six years. Comparisons have been made between the SRN5, SRN6, the larger SRN3 and that of a Fast Patrol Boat (FPB) in the Naval Patrol Role.

CP45/6 **The Naval Falkland Islands Hovercraft Unit.** V.PHILLIPS. NATO Restricted.
AGARD Conference Proceedings CP 45, Paper 6, pp.65-72, 1968. (circulation restricted).
This report records the operational experience of a Royal Navy Hovercraft Unit using an SR.N6 hovercraft in and around the Falkland Islands.

CP45/7 **Concept for Employment of Air Cushion Vehicles During 1970-1975.** B.C.CROSBY.
AGARD Conference Proceedings CP 45, Paper 7, pp.73-77, 1968.
This paper expresses the view that Air Cushion Vehicles will perform the role of lightly armoured cavalry vehicles in marginal terrain, riverine area, during the period of 1970 to 1975. The roles and equipment of three types which are expected to operate together, Scout, Weapons, and Transport ACVs, are described.

CP45/8 **French National Requirements in Ground Effect Vehicles.** (in French). F.Y.LEENHARDT.
NATO – Diffusion Restrainte.
AGARD Conference Proceedings CP 45, Paper 8, pp.79-87, 1968. (circulation restricted).
A report for limited distribution which describes the requirements for air cushion vehicles of the Army, Air Force, Navy and finally Civil.

CP45/9 **The Potential Military Application of Hovercraft.** R.J.MacGAREL, G.ROVES. NATO Restricted.
AGARD Conference Proceedings CP 45, Paper 9, pp.89-96, 1968. (circulation restricted).
The paper discusses the UK requirements in the military fields which might be met by Hovercraft vehicles.

CP45/10 **Technical Problems in Development of Military Hovercraft.** M.S.IGGLESDEN. NATO Restricted.
AGARD Conference Proceedings CP 45, Paper 10, pp.97-101, 1968. (circulation restricted).
This paper discusses the technical problems posed by the previous paper and suggests possible solutions.

CP45/11 **R and D Requirements for Military Air Cushion Amphibians.** W.E.SICKLES.
AGARD Conference Proceedings CP 45, Paper 11, pp.103-110, 1968.
The paper discusses, in the light of experience in Vietnam, the requirements for US Army Air Cushion Vehicles. It is stated that operations using a modified commercial ACV, the Bell SK-5, have demonstrated that there is a role which the ACV can perform better than anything at present in the Army inventory. Cost, however, is high. Problems are discussed and a possible design is suggested.

CP46 **Aeroelastic Effects from a Flight Mechanics Standpoint.** P.LECOMTE (Editor).
AD-705-368 AGARD Conference Proceedings CP 46, 418pp., March 1970.
N70-29401 Twenty-five papers, together with discussions, are contained in this Proceedings. The papers are grouped under the following sessions: I. Preliminary session devoted to the state-of-the-art; II. Flight Dynamics of a Flexible VTOL Rotor; III. Flight Dynamics of Flexible Airplanes Theoretical Methods; IV. Experimental Methods for Flight Dynamics of the Flexible Airplane; V. Stability and Control Augmentation Devices.

CP47 **Techniques for Data Handling in Tactical Systems.** I.J.GABELMAN (Editor).
AD-699-488 AGARD Conference Proceedings CP 47, 27 Papers, 360 pp., many refs., 1969.
N70-19968 This volume presents the papers given at the 15th Symposium of the AGARD Avionics Panel held in Amsterdam 4-7 November 1968. These Proceedings contain twenty seven papers, grouped under the following technologies: Requirements, Processing, Communications, Computers in Tactical Applications, Integrated Circuits and Displays. The application of data handling techniques, utilization of sensors at remote locations, information transmission and processing, reduction and sorting techniques – particularly applicable to the tactical situation – are discussed. The 27 papers are dealt with individually in the following abstracts.

CP47/1 **Technology for the Tactical Environment.** D.SHORE.
AGARD Conference Proceedings CP 47, pp.1-6, 1969.
This paper describes trends in the operational environment and develops a system concept for post-1973 Tactical Air Command and Control. With this systems concept as a model, technology requirements are identified. The importance of mobility and the need to maintain effectiveness during any enemy attack are emphasised.

CP47/2 **Computer Controlled Communication Networks for Tactical Systems.** F.D.TRAPANI, R.ROSELLI.
AGARD Conference Proceedings CP 47, pp.7-20, 1969.
The use of digital computers in a military communication system is described and the various tasks described. The importance of standardization of equipment, language, codes and procedures is emphasised.

CP47/3 **Future Requirements for Tactical Data Handling Techniques in Aircraft.** R.S.AHA.
AGARD Conference Proceedings CP 47, pp.21-41, 21 refs., 1969.
Presents the need for developing data handling techniques for present and future tactical aircraft. Discusses data handling requirements for existing and projected aircraft and states that several are up to the threshold of the state-of-the-art. Finally a case is made for the formation of an Avionics Panel to deal with data handling requirements for new aircraft.

CP47/4 **Tactical Air Traffic Control.** M.STAAL.
AGARD Conference Proceedings CP 47, pp.43-57, 3 refs., 1969.
Describes a proposed integrated civil-military air traffic control system allowing for radar control, traffic planning and ad hoc radar control. As an introduction a short explanation is given of the fixed route ATC system now in operation at Amsterdam. Finally the case is made for 3D radar to assist in solving control problems.

CP47/5 **Philosophy and Structure of a Multiradar Tracking System.** H. von ISSENDORFF, W.PANDIKOW.
AGARD Conference Proceedings CP 47, pp.59-64, 4 refs., 1969.
Describes a multiradar system. Each radar is connected to a computer, called the radar computer which runs a tracking program in the normal way. Each radar computer system is fully operable in itself but several are connected to a central computer which receives messages on all tracks in a selected area and provides for data exchange between the radar and computers.

CP47/6 **A Limited Area Radar Auto-Tracking System.** L.MOORE.
AGARD Conference Proceedings CP 47, pp.65-76, 1969.
Describes an experimental system designed to investigate simple means by which automation may be applied to tracking radar contacts. Simplification is obtained by: manual track initiation, data extraction is confined to areas of immediate interest and there is no association of new data with existing tracks. Manual system management is required and the techniques required are discussed. Fields of application tried are the sea surface and to a lesser extent subsonic air targets. Feasibility has been proved and experimental results are summarised.

CP47/7 **Study by Realistic Simulations of Battlefield Tactical Systems Data Processing.** (in French).
L.A.GERARDIN, G.M.GOIX, C.R.HALNA.
AGARD Conference Proceedings CP 47, pp.77-90, 1969.
Prospective evaluations of the structures of data processing systems for land battlefield have been carried out using methods as realistic as possible. The tracking of level ground trails is first presented, and the influence of the false alarm of sensors is discussed. An animated cartoon technique is utilized to investigate the evenness of tracking of useful trails. Non-visibility effects ascribable to terrain roughness have been studied by tracing coverages taking account of such roughness, in order to get non-visibility sections on the data of vehicle studs. Since the purpose in view is merely to draw a prospective comparison between sensor network structures, it has been deemed preferable to produce mechanically realistic synthetic terrains defined by a few overall parameters – altitude dispersion, altitude correlation function – rather than digitalize topographical data obtained from actual maps. Examples of such terrains and of calculated coverages show the value of this type of realistic simulation for the prospective evaluation of information systems of the land battlefield.

CP47/8 **Automatic Initiation of Radar Tracks in Tactical Systems.** P.REGI.
AGARD Conference Proceedings CP 47, pp.93-104, 1969.
Two types of initiation procedures with different degree of automation are described: manual aided, initiation where the operation feeds positional data to a computer, and fully automatic initiation. The conclusions based on operational experience in Italy are: Automatic initiation processes can compete in effectiveness with manual procedure and their advantages are considerable, particularly during extended operations. However they cannot completely meet operational needs and it is desirable to also supply manually aided equipment.

CP47/9 **Self-Adapting Smoothing from Data Delivered by a Tracking Radar.** (in French). J. de BARBEYRAC, P.G.CAUMON.
AGARD Conference Proceedings CP 47, pp.105-117, 1969.
During recent years, the adaptation and self-adaptation of systems with a view to their optimization under various conditions of use, have been common concerns. However, while these problems have resulted in fruitful theoretical studies, the associated practical developments have not progressed similarly. Nevertheless, it appears that the increasingly extensive use of all purpose digital computers will make it possible to develop adaptation patterns for real-time data handling systems. in view of their considerable flexibility, digital computers can evaluate the quality of the processing to which they submit information, and modify parameters consequently. This paper is concerned with the self-adaptation of the parameters of the digital screening of data provided by a tracking radar. Therefore, from a theoretical viewpoint, we are faced with the problem consisting in optimizing digital screening in terms of the characteristics of the signal to be processed.

CP47/10 **Automatic Radar Signal Processing.** G.R.RAAB.
AGARD Conference Proceedings CP 47, pp.119-129, 1969.
Describes automatic data processing for air traffic control. Primary and secondary radars are used and the information from each is fed through a "Radar Plot Extractor", which converts the signals to information which can be fed to the operation centre over narrow band channels. At the operation centre the received signals are processed to provide the required track information.

CP47/11 **An Analysis of an Accumulator Detector.** F.MARCOZ.
AGARD Conference Proceedings CP 47, pp.131-146, 5 refs., 1969.
Describes the theory of plot extraction making use of the "moving window" logic. This makes good use of the available information but usually requires bulk memory stores. An alternative is the accumulator detector, this is discussed in detail and it is shown that the detection performance is substantially the same with a much smaller memory.

CP47/12 **Phase Coding MTI.** (in French). M.CARRE.
AGARD Conference Proceedings CP 47, pp.147-165, 2 refs., 1969.
The phase coding MTI (Moving Target Indicator) is a new device based on the phase measurement of received signals. It is intended for radars transmitting recurrent pulses. It aims at separating mobile echoes from fixed or slowly mobile echoes like ground or rain echoes. Such discrimination is achieved by setting off the phase variations which occur between the successive echoes of the mobile targets. The device which has been developed is mostly a digital, integrated circuit system. The advantages of this new device over the former MTI devices can easily be seen on a panoramic screen: images are more neat and condensed. False alarm is very much reduced in the areas contaminated by parasite echoes, and target detection is not degraded in clear areas. Comparative views will be shown during the presentation.

CP47/13 **Transmission Technique Performance and Channel Parameter Relationships in Data Communications.** R.C.WAAG.
AGARD Conference Proceedings CP 47, pp.167-189, 17 refs., 1969.
Selected modern techniques and recent channel descriptions are surveyed and notes made for the comparison of data transmission techniques. Basic modulation techniques are discussed and the importance of highly automatic instrumentation and the knowledge of the channel characteristics is emphasised.

CP47/14 **Error Control for Digital Communications in the Tactical Environment.** K.BRAYER, W.F.LONGCHAMP.
AGARD Conference Proceedings CP 47, pp.191-207, 13 refs., 1969.
This paper considers error detection with retransmission and forward error correction for the transmission media used in the tactical environment: i.e. troposcatter and high frequency radio. A practical approach used in the design of coding systems (which prevent information degradation) incorporates channel testing. The error patterns so collected are used in the simulation of various coding techniques, with the object of selecting the most promising.

CP47/15 **A Computer Controlled Telegraph Message Switching System for Use in a Tactical Headquarters.** J.A.CLARK, R.LITTLE.
AGARD Conference Proceedings CP 47, pp.209-226, 1969.
After a user survey an experimental model was made using an Elliot 920B computer with a 16K word core store which was backed by a Vermont 8.4M magnetic drum to serve as buffer store for one days traffic. The system provides handling and routing of formal telegraph traffic and connections to thirty duplex lines are available with a daily total traffic density of 2,000 messages. Details are given and it is shown that the overall limitation is drum capacity and access time.

CP47/16 **Tactical Data Communication Via Satellite.** M.TELFORD.
AGARD Conference Proceedings CP 47, pp.227-237, 1969.
Considers the relative advantages of normal radio communication and transmission via satellite. Use of existing bands between 7 and 8.5 GHz is attractive because of ready availability of equipment but change to higher frequencies above 10 GHz may be desirable. It is suggested that all signals (including speech) should be in digital form and that use of "vocoded" speech may be necessary.

CP47/17 **Improvements in Communications, Navigation and Identification – CNI – by Integration.** I.J.GABELMAN.
AGARD Conference Proceedings CP 47, pp.239-250, 4 refs., 1969.
The US Air Force Study Team recognising that C, N & I are elements of information has configured a CNI system. Transfer of information between system terminals is via a common modulation waveform and the system promises not only to reduce the number of antennae, transmitters and receivers but could improve performance. Application depends on further work and requires further advances in technology. These are discussed.

CP47/18 **High-Level Languages for Radar Data Processing – A Practical Approach.** J.G.GIBBS.
AGARD Conference Proceedings CP 47, pp.251-258, refs., 1969.
While it is claimed that the use of high-level programming languages has many advantages they have not been much used in radar data processing and air traffic control. This paper discusses the reasons and suggests an approach to the design of high-level languages more appropriate to the practical problems. Examples are given.

CP47/19 **Application-Oriented Microprogramming in Tactical Data Processing.** E.T.WALENDZIEWICZ.
AGARD Conference Proceedings CP 47, pp.259-266, 1 ref., 1969.
This paper briefly discusses the characteristics and organization of a hypothetical, current generation, microprogrammable, general purpose computer. Comparison of processing speeds and storage requirements for conventional and microprogrammed approaches for several applications are given and discussed in detail and it is shown that ten-to-one improvements in processing speed are sometime possible.

CP47/20 **Simulating a Tactical Image Interpretation Facility in the Laboratory.** J.J.EVANS.
AGARD Conference Proceedings CP 47, pp.267-290, 1969.
Describes work in progress on an automated photo-interpretation process, in which a laboratory simulation of an advanced tactical image interpretation has been set up. A computerized system was designed to provide: rapid retrieval of needed references, specifications for operation methods, and procedures. Particular attention is paid to the balanced sharing of systems work between the man and the machine and important compromises are discussed.

CP47/21 **Advanced System Effectiveness Techniques.** R.M.STUCKELMAN.
AGARD Conference Proceedings CP 47, pp.291-298, 10 refs., 1969.
This paper describes advanced techniques for defining and evaluating the effectiveness of command and control systems. The techniques were developed for the TACFIRE system, being developed for the US Army but are applicable to most command/Control/information processing systems. Application to other systems is discussed.

CP47/22 **A Small-Size Computer for Radar Data Processing.** H.GÖRLING, R.STARK.
AGARD Conference Proceedings CP 47, pp.299-308, 1969.
The tasks are examined in some detail and it is shown that requirements can be met by a general purpose computer and a signal data converter. A breakdown of both time and storage requirements shows that about 50% of the computer time is used by a simple version of the program and about 65% of storage capacity is occupied by the program and the associated lists. There is thus considerable capacity for extension.

CP47/23 **Improvements in Radar Data Handling Systems.** A.W.H.CARTER.
AGARD Conference Proceedings CP 47, pp.309-322, 2 refs., 1969.
This paper argues that the application of new technologies can now be used to produce mobile radar data handling systems at reduced cost, weight and space. Advantages of the proposed methods include the elimination of the need to re-design as variations in system capacity are required and the prospect that each system can be computer evaluated before a prototype is built. As examples, two present-day mobile radar data handling systems are compared with one using integrated circuits.

CP47/24 **The Application of Advanced Integrated Circuit Techniques to Radar and Sensor Data Handling.** H.H.STEENBERGEN, L.J.MICHEEL.
AGARD Conference Proceedings CP 47, pp.323-327, 1969.
Describes recent integrated circuit developments and discusses their application to radar and sensor data handling. Thus the Planar Distributed Function Generator (PDFG) may replace electromechanical devices such as servos and other rotating components to give comparable accuracy at less cost and power consumption. Other forms of integrated circuits are described and the applications discussed.

CP47/25 **Display System "Visu IV".** (in French). G. la ROSA.
AGARD Conference Proceedings CP 47, pp.329-337, 1969.
The VISU IV data display system has a module structure and incorporates the most recent advances of technology; its possibilities of use are much higher than those of the former conventional visualization systems. The system structure is presented and its various components described, i.e.:
– the working station, and the images that can be displayed therein.
– the technical development and visualization components.
– the element insuring the liaison with the main computer of the processing system.
The all purpose VISU IV material can be integrated into any data processing system, in particular into tactical systems.

CP47/26 **Data Handling Techniques for Light Attack Aircraft.** R.Y.BEESBURG.
AGARD Conference Proceedings CP 47, pp.339-348, 1969.
Discusses various data handling techniques and how they can be applied to an integrated avionics system using a functionally modular building block design from the sensor, processing and display point of view. It is concluded that the integration of avionics equipment in modern light aircraft into a reliable and effective system has become an art in itself.

CP47/27 **An Offset Target Indicator System (OTIS) Derived from Animated Radar Surveillance.**
I.H.F.MARTIN, B.D.PARKER.
AGARD Conference Proceedings CP 47, pp.349-359, 1 ref., 1969.
Discusses the difficulties of identifying and tracking enemy warships in crowded shipping lanes in order to avoid the first critical blow while the picture is still complicated by peacetime traffic. While merchantmen sail mainly in well defined sea lanes at constant speed, warships are less constrained and tend to change course and vary speed when on patrol. The PPI can be recorded electronically or photographically at intervals of about 1-3 minutes. The record can then be played back on the PPI at high speed so that the resultant animation will highlight those contacts differing from the majority. Other uses are discussed and a short description of the complete OTIS system is given.

CP48 **Aerodynamics of Atmospheric Shear Flows.** A.D.YOUNG (Ed.).
AD-702-659 AGARD Conference Proceedings CP 48, 452 pp., February 1970.
N70-23165 The papers in this Proceedings fall under three headings: I. Structure of Atmospheric Shear Flows; II. Basic Problems related to Atmospheric Shear Flows, and III. Industrial Problems. In addition, associated with each topic, is a general review paper by a leading exponent in that field. 27 Papers, together with Discussions and a Round Table Discussion are included.

CP49 **Ionospheric Forecasting.** V.AGY (Ed.).
AD-700-896 AGARD Conference Proceedings CP 49, 500 pp., January 1970.
N70-23112 With the continual demand for more communication channels to meet the increasing world traffic requirements, communicators are seeking ways to increase ionospheric communication reliability. Monthly median ionospheric predictions, although not perfect, provide guidelines for circuit planning. To improve system operations, it is necessary to forecast parameters pertinent to system performance on a shorter time period (days and hours).

The symposium is primarily concerned with:
1. current forecasting systems and their relation to forecast requirements,
2. ionospheric forecasting techniques including the use of ionospheric monitors, and
3. the influence of solar-geophysical events on the ionosphere, and forecasting of these events.

CP50 **Opto-Electronics Signal Processing Techniques.** J.BERTRAIS (Ed.).
AD-701-805 AGARD Conference Proceedings CP 50, 500 pp., February 1970.
N70-32686 The development of Opto-Electronics in the field of Avionics and, more particularly, in the field of signal processing has become increasingly important.

The publication will enable scientists and engineers in NATO member countries to increase their perspectives within the following opto-electronics processing areas:
1. Optical communications – Oscillators, Mixers – Telecommunications.
2. Memories, Recording and Displays.
3. Optical filtering – Holography – Pattern recognition.
4. Optical processing in real time – Radar signal processing – Applications of lasers.

CP51 **Testing of Airborne Avionics Systems.** R.W.FISH (Ed.).
AD-867-857 AGARD Conference Proceedings CP 51, 428 pp., March 1970.
N70-32151 Twenty-eight papers, together with discussions, are included in this Proceedings. The papers are grouped under the following seven session titles: I. The Operational Requirement; II. Evaluation of Avionics System Testing Concepts; III. Built-in Test Equipment (B.I.T.E.); IV. On-Board Test Equipment; V. Automatic Test Equipment (A.T.E.); VI. Automatic Test Equipment Software; VII. Specialized Applications.

CP52 **Reactions Between Gases and Solids.**
AD-702-657 AGARD Conference Proceedings CP 52, 497 pp., February 1970.
N70-24551 The kinetics and equilibria of gas-solid interactions are encountered in connection with a diversity of phenomena – combustion, ablation, corrosion, erosion, catalysis – each of which is usually studied and practised as a separate engineering speciality.

This colloquium brought together workers in all these disciplines. Research papers described current advances in NATO laboratories and authoritative surveys afforded a perspective to show the common thread of basic knowledge that connects these technologies as well as the differences in goals and emphasis that make each field unique.

Direct communication between specialists, crossing inter-disciplinary boundaries, is intended to stimulate new insights in dealing with the many practical problems which involve some aspect of gas-solid reactions.

CP53 **Engineering Practice to Avoid Stress Corrosion Cracking.** G.B.EVANS (Ed.).
AD-701-789 AGARD Conference Proceedings CP 53, 276 pp., February 1970.
N70-23051 All the papers are directed to the practical aspects of the prevention of stress corrosion cracking, not only from a technical view but as a management function, and are of most value to senior design and production engineers.

Discussions which followed the presentation of the papers are included.

CP54 **Hybrid Navigation Systems.** C.T.LEONDES (Ed.).
AD-701-775 AGARD Conference Proceedings CP 54, 332 pp., January 1970.
N70-23501 In recent years there has been an increased emphasis on hybrid navigation techniques. The tendency to use either pure inertial or ground-based radio systems for navigation of aircraft has been gradually changing. This symposium examines some of the techniques currently in use or planned for use in future missions.

The program covered five aspects of hybrid navigation: I. Systems Applications of Hybrid Navigation Techniques; II. Air Traffic Control and Systems Applications; III. The Interaction of Airborne and Ground Elements; IV. Aircraft Experience and Applications; V Analytical and Theoretical Considerations of Hybrid Techniques.

CP55 **Problems of the Cockpit Environment.** S.DOMJSHEK (Ed.).
AD-705-369 AGARD Conference Proceedings CP 55, 438 pp., March 1970.
N70-29618 Thirty-one papers are presented in this Proceedings, grouped under the following session titles: I. The Problems of Determining Crew Capability under Stress; II. Problems in Analysis and Measurement of Information Transfer Requirements and Effectiveness for Various Missions; III. The Problems of Correlating Crew Training, Crew Size and Composition, and Automated Assistance; IV. The Problems of Cockpit Design including Instrumentation Computer/Display/Control Systems and Components; V. The Problems of Cockpit Information Generation; VI. Open Forum for Inter-Disciplinary Discussions; VII. The Problems of Deriving In-Cockpit and Head-up Information Display Configurations; VIII. Session Chairmen ummary and Conclusions, Presentations to Whole Assembly.

CP56 **Measurement of Aircrew Performance: the Flight Deck Workload and its Relation to Pilot Performance.**
AD-699-934 AGARD Conference Proceedings CP 56, 108pp., many refs., 1969.
N70-19779 Papers presented at the meeting of the Aerospace Medical Panel of AGARD in Texas in May 1969. Attention was drawn to the difficulties associated with the quantitative assessment of workload and the prediction of loss performance resulting from high or prolonged workloads. Whereas the effect of specific components of workload (e.g.; thermal stress) on pilot efficiency is understood to an extent that allows the aeromedical specialist to offer an evaluated opinion to the operational commander, a comparable situation does not exist when a more general assessment has to be made of the aviator's workload and the operational consequences predicted. However, it was reassuring to find work in progress in two major areas of operational importance in civil as well as military flying. One was concerned with the study of short-term high workload during approach and landing, the other with an examination of the factors, such as sleep loss and duty schedules, that determine the long-term workload. The eight papers are dealt with individually in the following abstracts

CP56/1 **Flight Deck Workload Studies in Civil Transport Aircraft.** J.S.HOWITT.
AGARD Conference Proceedings CP 56, Reference 1, pp.1-1 to 1-7, 1969.
During the past four years a small team, from the Board of Trade and the Royal Air Force has been making field studies in civil airlines on long-haul and short-haul operations. The work is divided into three main areas, that associated with short-term workload, that with accumulated effects over a particular period and that associated with the total working environment. The methods used and further areas of research are discussed.

CP56/2 **Energy Cost of Piloting Fixed and Rotary Wing Army Aircraft.** D.E.LITTELL.
AGARD Conference Proceedings CP 56, Reference 2, pp.2-1 to 2-4, 1969.
The energy cost of piloting three US Army helicopters and one utility fixed wing aircraft was investigated by measuring expired oxygen. Data was collected on 16 pilots. For the conditions studied the energy cost is classed as very light work while the energy cost of less skilled pilots flying the fixed wing aircraft was greater and in conformity with previous work.

CP56/3 **Psychomotor Performance Under Thermal Stress: A Critical Appraisal.** R.D.JONES.
AGARD Conference Proceedings CP 56, Reference 3, pp.3-1 to 3-15, 51 refs., 1969.
This paper criticises previous work on thermal stress on the ground of the measurements of tolerance levels. It is suggested that research should be concentrated on the adoption of a standardized index representing what is now loosely called "heat". Other work including the formulation of a definition of "stress" in terms of a subjects ability to perform a given task is discussed.

CP56/7 **Operational Measures of Pilot Performance During Final Approach to Carrier Landing.** C.A.BRICTSON.
AGARD Conference Proceedings CP 56, Reference 7, pp.7-1 to 7-11, 5 refs., 1969.
Measurements of pilot performance during night carrier landings are found to be statistically and practically different from daytime performance in terms of altitude control. Empirical landing performance criteria are developed from the data and used to predict the probability of landing success as a function of deviations in final approach performance.

CP56/8 **Aircrew Task Loading in the Boeing Multimission Simulator.** L.P.ZAITZEFF.
AGARD Conference Proceedings CP 56, Reference 8, pp.8-1 to 8-3, 1969.
A short paper on a simulator which combines a 160° "real world" colour display with a completely functional cockpit. Visual target acquisition was used as a measure of task loading in tests of one- and two-man crews flying realistic military missions. Visual target acquisition is shown to be significantly better with a two-man crew.

CP56/9 **Physiological Assessment of Pilot Stress During Landing.** K.G.CORKINDALE, F.G.CUMMING, A.M.HAMMERTON-FRASER.
AGARD Conference Proceedings CP 56, Reference 9, pp.9-1 to 9-4, 4 refs., 1969.
Describes an experimental programme jointly undertaken by the RAF Institute of Aviation Mission and the Royal Aircraft Establishment. A physiological recording system is described which records in digital form. After laboratory tests this was installed in a Comet Jet transport. The programme is described and it is concluded that measurement of pilot stress is feasible and that there is need for a more portable digital recording system.

CP56/11 **Flight Deck Work Load and Night Visual Approach Performance.** C.L.KRAFT, C.L.ELWORTH.
AGARD Conference Proceedings CP 56, Reference 11, pp.11-1 to 11-14, 12 refs., 1969.
Research with a simulator is said to provide data supporting a logical explanation for about 16% of air transport accidents.

CP56/12 **Exploratory Study of Pilot Performance During High Ambient Temperatures/Humidity.** S.MORGAN, J.A.BARNES.
AGARD Conference Proceedings CP 56, Reference 12, pp.12-1 to 12-24, 17 refs., 1969.
Describes a study to explore techniques to provide quantifiable information and to assess pilot performance in a hot environment. A prototype OH-6A Helicopter was instrumented as a test vehicle and was flown by four experienced pilots in precision patterns wearing four separate clothing configurations. Results are described and correlated with temperature/humidity.

CP57 **Problems in Mechanization of Small Information Centres.** J.J.IRVINE (Ed.).
AD-702-660 AGARD Conference Proceedings CP 57, 125 pp., February 1970.
N70-23076 This volume contains the text of eleven papers presented at the Specialist Meeting of the Technical Information Panel which was held at the National Library and Archives Building in Ottawa on 16 and 17 September 1969.

The purpose of this meeting was to discuss and exchange experiences concerning the many practical problems that occur in the setting up of an automated centre; from the seeking of approval for the project, to the commencement of its successful operation.

Topics covered are: the advantages to be gained with the establishment and operation of Small Information Centres, the role of Small Information Centres in the NATO community, assessing the value of the pilot project approach, the importance of greater participation by the user both in the preparation of better profiles and in the provision of feedback data, the comparison of cost and effectiveness of the operation, assessment and selection of hardware, the importance of training and retraining of personnel.

CP58 **Advanced Control System Concepts.** C.T.LEONDES (Ed.).
AD-701-546 AGARD Conference Proceedings CP 58, 218 pp., January 1970.
N70-23026 The papers presented at the Symposium on Advanced Flight Control Concepts, a joint meeting of the Flight Mechanics Panel and the Guidance and Control Panel of AGARD, held in Oslo in September 1968. One group of papers described the theory, development and application of sophisticated adaptive control techniques to aircraft and missiles, justifies the system complexity and discusses future trends; papers in the other group are concerned primarily with the integration of the aircraft with these new concepts, which have been made possible by advances in electronics and electromechanical systems and are now approaching flight implementation. These concepts could result in a revolutionary change in aircraft control capabilities through automation, leading to an order-of-magnitude improvement in flight safety under all-weather conditons, and they are essential if the full potential of VTOL aircraft for safe all-weather operations is to be realized.

CP59 **Aircraft Landing Systems.**
N71-12425 AGARD Conference Proceedings CP 59, 330 pp., September 1970.
With expanding air traffic, the problem of aircraft landing systems is assuming ever-increasing importance. Safety throughout the flight profile of any aircraft is essential. Certainly, however, at the terminal point the problem is complicated and aggravated by the confluence of many aircraft wishing to use the same landing field and which arrive there at or near the same time. An additional complicating factor is bad weather conditions, which makes it highly desirable to develop aircraft landing systems of zero visibility capability.

For these reasons and others, it was most appropriate for the Guidance and Control Panel to devote its May 1969 symposium to the rather broad subject of Aircraft Landing Systems, with six technical sessions covering many of the significant areas of Aircraft Landing Systems. The symposium proceedings consists of the papers presented at this meeting.

The first session, entitled 'Needs and Requirements: Conventional and V/STOL' was devoted to a definition of many of the important problem areas of aircraft landing systems.

The second session, 'System Details for Conventional Aircraft', dealt with fundamental systems considerations for aircraft landing systems. Short flight problems between closely-located urban centers, for instance, are assuming greater importance, and the third session, 'System Details for V/STOL Aircraft', quite appropriately treated this area. Backing up the systems considerations of the earlier sessions, the fourth session 'Experience with Aircraft Landing Systems', included a number of valuable papers detailing landing experience. The fifth and sixth sessions, 'Technical Hardware' described a rather broad and significant array of technical hardware aspects of landing systems.

CP60 **Numerical Methods for Viscous Flows.**
AD-708-697 AGARD Conference Proceedings CP 60, 83 pp., May 1970.
N70-32570 This Conference Proceedings contains extended abstracts of papers presented at a Seminar organised by the Fluid Dynamics Panel of AGARD in September 1967 on this subject. Contents are divided into three sections: Solutions of the Navier-Stokes Equations; Numerical Methods for Turbulent Boundary Layers; Solutions of the Higher Order Boundary Layer Problems.

CP61 **Medico Legal Aspects of Aviation.** A.SCANO (Ed.).
N71-11801 AGARD Conference Proceedings CP 61, 330 pp., September 1970.
This volume contains the speeches and papers presented at the 26th Meeting of the Aerospace Medical Panel in Florence, 21-24 October 1969. It is composed of two parts. The first reviews many aspects of Legal Medicine applied to Aviation: theoretical aspects, professional pathology of aviators, protection of personnel, selection of pilots, investigation after accidents. The second part is devoted to various topics on recent advances in Aerospace Medicine: it gives the present situation in the aerospace medicine fields of research, and particularly the biological aspects of the Apollo missions.

CP62 **Preliminary Design Aspects of Military Aircraft.**
AD-705-370 AGARD Conference Proceedings CP 62, 300 pp., March 1970.
N70-11801 This Proceedings contains nineteen papers grouped under the following seven sessions: I. Project Design; II. Aerodynamics; III. Power Plant; IV. Structures; V. Airframe Systems; VI. Operations Systems; VII. Operational Requirements.

CP63 **Composite Materials.**
AGARD Conference Proceedings CP 63, (Pre-print), March 1970.
The scheme of this publication reflects the outlines of the Cooperative Program of the Structure and Materials Panel on Composite Materials.

Parallel to the Cooperative Program, the publication includes the following subjects:
- Study of the elastic properties of composite materials,
- Investigation of different testing methods for these characteristics,
- Problems involved in the manufacturing of materials with metallic matrices,
- Problems of the interface,
- In conclusion, the review of the state-of-the-art and of the different problems that would be useful to study for the further development of technology in this field.

These different items are explained by eighteen papers which are presented as the contribution of five countries to the Cooperative Program on Composite Materials of the Structures and Materials Panel: Belgium, France, Netherlands, United Kingdom and United States.

CP64 **Advanced Technology for Production of Aerospace Engines.**
N71-11626 AGARD Conference Proceedings CP 64, (Pre-print), pp. 414, March 1970.
Over the past two decades, there have been tremendous advances in turbojet performance. A modern jet engine will be about a third as heavy, a fifth the volume, and half as long as the same thrust engine built 20 years ago. In addition, the modern turbojet burns about a third less fuel. These improvements have been accomplished, in part, as a result of advances in internal aerodynamics, turbine cooling and pressure ratio. Manufacturing techniques and methods have played a significant role.

During the same two decades, rocket thrust levels have increased by a factor of a thousand. Once again the advancement in performance has been paced by new manufacturing techniques, as well as exploitation of new materials. It is appropriate to focus attention on advanced production technology.

CP65
N70-40841

Fluid Dynamics of Blood Circulation and Respiratory Flow.
AGARD Conference Proceedings CP 65, (Pre-print), 353 pp., May 1970.
The rapidly developing field of biofluid dynamics has important implications for future aerospace operations and for cooperation among research workers involved or interested in medical and biological applications of fluid dynamics. The area of biofluid dynamics is so broad it was decided to limit the scope to the above.

The subjects covered are recent developments connected with the fluid dynamics of blood circulation in the human body, and gas flows within the lungs. Approximately 34 papers are collected here, with special emphasis on micro-circulatory systems, effects of vibration and gravity, pulsative flows, transport problems and measuring techniques.

CP66
N71-13901 to
N71-13939

Advanced Radar Systems.
AGARD Conference Proceedings CP 66, (Pre-print), 582 pp., April 1970.
This is the 19th Symposium of the Avionics Panel and the papers were prepared in response to the following theme. A considerable number of advances have been made over the whole range of components used in radar systems and numerous new devices have arrived on the scene. The digital computer has become established and plays an important role in the optimal control of the radar and manipulation of its output. Not only have these developments led to the realisation of many system techniques that until recently have existed only as intriguing ideas but they have also brought with them a number of important novel principles. The new facilities now feasible have also suggested new methods for separating targets from clutter which, in turn, has led to extensive measurement programs and a considerable wealth of fresh knowledge of target and clutter characteristics.

CP67
N71-13826 to
N71-13854

Data Handling Devices.
AGARD Conference Proceedings CP 67, (Pre-print), 398 pp., April 1970.
The information explosion noted during the last several decades in the scientific and technical fields has also been felt in the military and business management areas as well. Manual and semi-automatic means of handling this immense volume of information have proved inadequate and have hindered its effective and expeditious application. The development of automatic means of handling data using computer technology is providing the rapid control and processing capability required. Parellelling the growth of computer technology has been the development of devices for the handling of data in its various forms.

The 'Data Handling Devices' symposium considers operational requirements, theoretical considerations, development and design, description and application of devices and their impact upon the data handling community. Extension of existing devices and research and development for new devices are of definite interest. Theoretical and applications studies regarding systems implementations and the performance of devices such as reliability, cost effectiveness and hardware and software trade-offs are considered as well as equipment descriptions. Data sensors, such as antennae, detectors, etc. are not considered in this symposium and concentration is focussed upon devices which perform the remaining functions of data handling.

CP68
N71-12601

Applications of Digital Computer to Guidance and Control Systems. G.A.WHITFIELD (Ed.).
AGARD Conference Proceedings CP 68, (Pre-print), 296 pp., May 1970.
Until the early 1960s, the very low reliability of discrete electronic components and assemblies severely limited the nature of the calculations which could be performed in aerospace vehicles. Since then the availability of comparatively cheap yet very reliable integrated circuits and medium size integrated devices has greatly reduced this limitation. Further, it has made it possible to design useful digital computers which have, consequently, improved the use which can be made of information provided by sensors.

A symposium to review the work being done and to perhaps resolve some of the remaining differences of opinion in this area was considered timely. In the papers presented, and which are reproduced in full in this Proceedings, the emphasis was on both the manner in which digital computers are being or can be used to improve the navigation and control of aerospace vehicles, and on the design of the computers themselves.

CP69

V/STOL Aircraft and Their Applications (Classified).
AGARD Conference Proceedings CP 69, 168 pp., July 1970.
This document is a collection of the papers presented at the AGARD Meeting on the above subject held at the NATO Headquarters, 8-10 December 1969. This meeting was a follow-up to the publication of AGARD Advisory Report 18 on 'V/STOL Comparison Study'. The most important parts of the periods of discussion are also included, wherever possible in their original form.

CP70

Tropospheric Radio Wave Propagation.

AGARD Conference Proceedings CP 70, (Pre-print), July 1970.

Although many of the main aspects of Tropospheric Radio Wave Propagation have become known after research work commenced in this general field some two decades ago, a definite need existed for a symposium covering the present status. Attention is given to detailed characteristics such as side scatter, signal distortion and intermodulation with tropospheric scatter propagation and tropospheric transparency for space communications. Problems of tropospheric propagation predictions are dealt with in detail.

The symposium takes into account the relevant requirements of both the more theoretical approach and also applications in the military fields; these are represented by predictions of strength and quality of signals propagated on paths within the terrestrial surface regions as well as to and from communication satellites.

The program covers five major sessions with approximately 50 papers being presented over a period of five days. Session topics are as follows: I. Tropospheric Characteristics; II. Propagation through the Troposphere; III. Reflection and Refraction in the Troposphere; IV. Tropospheric Scatter Propagation; V. Tropospheric Propagation Predictions.

CP71

Aerodynamic Interference.

AGARD Conference Proceedings CP 71, (Pre-print), September 1970.

This publication reports the results of the Specialists' Meeting on Aerodynamic Interference of the Fluid Dynamics Panel, Silver Spring, Maryland, U.S., September 1970. The meeting was established for presentation and discussion of theories and experiments, including flight, which would provide new insight into the basic mechanism and features of aerodynamic interference. It emphasized aerodynamic interaction phenomena which may improve the flight characteristics of military aircraft, commercial airplanes, and weapons. The speed regime was restricted to subsonic, transonic and supersonic Mach numbers. A total of 36 papers are published in six sections covering: I. Configurations studies of lift, drag and moment characteristics; II. Aerodynamic and high angle of attack characteristics; III. Airframe influence for favourable inlet and exhaust nozzles; IV. Optimum configuration for transonic-supersonic cruise; V. Influence of internally and externally carried stores; VI. Aircraft performance and stability – and control characteristics.

CP72

Low Altitude Flight Control Problems.

AGARD Conference Proceedings CP 72, (Pre-print), July 1970.

Since the formation of the Guidance and Control Panel in 1965, one of the problems on its agenda has been automatic flight control at very low altitudes. One of the best methods for penetrating a well established air defense system, and one of the most difficult, is to go in as low and as fast as possible. Unfortunately, to be an acceptable tactic, the maneuver must be possible in all conditions of weather and illumination, and hence it must be fully automatic. Papers for this symposium were designed to address the problem from several aspects in order to gain a comprehensive view of what should be done, what has been done, and what can be done in the future.

While the Guidance and Control Panel holds the view that the resolution of these problems lies in the Guidance and Control area, the best way to do it is to bring together the specific disciplines concerned, to view the problems and the proposed solutions together from a systems point of view. Therefore, the Avionics, Flight Mechanics and Aerospace Medical Panels of AGARD participated in this symposium.

CP73
N71-17372 to
N71-17402

High Temperature Turbines.

AGARD Conference Proceedings CP 73, (Pre-print), September 1970.

During the thirty years or so that aircraft gas turbine engines have been under development and in use, continuing efforts have been made towards increasing operating temperatures. From a glance at Carnot's diagram it can be seen that increasing the maximum cycle temperature results in improved efficiency (or reduced consumption). Specific power, which is a major concern in aeronautics, increases with temperature.

Although aeronautical turbines are a product of a technologically advanced industry, they operate at temperatures of 800 to 1200°C which are markedly lower than those in other types of engine, for example 1800 to 2800°C in Diesel or gasoline engines. This results from the very nature of turbine engines, which are continuous combustion engines in which vital mechanical components are continuously submerged in hot flowing gases.

In the earlier years of development, metallurgical advances of themselves made it possible to raise turbine operating temperatures from the region of 700°C to around 1000. During the last decade, an important step forward was achieved with the introduction of the use of cooled turbine blades. Today, turbine engines are under development and in use which incorporate cooled blades operating at temperatures of about 1150°C. Considerable effort is continuing in the investigation of new and improved materials and of more advanced blade cooling methods, with the aim of raising operating temperatures up to and beyond 1300°C.

The purpose of this meeting was to review and highlight the main aspects of the problems of achieving high temperatures in aeronautical turbines, problems whose resolution will lead to overall improvements in the performances of turbine engines and open up wider fields for their utilisation.

CP74
N71-16905 to
N71-16916

Rest and Activity Cycles for the Maintenance of Efficiency of Personnel Concerned with Military Flight Operations. A.J.BENSON (Ed.).
AGARD Conference Proceedings CP 74, 116 pp., December 1970.
This book is composed of the 10 papers presented in Oslo, 13-14 May 1970 at a Specialist Meeting of the Aerospace Medical Panel. It covers some specific aspects of the broad problem concerned: Laboratory studies on circadian rhythms and task performance, and on sleep loss; transport operation problems : double crew operations, single crew operations; air traffic control operation problems.

CP75
N71-13876 to
N71-13897

Education and Training in Aerospace Medicine. D.FRYER (Ed.).
AGARD Conference Proceedings CP 75, 158 pp., November 1970.
This volume contains the text of the 20 papers presented in Oslo, 12-13 May 1970 at a Specialist Meeting organized by the Panel. It reflects the procedures and the programs used in the various NATO nations for Aerospace Medicine teaching and training, not only for doctors, but also for nurses, aircrew and engineers.

CP76

Lessons with Emphasis on Flight Mechanics from Operating Experience Incidents and Accidents.
AGARD Conference Proceedings CP 76, (Pre-print), October 1970.
The pre-print consists of four papers: I. A Brief Review of Some Safety Studies based on Operational Flight Recording; II. V/STOL in the Royal Air Force – Some Lessons from the first 18 Months; III. Risks in Instrument Flying and Low Visibility Approaches; IV. Etablissement des Marges de Sécurité au Décollage et à l'Atterrissage pour le Breguet 941.

CP77
N71-13701 to
N71-13741

Electromagnetics of the Sea.
AGARD Conference Proceedings CP 77, 586 pp., November 1970.
The growing interest and increased activity in exploiting ocean resources promotes this Specialists' Meeting for the dissemination, exchange and integration of experimental and theoretical findings as well as formulating cooperation for problems remaining unsolved.

Underwater Electromagnetic Propagation has experienced a rebirth with increased activity beneath the oceans. Two portions of the electromagnetic spectrum fill the gap previously occupied by acoustics – VLF/ELF and optics. This resulted from their common characteristic of propagation along air-sea transmission paths. Optics gives high resolution at short range, VLF offers low information rates at long ranges.

Typical optic applications for both military and commercial utilization are identification, recognition and salvage. VLF/ELF offers extensive communication possibilities and underwater remote control. Bottom mapping from the air with coherent radiation shows promise.

The program has been divided equally between radio and optics under the following sessions: I. VLF/ELF Radiation and Propagation in Sea; II. VLF/ELF Electromagnetic Noise; III. Air Sea Interface and Scatter; IV. MHD of the Ocean; V. Round Table, open forum; VI. Optical Properties of Sea Water; VII. Imagery; VIII. Research Program in Optical Oceanography; IX. Round Table, open forum.

CP78

Information Analysis Centres.
AGARD Conference Proceedings CP 78, (Pre-print), November 1970.
This publication contains the papers presented at the Specialists Meeting of the Technical Information Panel, in Amsterdam, 10-11 November 1970, on

1. Concept, Mission, and Operation of Scientific and Technical Information Analysis Centres
2. Un Centre de Documentation Spécialisé : Son Organisation – Ses Méthodes – Son Efficacité
3. The Harwell Heat Transfer and Fluid Flow Information Analysis Centre
4. Proposal for an International Air Pollution Information Analysis Centre
5. Maritime Pollution

EARLY AGARD PAPERS

AG1/P1
AD-688-680
N70-73192

See GA2

AG2/M1
AD-688-681
N70-70356

Some Applications of Strain Gages in Aeronautical Research. I.H.ABBOTT.
AGARD Mem. AG 2/M1, 3-26, 1952.
Three fields of application are. direct measurement of stress or strain in structures, measurement of aerodynamic loads on aircraft in flight; instrumentation, such as for miniature pressure transducers, control force instruments, torque meters and balances. Their use in the last category, especially for wind tunnel instruments, is considered in detail. The other aspects are treated summarily.

AG2/M1/1

Flight Test Applications of Strain-Gages. W.K RICKERT.
AGARD Mem. AG 2/M1, 27-53, 4 refs., 1952.
The advantages of using strain-gages are reviewed. These include: linear output with strain, accuracy, stability, small size, use with remote location, and low cost. Temperature compensation is generally easy and several may be combined to give a single output. Recording systems and the practical applications in flight tests are discussed.

AG3/M2
AD-688-683
N63-90338

Methods Used by NACA for Data Reduction. I.H.ABBOTT.
AGARD Mem. AG3/M2. 17pp., 1952.
NACA developments in this field have followed two lines. the development of flexible semi-automatic methods of processing which can handle all kinds of data regardless of source or method of measurement; and almost fully automatic methods for processing specific types of measurements made in a standardized manner and in large numbers.

AG4/M3
AD-084-991
N-27631X
Superseded by
Spec.2
AD-209991
N-27631Y

Specifications for AGARD Wind Tunnel Calibration Models.
AGARD Mem. AG4/M3, 6pp., 1955 (Revised Edition).
To enable valid comparisons to be made between tests in different tunnel facilities of the various AGARD research centres, proposals are made for a standardized configuration of model for calibrating the tunnels. Only the external geometry of the models is considered here.

AG5/P2
AD-688-682
N70-73191

Technical Presentations Before the AGARD Combustion Panel, Italy, 1952.
AGARD Publ. AG5/P2, 90pp., 58 refs., 1952.
Seven papers presented before the AGARD Combustion Panel, Rome, Italy, December, 1952, are reproduced. Abstracts of the individual papers are given in the succeeding items.

AG5/P2/1

Introduction to Chemical Kinetics for Aeronautical Engineers. S.S.PENNER.
AGARD Publ. AG5/P2, 1-8, 1952.
A survey is presented of the basic principles in the course of the solution of representative problems on chemical reactions in flow systems. Two special problems are treated by using linearization procedures of the type commonly employed in the solution of problems in aerodynamics.

AG5/P2/2

Experimental Investigation of Internal Structure of Flames. J.W.LINNETT.
AGARD Publ. AG5/P2, 9-15, 26 refs., 1952.
A plane flame of infinite extent with gas moving through it in a direction normal to the flame front is considered. The ways in which information about the following quantities can be obtained are discussed: (i) burning velocity; (ii) the variation of temperature with position (i.e. x-co-ordinate), assuming that the distribution of energy among the molecules in any layer is in statistical equilibrium; (iii) the variation with the x-co-ordinate of the partial pressures of all the chemical substances in the flame.

AG5/P2/3

Ignition Delay Measurements on Gas Turbine Fuels by the N.G.T.E. Method. B.P.MULLINS.
AGARD Publ. AG5/P2, 16-31, 21 refs., 1952.
Previous measurements of spontaneous ignition temperatures were all made under conditions substantially different from those occurring in gas turbines. The N.G.T.E. method, specially developed to provide data for gas turbine calculations, is briefly described. Some of the experimental results obtained by this method are presented in the form of ignition delay-temperature curves, and are discussed.

AG5/P2/4

Combustion Instability in Rocket Motors. (In English and French). L.CROCCO.
AGARD Publ. AG5/P2, 32-53, 11 refs., 1952.
The purpose of this paper is to review some ideas and theoretical results concerning the phenomenon of unstable or abnormal combustion.

AG5/P2/5 **Combustion Problems in Turbojets.** (In English and French). J.SURUGUE.
AGARD Publ. AG5/P2, 54-67, 1952.
Three aspects of these problems are discussed: (i) the importance of basic investigations of the combustion process; (ii) the importance of the production and evolution of liquid fuel clouds due to the injection nozzles, and the behaviour of these clouds in the combustion zone; (iii) the possibilities offered by chemistry toward solving some of these problems.

AG5/P2/6 **Report on Combustion Symposium: Combustion Chamber Problems.** (In English and French). J.FABRI.
AGARD Publ. AG5/P2, 68-78, 1952.
Summarizes the main conclusions of the papers given at the Fourth Symposium on Combustion held at Cambridge, Mass., September, 1952. Contents: laminar flame structure, turbulent flames, flame propagation, burning of liquid fuels, flame stabilization by bluff bodies, flammability limits and ignition, detonation waves, instability phenomena in combustion chambers.

AG5/P2/7 **Combustion Problems in Ramjets.** (In English and French). R.SIESTRUNCK.
AGARD Publ. AG5/P2, 79-90. 1952.
The following points are discussed: the vibrations due to purely mechanical causes, the more critical pulsations generated by the flame itself, and the conditions of flame stabilization in the wake of bluff bodies.

AG6/P3 See GA3
AD-070-449
N63-82586

AG7/P4 See MP2
AD-695-273

AG8/M4 **Some Factors Contributing to Scale Effect at Supersonic Speeds.** I.H.ABBOTT.
AD-662-965 AGARD Mem. AG8/M4, 26pp., 27 refs., 1953.
N63-82534 The important effects resulting from changes in the boundary-layer between model and full-scale conditions can be broadly classified as: (i) variations of skin friction coefficients with Re; (ii) movement of transition point with variations in Re; (iii) changes in location and extent of boundary layer separation with changes in Re. In this paper information is given on the Re effects at supersonic speeds on skin friction, transition and separation, and brief consideration of some effects of turbulence, weak shock waves from the walls, and heat transfer.

AG9/M5 **A Scheme of Automatic Data Reduction for Wind Tunnels.** K.V.DIPROSE.
AD-041-669 AGARD Mem. AG9/M5, 17pp., 1953.
N69-80408 Describes some of the devices used at the Royal Aircraft Establishment, Farnborough, U.K.

AG10/M6 **A Note on the Use of Strain Gauges in Wind Tunnel Balances.** J.R.ANDERSON.
AD-041-670 AGARD Mem. AG10/M6, 20pp., 1953.
N69-80625 Discusses some of the experience obtained in the smaller high speed tunnels of the Aerodynamics Dept., Royal Aircraft Establishment, U.K. With care taken in all stages of design and construction an accuracy to within 1% of measurement can be obtained.

AG11/M7 **Diffusion Flames in the Laboratory.** J.BARR.
AD-040-033 AGARD Mem. AG11/M7, 10pp., 55 refs., 1954.
N69-80443 Laminar diffusion flame structure is described. Suggestions are made for further research. Turbulent diffusion flames and vibrating diffusion flames are briefly mentioned.

AG12/M8 **Formation and Deposition of Carbon in the Combustion Chambers of Aircraft Turbine Engines.**
AD-471-225 (In French). C.FOURE.
AGARD Mem. AG12/M8, 21pp., 13 refs., 1954.
The phenomenon of carbon deposition in liquid-fuelled industrial furnaces has been known for some time. The operation of gas turbines with the present fuels is not seriously affected by carbon deposition. The use of additives to fuels to reduce this deposition has not been fully explored but one could foresee modifications to combustion chambers to reduce the formation and eventual deposition of carbon on the walls.

AG13/M9 **The Mechanism of Carbon Formation.** G.PORTER.
AD-044-761 AGARD Mem. AG13/M9, 16pp., 26 refs., 1954.
N69-80420 A fairly detailed theory of the mechanism is presented; other theories are critically reviewed and some experimental data summarized from flash photolysis experiments. The proposed mechanism envisages the formation of carbon from simultaneous condensation and dehydrogenation of the acetylene formed in high temperature pyrolysis.

AG14/P5
AD-066-491
N69-80501

See GA4

AG15/P6
AD-070-450
N70-71126

Papers Presented at the Fifth Meeting of the Wind Tunnel and Model Testing Panel.
AGARD Publ. AG15/P6, 192pp., 1954.
Ten papers presented at this meeting held at Scheveningen, Netherlands, in May, 1954, are reproduced. Abstracts of the individual papers are given in the succeeding items.

AG15/P6/1

Measurement of Aerodynamic Forces on Oscillating Aerofoils. A.I.Van De VOOREN.
AGARD Publ. AG15/P6, 7-13, 1954.
Contents: Introduction; General principles; Apparatus; Results for the wing derivatives; Measurements for a wing flap system.

AG15/P6/2

A Review of the Techniques of Measuring Oscillatory Aerodynamic Forces and Moments on Models Oscillating in Wind Tunnels in Use on the Continent. J.VALENSI.
AGARD Publ. AG15/P6, 14-49, 15 refs., 1954.
The principles of the three basic methods of determining stability derivatives in wind tunnels (decaying oscillations, forcing through a spring, and inexorable forcing) are stated. The equations of motion for small symmetric and asymmetric disturbances from steady symmetric flight are then reviewed. The three methods are thoroughly discussed with reference to practice in several laboratories in NATO countries and also K.T.H. and F.F.A.

AG15/P6/3

Methods and Results of Non-Stationary Airfoil Theory. R.TIMMAN.
AGARD Publ. AG15/P6, 50-55, 65 refs., 1954.
Reviews the problems which have been solved either exactly or by approximate methods in two-dimensional compressible and incompressible flow and three-dimensional theory.

AG15/P6/4

Techniques of Model Testing in Free Flight. J.A.SHORTAL.
AGARD Publ. AG15/P6, 56-68, 1954.
Concerns principally rocket-propelled model-testing techniques, although the methods can be applied to free-fall models. Describes the general methods used by the Pilotless Aircraft Research Division, NACA Langley Aeronautical Laboratory, and cites a few examples of the types of investigation.

AG15/P6/5

Jet-Engine-Driven Wind Tunnels. F.B.GREATREX.
AGARD Publ. AG15/P6, 69-83, 1954.
Topics include: advantages of injector tunnels driven by jet engines; flexibility of operation; simplicity; elimination of electrical equipment; theoretical considerations; design of typical tunnel; tunnels now in operation; supersonic wind tunnels.

AG15/P6/6

Some Aspects of Supersonic Wind Tunnel Operating Techniques. J.R.MARKHAM.
AGARD Publ. AG15/P6, 84-97, 1954.
The considerations which went into the design and selection of the components of the Naval Supersonic Wind Tunnel (Massachusetts Institute of Technology) are reviewed, and experience gained in its construction and operation is discussed.

AG15/P6/7

Development of Intermittent Wind Tunnel Technique. J.LUKASIEWICZ.
AGARD Publ. AG15/P6, 98-126, 17 refs., 1954.
Two types of intermittent wind tunnel drives: the pressure storage drive and the vacuum storage drive are examined; the design of components of intermittent tunnel installations, their operation and instrumentation are then considered. Two tunnels are considered as examples of large intermittent installations: a 4 ft. square pressure-driven tunnel, and a 6 ft. square vacuum-driven tunnel.

AG15/P6/8

The Design of Large High-Speed Wind Tunnels. R.F.HUNTSBERGER, J.F.PARSONS.
AGARD Publ. AG15/P6, 127-152, 10 refs., 1954.
Contents: Selection of components; Nozzles, Diffusers: Subsonic air passages; Compressor selection; Compressor design; Power systems; Other wind-tunnel components, Structural considerations; Test instrumentation; Concluding remarks.

AG15/P6/9

Notes on the Design and Construction of the Welded Steel Structure for the 8 feet x 8 feet High Speed Wind Tunnel at the National Aeronautical Establishment, Bedford. W.WADKIN, T.BARNES.
AGARD Publ. AG15/P6, 153-166, 1954.
Deals with some of the engineering problems encountered in the design of the welded steel structure for this project, and references to aerodynamic requirements, tunnel compressor and drive, auxiliary plant, etc. are made only where necessary to illustrate the main objectives. The general geometry of the structure, and its main dimensions, are given.

AG15/P6/10 **Design and Construction Aspects of High Power Wind Tunnel Drive Systems and Large Diameter Wind Tunnel Compressors.** J.CLARK.
AGARD Publ. AG15/P6, 167-191, 1954.
A brief review is given of certain aspects of the design criteria used for some of the large wind tunnel drives used by various groups in the NATO countries. The design criteria are presented in a general form to facilitate their application. Drive requirements, and major design problems are also discussed.

AG16/M10 **Some Aspects of Combustion of Liquid Fuel.** C.C.GRAVES, M.GERSTEIN.
AD-377-216 AGARD Mem. AG16/M10, 26pp., 25 refs., 1954.
N69-80425 Discusses: the burning of fuel sprays in air-streams, fuel spray spreading, spray burning in turbojet combustors; effect of volatility on combustion efficiency; effects of nozzle size and of inlet oxygen concentration on combustion efficiency.

AG17/P7 **Papers Presented at the Sixth Meeting of the Wind Tunnel and Model Testing Panel.**
AD-084-992 AGARD Publ. AG17/P7, 440pp., 1954.
N-39945 Papers presented at this meeting are reproduced. Abstracts of the individual papers are given in the succeeding items.

AG17/P7/1 **Calibrations of Test Sections and Accuracy of Measurements in Wind Tunnels.** (In French).
H.GIRERD.
AGARD Publ. AG17/P7, 1-40, 11 refs., 1954.
It is pointed out that despite recent advances of technique and equipment it is not possible to obtain, with great accuracy, the value of local forces in wind tunnels. The numerical values determined for global forces are certainly of the same order as the actual values (± 5%). In the methods of calculation proposed, the accuracy obtained is deemed satisfactory.

AG17/P7/2 **Requirements for Uniformity of Flow in Supersonic Wind Tunnels.** D.E.MORRIS, K.G.WINTER.
AGARD Publ. AG17/P7, 41-47, 1954.
An analysis is made of the effects of non-uniformity of flow on the pressure measurements on the surface of a model, and also on the force and moment measurements; standards of flow uniformity are derived. A brief analysis is made of the errors in model manufacture and their effects on force and pressure measurements.

AG17/P7/3 **Calibration of the Flow in the Working Section of the 3 feet x 3 feet Tunnel, National Aeronautical Establishment.** D.E.MORRIS.
AGARD Publ. AG17/P7, 48-90, 1 ref., 1954.
A number of calibrations (both pitot and static pressure measurements, and also flow direction measurements) were made of the flow in the working section of this supersonic tunnel. Some selected examples are given to show the general nature of the flow distribution with the M 1.4, 1.6, 1.8 and 2.0 nozzles, and to demonstrate points of interest in the measurements and in the flow characteristics.

AG17/P7/4 **Flow Direction Measurements in Supersonic Wind Tunnels.** D.J.RANEY.
AGARD Publ. AG17/P7, 91-108, 4 refs., 1954.
Some general requirements for satisfactory flow direction measurements in supersonic tunnels are stated and examples are given of the design and calibrations of typical yawmeters. The results of flow direction measurements made in two tunnels are given, and some of the flow characteristics are discussed.

AG17/P7/5 **Scale Effects at High Subsonic and Transonic Speeds, and Methods for Fixing Boundary-Layer Transition in Model Experiments.** A.B.HAINES, D.W HOLDER, H.H.PEARCEY.
AGARD Publ. AG17/P7, 109-166, 29 refs., 1954.
The major scale effects are discussed, and it is pointed out that, at low Reynolds numbers, these effects may often be minimized by fixing transition to turbulent flow by introducing an artificial disturbance such as that produced by excrescences attached to the surface. Several methods which can be used to fix transition are desribed, and the results obtained by using them are compared.

AG17/P7/6 **Methods of Determination and of Fixing Boundary Layer Transition on Wind Tunnel Models at Supersonic Speeds.** K G.WINTER, J B.SCOTT-WILSON, F V.DAVIES.
AGARD Publ. AG17/P7, 167-191, 21 refs., 1954.
An account is given of methods used in supersonic wind tunnels for observation of boundary layer phenomena, particularly the sublimation and oil film techniques. A rough guide is given for the minimum size of wire required for fixing transition, with an example of the use of wires. The results of a brief experiment on the profile of an artificially promoted turbulent boundary layer are also given.

AG17/P7/7 **Identification and Starting of Transition.** (In French). P.POISSON-QUINTON, J.P.CHEVALLIER.
AGARD Publ. AG17/P7, 192-198, 1954.
Problems relating to the fixing of the point of transition on wind tunnel models to give representative results for actual flight conditions are discussed. The main object of this paper is to define the ranges of Reynolds number where the starting of transition is necessary.

AG17/P7/8 **Transonic Wind Tunnel Development of the National Advisory Committee for Aeronautics.** H.J.ALLEN.
AGARD Publ. AG17/P7, 199-217, 13 refs., 1954.
In discussing NACA work on this subject, the efforts of the Langley Aeronautical Laboratory in developing transonic tunnels is first described; an account is then given of the work of the Ames Aeronautical Laboratory.

AG17/P7/9 **Some Aspects of the Behaviour of Perforated Transonic Wind Tunnel Walls.** P.F.MAEDER.
AGARD Publ. AG17/P7, 218-246, 4 refs., 1954.
Contents Introduction; The two-dimensional transverse slot of constant pressure; Infinite number of transverse slots; Flow through perforated walls of finite length.

AG17/P7/10 **Flow Establishment and Wall Interference in Transonic Wind Tunnels.** B.H.GOETHERT.
AGARD Publ. AG17/P7, 247-291, 1954.
Summarizes work carried out by U.S.A.A.F. Centres on transonic wind tunnel development (particularly at WADC and AEDC). In particular, problems relating to wall interference effects are discussed. Finally, details of some tests of a complete aircraft model in both a small and a large transonic tunnel are presented.

AG17/P7/11 **Heat Transfer and Skin Friction Investigations in the NOL Hypersonic Wind Tunnel.** R.E.WILSON.
AGARD Publ. AG17/P7, 293-310, 11 refs., 1954.
Deals with measurements made in the turbulent boundary layer on the wall of the U.S. Naval Ordnance Laboratory 12 x 12 cm. hypersonic wind tunnel at M 5.0 to 8.2 under varying rates of heat transfer.

AG17/P7/12 **Galcit Hypersonic Research.** H.T.NAGAMATSU.
AGARD Publ. AG17/P7, 311-332, 22 refs., 1954.
A brief description of the problems involved in the design and operation of the GALCIT hypersonic wind tunnels, and some of the recent results of the hypersonic research programme sponsored by the U.S. Army Ordnance and the U.S.A.A.F. are presented.

AG17/P7/13 **Development of Two Hypersonic Test Facilities at The National Advisory Committee for Aeronautics Ames Aeronautical Laboratory.** H.J.ALLEN.
AGARD Publ. AG17/P7, 333-372, 5 refs., 1954.
The two facilities discussed are: (i) a wind tunnel capable of continuous operation over a wide range of speeds with a not-too-complex drive system; (ii) a combination wind tunnel and ballistic range which allows operation over an even wider range of speeds, up to speeds which are difficult to attain in a conventional wind tunnel.

AG17/P7/14 **Ultra-High Temperature Aerodynamic Testing Facilities.** J.A.DODGE.
AGARD Publ. AG17/P7, 373-393, 10 refs., 1954.
Reviews some of the research programmes directed to extending aerodynamic testing into the ultra-high temperature region. These programmes relate to: (i) the most effective mechanism for driving a shock tube; (ii) practical nozzle and test-section design; (iii) deviations from thermodynamic equilibrium conditions in the test section; (iv) methods of flow phenomena measurement to be used in the impulse tunnel.

AG17/P7/15 **Improvements in the Study of Spinning in Wind Tunnels.** (In French). A.MARTINOT-LAGARDE, J.GOBELTZ.
AGARD Publ. AG17/P7, 394-398, 1954;
The main object of this paper is to indicate the methods used by the authors in obtaining results of tests on spinning in tunnels.

AG17/P7/16 **Design and Operating Techniques of Vertical Spin Tunnels.** A.I.NEIHOUSE.
AGARD Publ. AG17/P7, 399-420, 13 refs. 1954.
A general discussion of the use of dynamic tests in spin tunnels in order to obtain a better understanding of the spinning motion, and recovery therefrom.

AG17/P7/17 **The Vertical Spinning Tunnel at The National Aeronautical Establishment, Bedford.** A.E.CLARKE, R.L.MALTBY.
AGARD Publ. AG17/P7, 421-449, 1 ref., 1954.
The spinning tunnel at the R.A.E. is described. The choice of size and type of tunnel as well as some of the more interesting features of the design are discussed. The tunnel was not completed at the time this paper was written, and thus the material included may require revision in the light of subsequent experience.

AG18/P8
AD-092-552
N69-80252 **AGARD Papers Presented at the Joint Session of The Flight Test Techniques and Wind Tunnel and Model Testing Panels, Ottawa, Canada, June, 1955.**
AGARD Publ. AG18/P8, 134pp., 1955.
Seven papers presented at this meeting are reproduced. Abstracts of the individual papers are given in the succeeding items.

AG18/P8/1 **Modern Trends in Dynamic Stability Analysis and Experiment.** H.STEVER, J.T.Van METER, E.E.LARRABEE, J.BICKNELL, T.R.PARSONS.
AGARD Publ. AG18/P8, 1-12, 11 refs., 1955.
Briefly considers this topic under the heading dynamic analysis, cross-coupling large scale manoeuvre, form of data for dynamic analysis, dynamic stability wind-tunnel testing, dynamic stability flight-testing, and time-vector transient analysis.

AG18/P8/2 **An Investigation of Some Longitudinal Stability and Control Troubles at High Subsonic Speeds.** E.BILLION.
AGARD Publ. AG18/P8, 13-23, 1955.
Two sorts of troubles are considered: (i) slowly diverging instability, and (ii) pitch-up. The following veiwpoints are discussed: that of the pilot, in operation; the scientists' interpretation; the programming and interpretation of flight-testing; wind-tunnel testing.

AG18/P8/3 **Interpretation of Wind-Tunnel Data in Terms of Dynamic Behaviour of Aircraft at High Angles of Attack.** R.W.STONE, Jr.
AGARD Publ. AG18/P8, 24-50, 16 refs., 1955.
Some aircraft characteristics which can cause inadvertent and uncontrolled motions, and their recognition from wind-tunnel measurements, are discussed. Of major importance for aircraft of modern configuration are pitch-up, directional divergence, inertia coupling during combined lateral-longitudinal motions, and reductions in roll damping and dihedral effectiveness at angles of attack below the stall. Problems arising from combined manoeuvres cannot be recognized directly from wind-tunnel measurements, and require extensive calculations for any given design.

AG18/P8/4 **On-Line Automatic Data Reduction at The Arnold Engineering Development Center.** D.F.TAYLOR.
AGARD Publ. AG18/P8, 51-73, 1955.
'On-line' signifies that test data are fed directly from test measurements into a computer to present reduced data for each test point as the test progresses. Each input (e.g., a pressure reading) is converted by a transducer into an electrical signal. This is measured by a null-balancing servo-potentiometer. The position of the slide wire wiper is converted to a digital reading which is scanned and recorded. X-Y plotters plot selected data. Features of the unit are described, its performance and potential modifications are discussed.

AG18/P8/5 **Comparison of Flight and Wind-Tunnel Measurements Relating to the Characteristics of an Aircraft in the High Subsonic Régime.** (In French). F.VINSONNEAU.
AGARD Publ. AG18/P8, 74-105, 1955.
The measurements relate to rolling characteristics. Although tunnel tests were on small-scale models, sufficient agreement was obtained with flight test results to investigate faults and devise suitable remedies. The general manoeuvring characteristics of an aircraft can be satisfactorily forecast although pressure and bending moments require experimentation on a larger scale. Wind-tunnel measurements can advance design projects at an economical cost.

AG18/P8/6 **Some Comparisons Between Wing Tunnel Model and Flight Test Results on Aircraft At High Angles of Attack.** R.R.DUDDY.
AGARD Publ. AG18/P8, 107-125, 1955.
Results are given for aircraft with sweep angles from 30 to 45 deg. One aircraft had a 17% wing, the others were of 10% thickness chord ratio. Agreement for longitudinal stability was good at low M, but further data were required for high M. Prediction of damping could be approved. Speed stability could not be predicted accurately from tests at Re of 1.4×10^6 when the full-scale Re was 12×10^6. Data for studying buffet boundary conditions can be usefully obtained.

AG18/P8/7 **Icing Experiments in Flight and Comparisons with Wind Tunnel Te..ng.** D.FRASER.
AGARD Publ. AG18/P8, 126-134, 1955.
The relative advantages and disadvantages of simulated and natural icing investigations in flight or tunnel tests are discussed. Generally, tunnel test.ng is used when the full range of probable icing conditions is to be evaluated. Flight tests in natural conditions are essential to give true quantitative results.

AG19/P9 **Papers Presented at The Seventh Meeting of the Wind Tunnel and Model Testing Panel.**
AD-109-913 AGARD Publ. AG19/P9, 331pp., 1955.
N70-70176 Thirteen papers are included. The main subjects dealt with are the effect of engine-induced airflow both in model and full scale tests, the measurement and calculation of boundary layer flow, aerodynamic heating at high speeds, and icing investigations. Abstracts of the individual papers are given in the succeeding items.

AG19/P9/1 **The Representation of Engine Airflow in Wind Tunnel Model Testing.** J.SEDDON, L.F.NICHOLSON.
AGARD Publ. AG19/P9, 1-31, 4 refs., 1955.
Problems of engine airflow representation in wind tunnels are reviewed. Methods which have been used satisfactorily in low subsonic tunnels are briefly described. Special difficulties of transonic testing are noted. Techniques applicable to small supersonic tunnels are considered in some detail. It is shown that there are reasons why the representation of jets may be more important at supersonic than at subsonic speeds; the R.A.E. Jet Interference Tunnel (which is designed for the study of such problems) is described.

AG19/P9/2 **The Influence of Turbojet Airflow on the Aerodynamic Design of Airplanes.** H.LUSKIN, H.KLEIN.
AGARD Publ. AG19/P9, 32-52, 11 refs., 1955.
The momentum and angular momentum theorems are used to find the longitudinal forces and the moments acting on a turbojet aircraft. It is seen that the thrust force is strongly affected by inlet pressure recovery at supersonic speeds. The moments are discussed in connection with correction of power-off model data to power-on characteristics. Inlet particle aspiration, buffeting, heating, jet-noise and non-uniform flow into the inlet are briefly considered.

AG19/P9/3 **The Simulation of the Effects of Internal Flow in Wind Tunnel Model Tests of Turbojet Powered Aircraft.** A.J.EVANS.
AGARD Publ. AG19/P9, 53-68, 1955.
The use of 'complete' scale models, models of inlets, and the flow characteristics typical of these, are described. The effects of inlet and exit flow on overall flow geometry are of sufficient magnitude to invalidate test results if they are ignored.

AG19/P9/4 **Boundary Layers on Swept Wings: Their Effects and Their Measurements.** D.KUCHEMANN.
AGARD Publ. AG19/P9, 69-100, 31 refs., 1955.
A review of work done at R.A.E. on three-dimensional boundary layers, including some theoretical and practical results which characterize swept wings. Lift reduction and drag increment resulting from boundary layer are compared with values in inviscid flow, and types of flow resulting from separation are described. The instrumentation used is noted.

AG19/P9/5 **The Use of Pitot Tubes in the Measurement of Laminar Boundary Layers in Supersonic Flow.** R.J.MONAGHAN.
AGARD Publ. AG19/P9, 101-131, 13 refs., 1955.
The results for tubes of fairly large diameter used on cones and flat plates, show that the most noticeable distortion of the velocity profile is the appearance of a peak near the outer edge of the boundary layer. Displacement of the main body of the profile may be small in supersonic flow. These effects may cause errors in calculation of displacement and momentum thicknesses. If the ratio of the tube diameter to boundary layer thickness is less than 0.2, measured values of the thicknesses may be less than 4% above their true value. The use of flattened tubes may cause additional distortion for layers on slender bodies of revolution.

AG19/P9/6 **Method of Calculating the Three-Dimensional Boundary Layer: Application to a Slender Body Inclined to the Flow.** (In French). E.A.EICHELBRENNER, A.OUDART.
AGARD Publ. AG19/P9, 132-179, 3 refs., 1955.
Gives the results of a preliminary investigation of some problems of incompressible flow and suggests a method based on the use of equipotentials and streamlines in perfect inviscid flow. The method assumes that velocity normal to the streamlines is small. The method is applied to an elongated ellipsoid, the axis of revolution being inclined to the airflow.

AG19/P9/7 **A Brief Review of Three-Dimensio.. Boundary-Layer Flows.** W.R.SEARS.
AGARD Publ. AG19/P9, 180-.., 13 refs., 1955.
Deals very briefly with the theory of boundary layers in three-dimensional flow. Emphasis is placed on the evidence for the turbulent flow case.

AG19/P9/8 **The Simulation and Measurement of Aerodynamic Heating at Supersonic and Hypersonic Mach Numbers.** J.R.STALDER, A.SEIFF.
AGARD Publ. AG19/P9, 191-206, 18 refs., 1955.
Techniques used by NACA for the experimental study of aerodynamic heating at supersonic and hypersonic Mach numbers are discussed, with particular reference to met' ls used in wind tunnels at the Ames Laboratories, and a technique used in small-scale free-flight testing to attain extremely high stagnation temperatures.

AG19/P9/9 **The Status of Heat Transfer and Friction Investigations at Supersonic Speeds.** H.H.KURZWEG.
AGARD Publ. AG19/P9, 207-229, 24 refs., 1955.
Major results of theroetical and experimental investigations on the subject are summarized. The air is considered as an ideal gas for this purpose. It is considered that the accuracy of experimental results is no better than the uncertainties of theory and the greatest need is for measurements in supersonic tunnels with very high stagnation temperatures, to check the effect of the non-linear temperature-viscosity law on recovery temperature, friction and heat transfer coefficients.

AG19/P9/10 **The N.R.C. Icing Wind Tunnels and Some of Their Problems.** C.K.RUSH.
AGARD Publ. AG19/P9, 230-243, 1 ref., 1955.
The 4½ ft. and blower icing tunnels of the N.R.C. are described. Some of the difficulties encountered due to the icing function and the methods of dealing with them are discussed. The nature of tests undertaken in tunnels is outlined, and a few typical tests are described.

AG19/P9/11 **Wind Tunnel Simulation of Atmospheric Icing Conditions.** C.K.RUSH, R.L.WARDLAW.
AGARD Publ. AG19/P9, 244-259, 19 refs., 1955.
Techniques are reviewed and conditions for ideal simulations outlined. Departures from the ideal and their effects on interpretation of results are discussed. Consideration is given to improving simulation at high subsonic speeds where adiabatic cooling effects complicate conditions.

AG19/P9/12 **The Fluid Flow Associated With the Impact of Liquid Drops With Solid Surface.** P.SAVIC, G.T.BOULT.
AGARD Publ. AG19/P9, 260-292, 4 refs., 1955.
The shape of the spreading drop, and the pressure distribution over the impact plane, are calculated. Experiments, using a high-speed spark camera, confirm the main features predicted by theory. The pressure distribution for water drops impinging on a hot surface is also predicted satisfactorily, but molten wax impinging on a hot surface shows a marked increase in splashing compared with theoretical predictions; an explanation is attempted by consideration of the interaction of fluid flow and heat transfer.

AG19/P9/13 **The I ng Problem - Current Status of N.A.C.A. Techniques and Research.** U.H.von GLAHN.
AGARD Publ. AG19/P9, 293-331, 40 refs., 1955.
Sufficient data have been obtained and generalized, and satisfactory techniques established so that icing protection requirements for most aircraft components can be determined with sufficient accuracy for engineering purposes. Appendices discuss the facilities at the NACA Lewis Laboratory in detail, specific test equipment and testing techniques, also several icing instruments.

AG20/P10 See GA5
AD-092-551
N69-80580

BIBLIOGRAPHIES

BB1
AD-236-361
N62-10060
Magneto-Fluid-Dynamics. A.G.VANNUCCI (Editor).
AGARD Bibl. 1., 30pp., 1960.
Comprises a bibliography of 759 items, together with an author and subject index. Abstracts to most of these references are provided in a separately bound appendix issued with the bibliography.

BB1/1
AD-272-673
Magneto-Fluid-Dynamics. L.G.NAPOLITANO, G.CONTURSI (Editors).
AGARD Bibl. 1., (Enlarged Edition), 251pp., 1962.
References to 2038 unclassified reports and open literature articles are given. Abstracts of 701 of these papers are also presented. Author and subject indexes are included, and also a list of the entries which were given in the original edition.

BB2
AD-248-340
N-103-532
VTOL/STOL. A.G.VANNUCCI (Editor).
AGARD Bibl. 2., 89pp., 1960.
Contains 583 entries, mostly with abstracts, including 40 in French, from published and unclassified sources Entries are arranged alphabetically by author. There is a general subject index and an author index.

BB2/1
AD-266-061
N70-70277
VTOL/STOL Aircraft. G.BOCK, H.SPINTZYK.
AGARD Bibl. 2., (Revised Edition), 161pp., 1961.
Covers the literature till the end of 1960, and comprises all available publications related to problems in the field of V/STOL; reports on helicopters and on ground-effects vehicles are not generally included. Gives approximately one thousand references (with abstracts).

BB2/2
AD-427-826
N69-80694
VTOL/STOL Aircraft. G.BOCK, H.G.KLUG, H.SPINTZYK (Editors).
AGARD Bibl. 2., First Suppl., 123pp., 1963.
Covers the literature published during the years 1961/1962 and comprises all available publications relating to problems in the field of V/STOL. Reports on helicopters and ground effect machines are not generally included.

BB2/3
AD-814-033
N67-30799
VTOL/STOL Aircraft: Bibliography 2, Second Supplement 1963/64/65. R.J.SHANAHAN.
AGARD Bibl. 2., Suppl. 2., 323pp., 1966.
This bibliography contains some 820 references and abstracts from published and report literature issued during the period 1963 to 1965; a few references from earlier years, from material not previously available, are also included, Literature references relating to helicopters and ground-effect machines are generally excluded. A detailed subject index, a personal author index, and a source/corporate source index are incorporated.

BB3
AD-254-485
N-95154
Crack Initiation and Propagation in High Strength Alloy Sheets. G.SERTOUR.(Editor).
AGARD Bibl. 3., 26pp., 1960.
The material in this bibliography is grouped under the following six headings. fundamental research, testing techniques, influence of metallurgical variables, influence of processing techniques, influence of external conditions (temperature), case histories. There are 348 references.

BB4
AD-294-674
Structural Stability of Conical and Spherical Thin Shells. W.THIELEMANN (Editor).
AGARD Bibl. 4., 31pp., 1961.
One hundred and sixty-eight items are listed commencing from the year 1902 and ending with the year 1961. Abstracts are included for many of the items.

BB5
AD-853-346
N69-27128
A Bibliography of Refractory Metals. Compiled by R.SYRE, Edited by K.J.SPENCER.
AGARD Bibl. 5., 426pp., 4381 entries, 1968.
Lists references to work on Refractory Metals and Alloys in the following groups. General, Basic Research, Technology and Protective Coatings. Contains a Subject and Author Index.

BB6
AD-476-423
N66-11633
Ejectors and Mixing of Streams. J.SEDDON, M.DYKE.
AGARD Bibl. 6 42pp., 1964.
Presents 585 literature references (a few with abstracts) on the title subject, divided into the following subject areas. (i) mixing of streams, (ii) ejectors, (iii) jet pump applications (induction wind tunnels, ejectors for boundary layer control), (iv) miscellaneous (noise of ejector nozzles, nacelle drag, technique of thrust measurement, etc.).

PROCEEDINGS OF THE SECOND AGARD GENERAL ASSEMBLY

GA2 **Presentations Before the AGARD General Assembly.** (In English and French).
AD-688-680 Proc. 2nd AGARD General Assembly AG1/P1, 134pp., 1952.
N70-73192 The assembly was held in Rome on the 12th-19th December 1952. An opening address given by Professor von Kármán and speeches of welcome were given to the delegates by Professor G. Colonnetti and Professor E. Pistolesi. Notices of other addresses and papers are given in the following items. The presentations are reproduced in both English and French; the pagination given in the document references is for the English language version.

GA2/1 **The Contribution of Italian Scientists and Technicians to the Development of Aeronautics.** (In English and French). S A.A.URBANI.
Proc. 2nd AGARD General Assembly AG1/P1, 9-12, 1952.
Briefly points out that the hiatus in research developments in Italy can be attributed to both the destruction of facilities during World War 2 and preoccupation with reconstruction problems in post-war Italy. The value of AGARD assistance is emphasized and the prospects for Italian scientists indicated.

GA2/2 **The Role of University Research and Utilization of Scientific Personnel by the U.S. Air Force.** (In English and French). J.F.PHILLIPS.
Proc. 2nd AGARD General Assembly AG1/P1, 15-19, 1952.
Outlines the research tasks in the development of weapons and weapon systems and indicates the type of research which the Universities can undertake in this connexion.

GA2/3 **Aeronautical Research in Italy in the Past and in the Future.** (In English and French). G.A.CROCCO.
Proc. 2nd AGARD General Assembly AG1/P1, 21-34, 1952.
Notes some early work by Forlanini, Costanzi and at the aeronautical laboratories in Turin and Rome. The numerous contributions of Italian research workers in the period 1920 to the present day are listed briefly. Many of the researches are recorded in the 'Atti di Guidonia' and the 'Atti della Accademia delle Scienze di Torino'.

GA2/4 **Bibliography of Aeronautical Research in Italy 1904-1952.** (In English and French). R.GIACOMELLI.
Proc. 2nd AGARD General Assembly AG1/P1. 66-134, 1952.
The bibliography includes: (i) studies and researches published in aeronautical reviews and reports; (ii) those published in the records of the Accademia delle Scienze of Turin, the Pontificia Accademia delle Scienze, and the Accademia Nazionale dei Lincei; (iii) studies and researches published elsewhere than (i) and (ii). No treatises or books are included.

PROCEEDINGS OF THE THIRD AGARD GENERAL ASSEMBLY

GA3 **Proceedings of the Third AGARD General Assembly.** (In English and French).
AD-070-449 Proc. 3rd AGARD General Assembly AG6/P3, 115pp., 72 refs., 1953.
N69-80478 The third assembly was held in London on the 7th and 10th September, 1953. The opening address by Dr. von Kármán, a speech of welcome from the Under-Secretary for Air, U.K. and greetings from other groups and delegates are reproduced. The text of eleven papers presented at this assembly is then given; abstracts of the individual papers are given in the succeeding items.

GA3/1 **Role of Research and Development in Aviation During the Last Ten Years.** H.C.GARNER.
Proc. 3rd AGARD General Assembly AG6/P3, 17-21, 1953.
Outlines the increase in aspects of 'performance' which have become recognized over the decade, including properties of equipment. The change in basic performance (speed, climb, endurance) is shown and discussed, especially the transition to supersonic speeds. Improvements in power plant and test-methods, and lack of improvement in flight economics, are considered.

GA3/2 **Some Tasks for AGARD.** O.H.WANSBROUGH-JONES.
Proc. 3rd AGARD General Assembly AG6/P3, 22-23, 1953.
Points out the potential value of AGARD in arranging the exchange of scientific information, particularly in aeronautics.

GA3/3 **Problems Arising in the Icing of Aircraft.** (In French). E.A.BRUN.
Proc. 3rd AGARD General Assembly, AG6/P3, 27-40, 1953.
The icing of an aircraft is considered when the aircraft flies through a cloud supersaturated with moisture. The icing phenomena are described, then methods of protection discussed.

GA3/4 **Thoughts on Future Noise Suppression Research.** E.J.RICHARDS.
Proc. 3rd AGARD General Assembly AG6/P3, 41-46, 1953.
Outlines the work which has been done on noise suppression, present understanding of noise and the fundamental mechanisms of noise, and indicates future lines of research

GA3/5 **The Structural Effects of Aerodynamic Heating.** N.J.HOFF.
Proc. 3rd AGARD General Assembly, AG6/P3, 47-66, 30 refs., 1953.
Discusses: heat generation in the boundary layer; heat transfer; thermal stresses; material properties at high temperatures; creep and structural behaviour; high temperatures in structural testing.

GA3/6 **Thermal Conditions Associated with Aircraft in Flight.** M.H.BLOOM.
Proc. 3rd AGARD General Assembly, AG6/P3, 67-78, 42 refs., 1953.
An Appendix to the paper GA3/5. Analytical expressions are presented for determining the thermal parameters for isothermal and non-isothermal surfaces and bodies of revolution in laminar and turbulent flow conditions.

GA3/7 **Simulation of Aerodynamic Heating in Structural Testing.** J.KEMPNER.
Proc. 3rd AGARD General Assembly, AG6/P3, 79-81, 1953.
An Appendix to the paper GA3/5. Briefly outlines the principles of induction and dielectric heating, radiant heating, contact heating, resistance heating, hot-air oven heating, immersion heating, and high-speed jet heating.

GA3/8 **Foundations of Operational Research.** T.von KARMAN.
Proc. 3rd AGARD General Assembly, AG6/P3, 82-84, 1953.
The aerodynamicist's viewpoint on operational research. Stresses the need for close liaison between scientists, engineers and those engaged in operational research and also close co-operation between the NATO member countries.

GA3/9 **Operational Research.** B.G.DICKINS.
Proc. 3rd AGARD General Assembly, AG6/P3, 85-89, 1953.
The main analytical and theoretical methods used for operational research are described and examples are given of use by the R.A.F. during World War 2.

GA3/10 **Aeromedical Interests - Looking Forward.** O.O.BENSON, Jr.
Proc. 3rd AGARD General Assembly, AG6/P3, 90-92, 1953.
Discusses the need for full protection of aircrew against environmental stresses to ensure high efficiency of human operators. The condition of weightlessness is discussed. With this lecture a film was shown of the flight of rhesus monkeys and mice in an Aerobee rocket.

GA3/11 **Examples of NATO Exchange of Scientific Personnel.** M.BRULL.
Proc. 3rd AGARD General Assembly, AG6/P3, 93-94, 1953.
Considers some of the possible forms which exchange visits might take, their duration and nature of the experience to be gained. It is suggested that AGARD could provide information channels in the preparation of, and encouragement of exchange arrangements.

GA3/12 **Tour of Western Europe: April 1953.** L.H.G.STERNE (Editor).
Proc. 3rd AGARD General Assembly, AG6/P3, 95-115, 1953.
Describes a tour by British aeronautical scientists to aeronautical centres in Paris, Modane, Rome, Turin, Brussels and Amsterdam. Problems of aerodynamics, flutter, vibration and structural research were discussed with personnel at these places. Some of the research facilities at various centres are briefly described.

PROCEEDINGS OF THE FOURTH AGARD GENERAL ASSEMBLY

GA4 **Proceedings of the Fourth AGARD General Assembly.**
AD-066-491 Proc. 4th AGARD General Assembly, AG14/P5, 160pp., 167 refs., 1954.
N69-80501 The 4th General Assembly was held in Scheveningen, Netherlands, in May, 1954. Part 1 of the proceedings contains addresses of welcome by Prince Bernhard and their Excellencies H.F.L.K. van Vredenburgh and F.J.Kranenburg, greetings from the Standing Group (NATO) and the U.S. Air Force and a paper by Professor Dr. H.J.van der Maas (Item 1820, below). Abstracts of the

individual papers given in Part 2 are given in the succeeding items (Nos. 1821 to 1833). Part 3 includes a description of the organization of AGARD and also a list of Panel papers.

GA4/1 **Aeronautical Research in the Netherlands.** H.J.van der MAAS.
Proc. 4th AGARD General Assembly, AG14/P5, 24-33, 1954.
The development of the National Aeronautical Research Institute (N.L.L.) is described, characteristic researches and successes of the Institute briefly outlined. Mention is also made of the National Aeromedical Centre, the Aeronautics Section of the University of Delft and the place of the aircraft industry in development.

GA4/2 **Human Factors in Aircraft Design.** M.G.WHILLANS.
Proc. 4th AGARD General Assembly, AG14/P5, 37-41, 10 refs., 1954.
Some observations, criticisms and suggestions are offered on the topics of: (i) simplification of tasks; (ii) visual problems; (iii) heat; (iv) safety and escape.

GA4/3 **Subjective Experiences and Reactions During Flight Testing in the Transonic Region.**
T.von KARMAN.
Proc. 4th AGARD General Assembly, AG14/P5, 42-52, 1954.
A Round Table discussion with test pilots R.Carpentier, W.J.Potocki, N.Duke, C.Yeager, S.Crossfield, giving their personal experiences of transonic flying. The moderator of the discussion was Dr. von Kármán.

GA4/4 **Low Temperature Operation of Aircraft.** R.M.ALDWINCKLE.
Proc. 4th AGARD General Assembly, AG14/P5, 53-68, 57 refs., 1954.
A survey of cold weather tests carried out during five winters by the Central Experimental and Proving Establishment Climatic Dept., R.C.A.F., Canada, on 23 different aircraft.

GA4/5 **The Use of Personal Equipment in Arctic Survival.** F.VOGT LORENTZEN.
Proc. 4th AGARD General Assembly, AG14/P5, 69-72, 1954.
A brief account of some experiments conducted at the winter training camps of the Institute of Aviation Medicine, Royal Norwegian Air Force. Practical pointers are given for survival under cold weather conditions.

GA4/6 **Some Problems in Canadian Aeronautical Research and Development.** D.C.MacPHAIL.
Proc. 4th AGARD General Assembly, AG14/P5, 73-83, 12 refs., 1954.
Outlines some of the work arising from operation in northern Canada, with problems of ski landing, parachute load dropping, icing of aircraft and simulation of icing conditions.

GA4/7 **Some Aspects of the Light Interceptor Problem.** S.STEFANUTTI.
Proc. 4th AGARD General Assembly, AG14/P5, 84-98, 1954.
Examines the potential performance of a light interceptor so that full economic value of use can be obtained by countries with limited budget resources for air weapons. Design requirements to fulfill specific range of missions are derived.

GA4/8 **Selected Aerodynamic Problems of High-Speed Flight.** K.E.Van EVERY.
Proc. 4th AGARD General Assembly, AG14/P5, 99-107, 43 refs., 1954.
The problems discussed relate to: (i) boundary-layer separation, especially when combined with local shock waves; (ii) non-stationary flow; (iii) transonic flow. The status of research work on these problems is reviewed and some other lines for research indicated.

GA4/9 **Laminarisation Through Boundary Layer Control.** G.V.LACHMANN.
Proc. 4th AGARD General Assembly, AG14/P5, 108-127, 45 refs., 1954.
Discusses the use of boundary layer control for stabilizing the boundary layer. The aerodynamic criteria for this state are derived and the mechanism of laminarisation and design of suction surfaces described. The method presents a fundamental means of improving flight economy in the subsonic régime.

GA4/10 **Airworthiness Requirements.** L.LAZZARINO.
Proc. 4th AGARD General Assembly, AG14/P5, 128-132, 1954.
The author shows that the establishment of a 'Standard Set of Requirements' for all NATO nations would be the logical development of present trends towards standardization. It is shown that differences between existing airworthy requirements of these countries are slight.

GA4/11 **Some Aspects of Aeronautical Research.** P.DUWEZ.
Proc. 4th AGARD General Assembly, AG14/P5, 133-136, 1954.
Considers three problem fields: improvements in structural strength by use of new metals or improved merallurgy; use of new or improved materials for heat-resistant parts in jet engines; advances in and application of titanium for medium temperature ranges (500 deg.C).

GA4/12 **Airborne Electronic Equipment.** M.DESIRANT.
Proc. 4th AGARD General Assembly, AG14/P5, 137-147, 1954.
Electronic equipment is used for: (i) control and stabilization; (ii) communications; (iii) auxiliary aids to performance accuracy (bomb-sights, etc.); (iv) navigational aids. The present status of airborne equipment is reviewed with respect to reliability, standardization and ease of maintenance.

GA4/13 **Some Studies of Laboratory Management.** H.A.SHEPARD.
Proc. 4th AGARD General Assembly, AG14/P5, 148-152, 1954.
Discusses the possible motivations which determine good or bad management and describes, generally, results of studies on the social characteristics of research groups, carried out at the Massachusetts Institute of Technology.

GA4/14 **The Advisory Group for Aeronautical Research and Development and its Place in NATO.**
Proc. 4th AGARD General Assembly, AG14/P5, 155-158, 1954.
Outlines the creation of AGARD and its functions. A chart shows AGARD in relation to other NATO groups.

PROCEEDINGS OF THE FIFTH AGARD GENERAL ASSEMBLY

GA5 **Proceedings of The Fifth AGARD General Assembly.**
AD-092-551 Proc. 5th AGARD General Assembly, AG20/P10, 157pp., 43 refs., 1955.
N69-80580 The fifth assembly was held in Ottawa, Canada on the 15th-16th June, 1955. The address of welcome by the Canadian Minister of Defence and greetings from NATO and service groups are reproduced. The text of the technical papers read is then given; abstracts of the individual papers are given in the succeeding items. Reports by the Chairmen of the Technical Panels, a Secretariat Report, and a list of Panel papers complete the Proceedings.

GA5/1 **History of Aeronautical Reaserch and Development in Canada.** J.H.PARKIN.
Proc. 5th AGARD General Assembly, AG20/P10, 21-32, 25 refs., 1955.
In reviewing the progress of development the author describes the work of the pioneers Turnbull, Alexander Bell, and the institutions of the University of Toronto, the National Research Council, the Institute of Aerophysics, and the Gas Dynamics Laboratory of McGill University.

GA5/2 **RCAF Development of Automatic Navigation System.** J.G.WRIGHT.
Proc. 5th AGARD General Assembly, AG20/P10, 35 38, 1955.
Describes the development of a system suitable for installation in fighter aircraft. The pilot is given information of the direction and distance to the target by the operation of two pieces of equipment: the R-Theta DR Computer and the Position and Homing Indicator. The general operation of these is briefly described.

GA5/3 **Advancing Temperature Frontiers.** A.A.HALL.
Proc. 5th AGARD General Assembly, AG20/10, 39-41, 1955.
A Round Table Discussion with Sir Arnold Hall as the moderator, who outlines the terms of the problems to be discussed.

GA5/4 **Aerodynamic Heating Versus Speed: Thermodynamic Aspects of the Struggle.** (In English and French). M.ROY.
Proc. 5th AGARD General Assembly, AG20/P10, 42-74, 18 refs., 1955.
Discusses. tolerable temperature limits for materials; aerodynamic heating; thermodynamics of the boundary layer; heat exchanges in supersonic aircraft; effects of duration of flight time; external insulation and thermal partitioning; fuel protection and fuel as a coolant; forced cooling systems; effects of aerodynamic heating on jet engine operation.

GA5/5 **The Structural Effects of Kinetic Heating in Supersonic Flight.** P.B.WALKER.
Proc. 5th AGARD General Assembly, AG20/P10, 75-81, 1955.
Discusses. the adverse effects of kinetic heating from the viewpoint of structures; deterioration of structural material; thermal stress and shock; temperature stresses; cooling and insulating; laboratory research.

GA5/6 **Man's Response to Temperature Extremes.** A.P.GAGGE.
Proc. 5th AGARD General Assembly, AG20/P10, 82-91, 1955.
Defines the descriptive units used for measuring heating, insulation, and cooling of the human body and illustrates their use in calculating heat exchange in a given environment. The application of heat data to the design of protective flying clothing is discussed.

GA5/7 **Where are the Limits of Combustion Intensity?** J.J.BROEZE.
Proc. 5th AGARD General Assembly, AG20/P10, 92-101, 1955.
Discusses: the combustion intensity in piston engines; combustion velocity at high initial temperature; analysis of combustion processes; turbulence in engines; comparison with continuous combustion; applications to continuous-combustion conditions.

GA5/8 **Aeroelastic Effects of Aerodynamic Heating.** H.L.DRYDEN, J.E.DUBERG.
Proc. 5th AGARD General Assembly, AG20/P10, 102-110, 955.
It is shown that aerodynamic heating can have adverse effects on the aeroelastic behaviour of structures and can cause a reduction of overall stiffness by the action of thermal stress.

GA5/9 **Increasing the NATO Research and Development Potential.** T.von KARMAN.
Proc. 5th AGARD General Assembly, AG20/P10, 111-127, 1955.
A round table discussion with Dr. von Kármán as the moderator. The main contributors were H.L.Maxwell (R.A.F., S.H.A.P.E.), H.P.Robertson (S.H.A.P.E.), G.E.Valley, Jr. (M.I.T.), and L.P.Weicker,(N.A.T.O.).

PROCEEDINGS OF THE SIXTH AGARD GENERAL ASSEMBLY

GA6 **Proceedings of the sixth AGARD General Assembly.** (In French and English).
AD-159-934 Proc. 6th AGARD General Assembly, 104pp., 1956.
N70-70346 This assembly was held in Belgium on the 28th and 31st August 1961. The address of welcome by the Belgian Minister of Communications and greetings from representative bodies are given. Technical papers presented to the assembly are then reproduced. Abstracts of the individual papers are given in the succeeding items. The Proceedings conclude with reports by the Panel Chairmen, and Secretariat Report, and a list of Panel papers.

GA6/1 **Belgian Aeronautics - Past and Present.** (In French). J.DUCARME.
Proc. 6th AGARD General Assembly, 23-29, 1956.
The developments of institutions and firms interested in aviation are outlined, from the Centre d'Etudes de la Navigation Aérienne au Congo (CENAC) in 1919, to the activities of SABENA today. Some of the associated products, investigations of materials and commercial developments are also described.

GA6/2 **Foreword to Papers on International Co-Operation in Scientific Research and Development.** M.M.FRESON.
Proc. 6th AGARD General Assembly, 35-36, 1956.
The co-operative activities of AGARD are emphasized, although no provision for such scientific co-operation is written into the North Atlantic Treaty.

GA6/3 **Mutual Weapons Development Team.** T.B.LARKIN.
Proc. 6th AGARD General Assembly, 39-41, 1956.
Briefly describes the formation and organization of this team which is authorized to provide financial assistance for military research and development programmes of countries friendly to U.S.A. Project agreements are on a government-to-government basis and relate to the development of specific end items, primarily for use by Western European countries.

GA6/4 **Military Agency for Standardization.** E.M.F.GRUNDY.
Proc. 6th AGARD General Assembly, 42-44, 1956.
The Military Agency for Standardization (MAS) is charged with fostering NATO military standardization in two fields: (i) non-material field, including procedures, tactics, techniques, terminology; (ii) the material field, including military equipment and stores. The possibilities of, and limitations in accomplishing this are discussed briefly.

GA6/5 **SHAPE: Air Defence and Operational Research.** (In French). P.M.GALLOIS.
Proc. 6th AGARD General Assembly, 45-61, 1956.
The problem of defence against an aerial nuclear attack, under surprise conditions, on western European territory is studied as a problem in operational research. Situations arising from moment-to-moment conditions are analyzed sequentially.

GA6/6 **SHAPE Air Defence Technical Center - Supreme Headquarters Allied Powers Europe.** G.J.SIZOO.
Proc. 6th AGARD General Assembly, 66-68, 1956.
The organization of SADTC, its place in the NATO groups, general objectives and the position of the Netherlands Government as host-nation to the Center are briefly outlined. The Center's programme of work includes operational research, system studies, planning in relation to air defence, evaluation and procurement of air defence equipment and initial tests of new systems

GA6/7 **Training Center for Experimental Aerodynamics.** (In French). F.HAUS.
Proc. 6th AGARD General Assembly, 69-70, 1956.
In 1955 Dr. von Kármán suggested that the Laboratory at Rhode-Saint-Genèse, belonging to the Belgian government and not then fully utilized, might be used for the training of aerodynamic specialists of the NATO countries. The formation of the Center is outlined.

GA6/8 **Air Research and Development Command.** D.FLICKINGER.
Proc. 6th AGARD General Assembly, 71-73, 1956.
Air Research and Development Command (ARDC), formed in 1950, was given the responsibility of joining with industry and the scientific community to provide a team capable of maintaining qualitative superiority of air power. The European Office of ARDC has the task of supporting areas of scientific research in Western Europe, relevant to the interests of ARDC and providing for exchange of information between U.S.A. and Europe. Charts illustrate the related functions of ARDC.

PROCEEDINGS OF THE SEVENTH AGARD GENERAL ASSEMBLY

GA7
AD-218-162
N63-86149 **Proceedings of the Seventh AGARD General Assembly.** (In French and English).
Proc. 7th AGARD General Assembly, 102pp., 1957.
The seventh assembly was held in U.S.A. The Proceedings include the text of greetings from the Standing Group, NATO, Department of Defence, U.S.A and the U.S.A.F., papers presented to the assembly, reports of the Panels and Secretariat, and a list of Panel papers. Abstracts of the individual papers are given in the succeeding items.

GA7/1 **Growth of Airpower in The United States.** N.F.TWINING.
Proc. 7th AGARD General Assembly, 7-10, 1957.
A short, general account of progress from the time of World War I up to the present in aircraft design and production and emphasizing the point when the importance of the research and development aspects of aviation became recognized. Major areas of advance since the Korean War are noted.

GA7/2 **Towards High Altitude.**
Proc. 7th AGARD General Assembly, 13-80, 1957.
A round table discussion under the Chairmanship of Dr. H.L.Dryden. Notices of the separate contributions are given in succeeding items.

GA7/3 **Physics of the Stratosphere and Ionosphere.** W.DIEMINGER.
Proc. 7th AGARD General Assembly, 14-20, 1957.
A general account of methods of investigation for obtaining aeronomic data on pressure and density, composition of the air, temperature, ionisation and electrical conductivity, motion, and extra terrestrial radiation. Charts illustrate recent results in these fields.

GA7/4 **Aerodynamics of Low Density Media.** G.N.PATTERSON.
Proc. 7th AGARD General Assembly, 21-31, 9 refs., 1957.
After a brief account of the kinetics of low density media and the significance of the Knudsen number the author discusses the characteristics illustrated in diagrams relating the parameters of low density flow, such as temperature, altitude, velocity, Stanton and Knudsen numbers, and variables of free-molecule flow.

GA7/5 **Propulsion at High Altitudes.** (In French and English). M.BARRERE, R.SIESTRUNCK, M.F.FLORIO.
Proc. 7th AGARD General Assembly, 32-62, 13 refs., 1957.
Discusses the effects of diminishing atmospheric pressure on the behaviour of turbojets, ramjets, and the variations in thrust, specific fuel consumption and performance of rocket engines with altitude. The special testing and research necessary to ensure correct operation of the vehicles are briefly considered.

GA7/6 **Human Parameters of Space Flight.** P.A.CAMPBELL.
Proc. 7th AGARD General Assembly, 63-73, 22 refs., 1957.
The rate of progress in atmospheric flight is compared with that in space-flight, or extra-atmospheric flight. The main environmental factors, such as acceleration gravity, temperature balance, and pressure balance, in space-flight problems are discussed. Other hazards are noted briefly.

GA7/7 **Flight Research at High Altitude. Pt. 1.** H.M.DRAKE.
Proc. 7th AGARD General Assembly, 74-76, 1957.
Aerodynamic problems associated with flight at high Mach numbers and/or low dynamic pressures include reduction of directional stability, poor dynamic stability, low control effectiveness, and

aerodynamic heating, and instrumentation problems. These are briefly indicated. Some of the high-altitude investigations on the X-1B aircraft are discussed, including preliminary studies on an analogue computer used as a simulator.

GA7/8 **Flight Research at High Altitude, Pt. 2.** I.C.KINCHELOE, Jr.
Proc. 7th AGARD General Assembly, 76-80, 1957.
Describes the flight programmes of the X-2 rocket research aircraft and the actual flight experiences of the author in flying this aircraft. Operation of fuel recording system, stability, dynamic pressures and general handling are described.

PROCEEDINGS OF THE EIGHTH AGARD GENERAL ASSEMBLY

GA8 **Proceedings of the Eighth AGARD General Assembly.**
AD-232-699 Proc. 8th AGARD General Assembly, 78pp., 1958
CN-63423 The eighth General Assembly was held in Copenhagen, Denmark on the 28th and 29th October, 1958. The Proceedings include the text of an address of welcome by the Danish Minister of Defence, Mr. P.Hansen, greetings from groups and associations, papers presented to the assembly, reports from the Panel Chairmen and the Secretariat, and a list of Panel papers. Abstracts of the individual papers are given in the succeeding items.

GA8/1 **Atomic Energy Research in Denmark.** T.BJERGE.
Proc. 8th AGARD General Assembly, 11-14, 1958.
After briefly outlining the general academic discoveries leading to an understanding of atomic phenomena, Dr. Bjerge noted briefly its present culmination in the production of military and civil power sources. Denmark has agreements for co-operation with U.S.A. and U.K., supplies enriched uranium and has built an Atomic Energy Research Establishment at Riscoe in Roskilde Fjord.

GA8/2 **The Impact of Space Technology on Research and Development.**
Proc. 8th AGARD General Assembly, 15-16, 1958.
A Round Table Discussion under the Chairmanship of Dr. N.F.Ramsey. Each speaker outlined the major problems in his field of interest. The separate contributions are noted in succeeding items. Only reported digests of the papers are given in the Proceedings.

GA8/3 **Environment.** P.E.MULLER.
Proc. 8th AGARD General Assembly, 17-18, 1958.
Discusses the problem of computing desired trajectories, taking into account terrestrial and extra-terrestrial force fields. The advantages of manned satellites are briefly noted. Problems arising from solar and cosmic radiations, occurrence of meteorites, and those associated with radio communications are indicated.

GA8/4 **Propulsion.** E.SANGER.
Proc. 8th AGARD General Assembly, 19-21, 1958.
A review of the status and future research requirements for power plants using solid and liquid propellant rockets, atomic rockets, ion and photon rockets. Major problems in the development of each type are noted.

GA8/5 **Structures and Materials.** F.R.THURSTON.
Proc. 8th AGARD General Assembly, 22-24, 1958.
General principles will be an extension of those used in aeronautics. The space vehicle has to encounter several types of environment in its flight phases; This is a major factor in the structural design. Mechanical and thermal aspects of design are discussed and areas where more information is needed are indicated.

GA8/6 **Guidance, Control and Stabilization.** A.W.LINES.
Proc. 8th AGARD General Assembly, 25-26, 1958.
Points out the need for well-defined orbits and trajectories for satellites with specific missions, such as communication satellites. The guidance accuracy required is discussed and the possiblity of using inertial guidance systems examined.

GA8/7 **Selection and Training of Personnel.** W.R.LOVELACE, 2nd.
Proc. 8th AGARD General Assembly, 27-28, 1958.
Discusses the bases for physiological and psychological assessment of personnel, with emphasis on the simulation of expected environmental conditions. The use of balloon-supported capsules and vehicles such as the X-15 research aircraft for environmental testing is noted.

GA8/8 **Biomedical Aspects.** D.FLICKINGER.
Proc. 8th AGARD General Assembly 29-30, 1958.
Discusses such topics as: capsule atmosphere control, design and layout, human engineering aspects of cabin design, instrumentation; use of animal tests for life-support systems; radiation hazards; implications of weightlessness.

PROCEEDINGS OF THE NINTH AGARD GENERAL ASSEMBLY

GA9 **Proceedings of the Ninth AGARD General Assembly.**
AD-261-836 Proc. 9th AGARD General Assembly, 114pp., 1959.
CN-63423 The ninth General Assembly was held in Aachen, Germany. The Proceedings include the text of the greetings from Aachen Technische Hochschule, the City of Aachen, and S.H.A.P.E., papers presented to the assembly, reports of the Panel Chairmen and the Secretariat, and a list of Panel papers. Abstracts of the individual papers are given in the succeeding items.

GA9/1 **Review of Aeronautical Research in the Federal Republic of Germany.** A.W.QUICK.
Proc. 9th AGARD General Assembly, 21-34, 1959.
Discusses the status and personnel complements of German research institutes carrying out work relevant to aeronautics and describes their fields of research. Future plans for research and the construction of research facilities are described.

GA9/2 **Space Research Techniques and Recent Experimental Data.**
Proc. 9th AGARD General Assembly, 36-87, 1959.
A round table discussion, based on a survey paper prepared by N.A.S.A. in which experts from NATO countries offer comments and contributions on their own activities, results and future research. These separate papers are noted in succeeding items.

GA9/3 **Space Research.** R.FELLOWS, J.E.JACKSON, H.E.NEWELL, Jr., M.STOLLER.
Proc. 9th AGARD General Assembly, 37-70, 1959.
This paper, produced by members of N.A.S.A reviews the several fields of space research, giving a brief account of the background knowledge and summaries of recent research on the atmosphere, ionosphere, radiation particles, electric, magnetic and gravitational fields, astronomy (in relation to space vehicle research), and space biosciences. The characteristics of space-sounding techniques are outlined together with ground support activities and instrumentation. Future research developments in all these spheres are discussed.

GA9/4 **Communication with Ballistic Missiles and Satellites.** W.A.JOHNSON.
Proc. 9th AGARD General Assembly, 71-79, 1959.
The communication system consists basically of transmitter, receiver and aerial systems. Limitations on these sub-systems involve: radiation patterns, propagation phenomena, power-handling capacity, noise and interference picked up by the aerials. These are examined in relation to typical space vehicles. A brief summary is given of U.K. experience in connection with these problems.

GA9/5 **On the Directing of Intense Photonic Beams by Means of Electron Gas Mirrors.** E.SÄNGER.
Proc. 9th AGARD General Assembly, 80-86, 1959.
Examines the possibility concentrating and aligning radiation intensities of the order of 10^9 cal. $cm^{-2}.sec^{-1}$, such as might exist in the black body radiation of heavy plasmas. Graphs demonstrate the reflective powers in comparison with reflection from metal surfaces at low temperatures.

PROCEEDINGS OF THE TENTH AGARD GENERAL ASSEMBLY

GA10 **Proceedings of the Tenth AGARD General Assembly.**
AD-263-704 Proc. 10th AGARD General Assembly, 105pp., 1960.
N69-80551 The Tenth General Assembly was held in Istanbul, Turkey on the 6th and 7th October, 1960. The Proceedings include the text of the addresses by the Turkish Chief of State, the Rector of the University of Istanbul, and the Govenor of Istanbul, papers presented to the assembly, reports of the Panel Chairmen and the Secretariat, and a list of Panel papers. Abstracts of the individual papers are given in the succeeding items.

GA10/1 **Research and Development in Turkey.** F.ULUG.
Proc. 10th AGARD General Assembly, 21-28, 1960.
The author, after a brief historical note on early science in Turkey, lists those recent occasions on which AGARD has aided research and development efforts.

GA10/2 **Ballistics and Aeronautics.**
Proc. 10th AGARD General Assembly, 29-76, 1960.
A Round Table discussion, with E.T.Jones as the moderator.

GA10/3 **Ballistics and Aeronautics: General Survey** H.DAVIES.
Proc. 10th AGARD General Assembly, 29-43, 9 refs., 1960.
After briefly surveying the historical progress of ballistics and aeronautics, the author looks at the future prospects and notes particularly the problems of kinetic heating and development of propulsion units for high-speed flight.

GA10/4 **Winged and Wingless Aerospace Craft for Hypersonic Flight.** B.F.RUFFNER.
Proc. 10th AGARD General Assembly, 45-49, 1960.
Considers ballistic vehicles e.g. those having no lifting capability and compares flight and construction characteristics with similar winged vehicles.

GA10/5 **Guidance Aspects.** (In French). P.CONTENSOU.
Proc. 10th AGARD General Assembly, 51-60, 1960.
The basic mechanics of guidance are summarized and the factors influencing accuracy are listed. The transfer of the rudimentary concepts to aeronautical and ballistic applications is then discussed.

GA10/6 **Contribution to the Achievement of High Speeds in Models.** (In French). R.E.KUTTERER.
Proc. 10th AGARD General Assembly, 61-72, 4 refs., 1960.
Describes the use of guns to propel models at high speed. Systems considered include guns using propellant charges, electrical impulses and multi-stage guns and rockets.

GA10/7 **Tracking Aspects** M.SANTUR.
Proc. 10th AGARD General Assembly, 73-76, 1960.
A general outline of principles of tracking considering tracking as an information problem of transmission and reception of energy forms.

PROCEEDINGS OF THE ELEVENTH AGARD GENERAL ASSEMBLY

GA11 **Proceedings of the Eleventh AGARD General Assembly.**
AD-294-420 Proc. 11th AGARD General Assembly, 119pp., 1961.
N63-17048 The Eleventh General Assembly was held in Oslo, Norway, on the 24th to 28th July, 1961. The Proceedings include the text of an address of welcome from the Norwegian government and from the University of Oslo, a statement from the Assistant Secretary General for Scientific Affairs, NATO, papers presented to the assembly, reports from the Panels and the Secretariat. Abstracts of the individual papers are given in the succeeding items.

GA11/1 **Research and Development in Norway.** R.MAJOR.
Proc. 11th AGARD General Assembly, 17-35, 1961.
After briefly summarizing the major natural sources of Norway, the author discusses the industrial and academic research facilities, giving representative figures for the distribution of scientists and academicians. A major government research institute is the Norwegian Defence Research Establishment, from which also developed the Institute of Atomic Energy. Representative of industrial research is the activity of the Royal Norwegian Council for Scientific and Industrial Research. Future problems are outlined.

GA11/2 **Scientific Aspects of Space Technology.**
Proc. 11th AGARD General Assembly, 37-38, 1961.
A round table discussion, with F.Lied as the moderator. Director Lied, in his opening address, discusses the basic reasons for space research, compounded of national prestige, technical and emotional ambitions.

GA11/3 **Space Physics.** H.FRIEDMAN.
Proc. 11th AGARD General Assembly, 39-52, 1961.
Discusses the exploration of radiation belts, layers of the outer atmosphere, extra-terrestrial incident radiation, solar phenomena, by the diverse means available from ground installations (radio-transmitters) and rockets. Information obtained on the structure of the solar surface is discussed in some detail.

GA11/4 **Space Medicine.** W.R.LOVELACE, 2nd.
Proc. 11th AGARD General Assembly, 53-64, 1961.
Reviews briefly education of flight surgeons, examination of space crews, behavioural sciences, biomedical data collection and processing, environmental stress, acceleration, radiation, nuclear propulsion, safety and reliability, extraterrestrial life.

GA11/5 **Space Communications.** S.R.DAUNCEY.
Proc. 11th AGARD General Assembly, 65-67, 1961.
Discusses the use of active and passive satellites to aid terrestrial communication. Merits and de-merits of both types of satellites are discussed. The problem of time-lag in reflection is noted. Modulation techniques are described. Areas for research relate to component development based on solid-state physics; study of radiation effects on components; development of power sources; mechanical problems and environmental physics.

GA11/6 **Communication Satellites.** W.F.HILTON.
Proc. 11th AGARD General Assembly, 69-75, 4 refs., 1961.
Discusses: choice of satellite; methods of stabilization; choice of orbits; number of satellites required; radio modulation techniques.

GA11/7 **Space Communications - Framing the Window.** A.G.HALEY.
Proc. 11th AGARD General Assembly, 77-90, 1961.
Considers the international 'moral' problems of the fair allocation of radio space and the maintenance of adequate 'windows' for free communication to all parts of space. Present means of controlling space communication rights are noted and discussed. Results of preliminary enquiries and investigations are reported.

PROCEEDINGS OF THE TWELFTH AGARD GENERAL ASSEMBLY

GA12
AD-422-489
N64-11877 **Proceedings of the Twelfth AGARD General Assembly.** B.J.DRISCOLL (Editor).
Proc. 12th AGARD General Assembly, 155pp., 1962.
The 12th General Assembly commemorating the Tenth Anniversary of AGARD was held in Paris, in July, 1962. Pt.1 includes the Official Opening Remarks by the Secretary General, NATO, Dr. Dirk U Stikker; a message from the Standing Group, NATO, from Admiral M. Douget; talks marking the occasion of the Tenth Anniversary by General L. Norstad, General G. Lavaud, Sir Solly Zuckerman, General J. Fergusson, General B.A. Schriver. Pt.2 is devoted to Dr. von Kármán's address on the 'Origin and Goals of AGARD'. Pt.3 includes talks illustrating the 'Historical Review of AGARD' by General D.L. Putt (U.S.), Prof. M. Roy (France), General Craigie (U.S.), Prof. G. Gabrielli (Italy), Prof. M. Anastassiades (Greece) and Dr. T. Benecke (Germany). Pt.4 is devoted to the technical session on the theme 'Manned Flight Systems, Past, Present and Future'; abstracts of these technical papers are given in the following items.

GA12/1 **Manned Flight Systems: Past, Present, Future. Fluid Dynamics Aspects.** L.F.NICHOLSON.
Proc. 12th AGARD General Assembly, 45-48, 1962.
Reviews briefly the work of the AGARD Fluid Dynamics Panel (and its predecessor the Wind Tunnel Panel), especially as it relates to the problems of manned flight systems; particular reference is made to AGARD studies on the feasibility of vertical take-off and landing, and work on separated flows.

GA12/2 **Manned Flight Systems: Past, Present, Future. Propulsion Aspects.** (In French). J.SURUGUE.
Proc. 12th AGARD General Assembly, 49-69, 1962.
This comprehensive survey of the propulsion problems posed by manned flight touches upon the following subjects: the development of jet-propelled aircraft and the use of ramjets or combined turbo-ramjets; rockets using propergolic propellants; advanced (non-chemical) space propulsion systems; the efforts of the AGARD Combustion and Propulsion Panel Working Party on the subject of increasing the power-to-weight ratio of engines; the rôle of the pilot in advanced flight systems.

GA12/3 **Manned Flight Systems: Past, Present, Future. Structures and Materials Aspects.** R.V.RHODE.
Proc. 12th AGARD General Assembly, 71-83, 1962.
In surveying the structures and materials problems of manned flight systems, the following aspects are considered: developments during the last ten years; current problems; trends that will pose future problems; the rôle of AGARD in structures and materials activities.

GA12/4 **Manned Flight Systems: Past, Present, Future. Avionics Aspects.** (In French). E.J.VARRY.
Proc. 12th AGARD General Assembly, 85-91, 1962.
The significant developments in avionics technology during the last ten years are first listed (these extend from the production of the first transistors to the successful operation of the Courier I active communications satellite). The work of the AGARD Avionics Panel (and particularly that relating to ionospheric studies) is then surveyed with frequent reference to the AGARD publications in this field.

GA12/5 **Manned Flight Systems: Past, Present, Future. Aero-Medical Aspects.** W.K.STEWART.
Proc. 12th AGARD General Assembly, 93-101, 1962.
The organization and development of the AGARD Aviation Medicine Panel and its sub-committees is described, and its activities over the last ten years are reviewed. Environmental stress, the control of the micro-climate in life-support systems, and bio-telemetry are indicated as three subject fields in which future efforts could be made.

GA12/6 **Manned Flight Systems: Past, Present, Future. Documentation Aspects.** J.A SCHÜLLER.
Proc. 12th AGARD General Assembly, 103-109, 1962.
Problems generated by the proliferation of technical and scientific published and unpublished information are discussed, with special reference to information retrieval and the tasks of documentation and information centres. The achievements of the AGARD documentation panel since its formation in 1953 are then summarized.

GA12/7 **Manned Flight Systems: Past, Present, Future. Flight Mechanics Aspects.** W.C.WILLIAMS.
Proc. 12th AGARD General Assembly, 111-115, 1962.
The major achievements of the AGARD Flight Test Panel (development of a standard flight test manual, light-weight fighter evaluation, sponsoring of symposia, assessment of V/STOL handling quality requirements) are first summarized. Current and future programmes are then outlined, and problems of the flight-testing of space vehicles are discussed.

GA12/8 **Pilot Experience with the X-15 Airplane.** R.A.RUSHWORTH.
Proc. 12th AGARD General Assembly, 117-123, 1962.
Discusses the rôle of the pilot in the control of flight vehicles, and the extent to which his abilities may be used. The discussion is presented in the light of the author's experience in flight-testing the X-15 rocket aircraft.

GA12/9 **Adaptation of Aircraft Testing Principles to Manned Space Flight.** W.C.WILLIAMS.
Proc. 12th AGARD General Assembly, 125-154, 1962.
The adaptation of aircraft testing principles to manned space flight is considered with reference to Project Mercury. Various aspects of Project Gemini (aims, the spacecraft itself, operational procedure) are then described; similar details of Project Apollo are given. Finally, the following are tabulated: Project Mercury flight data summary, various Mercury missions and test objectives, comparison of Mercury and Apollo missions, and Apollo mission manoeuvres.

PROCEEDINGS OF THE THIRTEENTH AGARD GENERAL ASSEMBLY

GA13 **Proceedings of the Thirteenth AGARD General Assembly.**
AD-439-862 Proc. 13th AGARD General Assembly, 126pp., 1963.
N64-22875 The thirteenth General Assembly was held in Greece from 8th to 19th July, 1963. These Proceedings contain the text of an address of welcome by Mr. P. Dragoumis, a eulogy for Theodore von Kármán, remarks by the Commander-in-Chief, Allied Forces, Southern Europe (Admiral J.S. Russell), various speeches of greeting, papers relating to the design, construction and operation of missile ranges, reports from the Panel chairmen and an AGARD staff report. Abstracts of the individual papers relating to missile ranges are given in the succeeding items.

GA13/1 **The Nato Missile Firing Installation.** M.XENOS.
Proc. 13th AGARD General Assembly, 27-35, 1963.
To obviate the necessity of sending crews to Fort Bliss (Texas) a European firing range has been constructed at Suda (Crete). This brief description illustrates the problems of construction and operation.

GA13/2 **Comprehensive Report of the Problems Posed by the Conception, Realization and Exploitation of Missile Test Ranges Experiences. (In French).** NATTA.
Proc. 13th AGARD General Assembly, 37-50 1963.
General organization of French missile test ranges, comparison of various test ranges used in France (Colomb-Bechar, Ile-du-Levant, Biscarrosse); general rules for the conception, realization and exploitation of missile test ranges; examples of methods used on French missile ranges.

GA13/3 **The Missile Range o Salto Di Quirra.** S.A.CESARE de PORTO.
Proc. 13th AGARD General Assembly, 51-59, 1963.
This range was established in 1956 by the Italian Air Force in Sardinia. The facility was expanded in 1960, and is now suitable for missile testing up to 500 Km range, and also, for launching sounding rockets. A brief description is given of the organization and of the type of equipment.

GA13/4 **Missile Ranges - Their Purpose, Design and Operation.** J.E.SERBY.
Proc. 13th AGARD General Assembly, 61-75, 1963.
Discusses the development of the U.K./Australian range at Woomera, Australia. These experiences are examined to see how far they apply to the planning of the NATO Missile Range in Crete.

GA13/5 **The Atlantic Missile Range.** L.I.DAVIS.
Proc. 13th AGARD General Assembly, 77-89, 1963.
A brief general description of this American facility. Mention is made of the ROTI tracking camera with a 500 inch lens. A map of the range is included.

PROCEEDINGS OF THE FOURTEENTH GENERAL ASSEMBLY

GA14 **Proceedings of the Fourteenth AGARD General Assembly.**
AD-480-310 Proc. 14th AGARD General Assembly, 118pp., 1964.
N65-28450 The fourteenth General Assembly was held in Lisbon from 14th to 22nd September, 1964. Pt.1 of the Proceedings includes the opening remarks by Prof.C.D.Perkins, the address of welcome by General M.G.de Araujo, various speeches of welcome, and a paper by Prof.H.A.Ferreira on scientific research in Portugal. Pt.2 includes three papers on the rôle of science in defence. Pt.3 presents papers on man-machine relationships. Abstracts of the individual technical papers are given in the succeeding items.

GA14/1 **Scientific Research in Portugal.** (In French). H.A.FERREIRA.
Proc. 14th AGARD General Assembly, 13-16, 1964.
The organization of scientific research in Portugal is desribed. There is no one central authority for co-ordination of research but there are organizations or government departments for co-ordinating research in specific disciplines; brief notes on these separate authorities are given. Industrial organizations that make a signif. nt contribution to research are listed. Portugal's contribution to medical research receives particular mention.

GA14/2 **The Rôle of Science in Defence: United States of America.** H.BROWN.
Proc. 14th AGARD General Assembly, 19-22, 1964.
It is suggested that the scope of the title subject should be extended to the rôle of science and engineering in defence. This rôle is discussed not only in relation to the research and development of equipment but also the application of scientific thought to such areas as procurement, operations and military strategy.

GA14/3 **The Rôle of Science in Defence: Federal Republic of Germany.** K.FISCHER.
Proc. 14th AGARD General Assembly, 23-26, 1964.
The question of the way in which the NATO alliance can be strengthened by joint work in the field of natural sciences and applied technology is considered. It is pointed out that the results of scientific research, and of its technical application, embody real power. International co-operation can avoid duplication, and the individual nations can make different contributions. The German contribution has been facilitated by post-war assistance from U.S.A.

GA14/4 **The Rôle of Science in Defence: France.** (In French). L.MALAVARD.
Proc. 14th AGARD General Assembly, 27-35, 1964.
A discussion of the interaction between scientific developments and defence policy is followed by a detailed description of the organization of defence research in France.

GA14/5 **Man-Machine Synergy.** T.C.D.WHITESIDE.
Proc. 14th AGARD General Assembly, 39-46, 1964.
In this consideration of the working together of man and machine (anthropomechanic synergy) the effects of the physical environment on the human operator are first discussed. Anatomical and physiological effects due to acceleration. Effects of unplanned imputs (e.g. illusions of tilting) are also discussed. The value of simulators for training and for detecting potential failures in the man-machine system is then considered. The presentation of information is also discussed.

GA14/6 **Adaptation of Man to the Machine.** J.M.QUASHNOCK.
Proc. 14th AGARD General Assembly, 47-63, 1964.
The title subject is discussed from two aspects: (i) protective devices to extend the tolerance limits of crews to aerospace hazards; (ii) simulators to reproduce such hazards at or near ground level for training and research purposes. Frequent reference is made to equipment (e.g. personal protective equipment) developed at the Wright-Patterson Air Force Base.

GA14/7 **The Rôle of the Pilot in the Mercury and X-15 Flights.** W.C.WILLIAMS.
Proc. 14th AGARD General Assembly, 65-81, 4 refs., 1964.
It is pointed out that although the vehicles used in the Mercury and X-15 flights were completely different, a common factor was that in both, one of the important rôles of the pilots was systems management. The various tasks of the pilots in these two missions are described. Physiological effects are not discussed.

GA14/8 **Some Aspects of High-Speed Manned Flight at Low Altitudes.** J.FERGUSON.
Proc. 14th AGARD General Assembly, 83-89, 1964.
Experience gained from U.S.A.F. high-speed low altitude flights is summarized. These studies indicate that a 30 to 50 ft decrease in altitude from normal minimum can increase the probability of self-destruction from a negligible factor to 50%. Gust sensitivity is discussed as are the improvements in flexibility and performance to be obtained from variable geometry aircraft. The advantages to be gained from suitable terrain-following radars are also considered.

GA14/9 **Man-Machine Problems in VTOL Aircraft.** T.BENECKE.
Proc. 14th AGARD General Assembly, 91-98, 1964.
The following are discussed: an historical review of vertical ascent and vertical landing; pilot's problems when flying VTOL aircraft; control aids for the VTOL pilot; the merits of simulation in VTOL aircraft engineering and pilot training; experience gained in flying the VJ-101 VTOL aircraft.

GA14/10 **"Concorde" Seen from the Point of View of Man-Machine Relationships.** (In French).
M.R.BLANCHET.
Proc. 14th AGARD General Assembly, 99-118, 1964.
Problems posed by flight at Mach 2.2 are discussed; it is stressed that machines will not replace man in piloting aircraft such as the Sud Aviation-BAC Concorde. The conditioning of the interior of the Concorde to provide a suitable environment for its crew and passengers is also treated in some detail.

GLOSSARIES AND DICTIONARIES

GL1
AD-421-429
N63-23199
AGARD Aeronautical Multilingual Dictionary. G.H.FRÉNOT, A.H.HOLLOWAY (Editors).
AGARD Publ. 'Aeronautical Multilingual Dictionary,' 1960.
This is a loose-leaf book based upon the British Standards Institutions 'Glossary of Aeronautical Terms and Definitions'. The Glossary has been translated into French, German, Italian, Dutch, Spanish, Turkish and Russian. Some American equivalents are also included.

GL 1/1
AD-421-429
N63-23199
First Supplement to AGARD Aeronautical Multilingual Dictionary. A.H.HOLLOWAY (Editor).
AGARD Publ. 'First Supplement to AGARD Aeronautical Multilingual Dictionary,' 333pp., 1963.
This supplement adds some 1287 terms to those in the original dictionary; all these additional terms are taken from the U.S. NASA Dictionary. In this supplement the terms are defined in English only, but a ninth language (modern Greek) has been added to the eight (English, German, Spanish, French, Italian, Dutch, Russian, Turkish), of the original dictionary. This supplement is issued as a bound volume in the interests of early publication but it is intended to make the contents available in loose leaf form at a later date for inclusion in the original dictionary.

GL2
AD-242-976
N63-22250
A Glossary of Terms Commonly Used in Aviation Medicine.
AGARD Publ. 'A Glossary of Terms Commonly Used in Aviation Medicine,' 30pp., 1960.
Definitions and equivalents in French and English of about 200 terms.

GL3
Not published

GL4
AD-700-329
N70-20920
Glossary of Terms Frequently Used in Documentation. H.A.STOLK.
AGARD Glossary, 40pp., 8 refs., 1968.
This glossary was prepared under the auspices of the AGARD Technical Information Panel. It defines the specialised terms used in Library and Documentation use.

GL5
Glossary of Documentation Terms. H.STOLK.
AGARD Glossary, January 1970.
This document contains a list of the most commonly used terms in documentation, with definitions and cross references, and is a second edition of Item GL4

HANDBOOKS

MATERIALS PROPERTIES HANDBOOK: VOLUME 1

HB1/1 **Materials Properties Handbook: Volume 1. - Aluminium Alloys.**
N-68112 AGARD Materials Properties Handbook, 1, 1958.
N66-87154 Gives data for grades of aluminium from various NATO countries.

MATERIALS PROPERTIES HANDBOOK: VOLUME 2

HB1/2 **Materials Properties Handbook: Volume 2. - Steel.**
N-68112 AGARD Materials Properties Handbook, 2, 1960.
Sections are included, giving data for representative grades of steel originating from various NATO countries. The information is presented in the form of tables. The introduction explains the basis of data selection.

MATERIALS PROPERTIES HANDBOOK: VOLUME 3

HB1/3 **Materials Properties Handbook: Volume 3. - Magnesium, Nickel and Titanium Alloys.**
AD-662-162 AGARD Materials Properties Handbook, 3, 249pp., 1963.
N63-18835 The Handbook is divided into national sections and gives data on those alloys which are of most interest for structural use in aircraft. The contributing countries are Canada, France, Germany, Italy, Netherlands, U.K. and U.S.A.

MATERIALS PROPERTIES HANDBOOK: VOLUME 4

HB1/4 **Materials Properties Handbook: Volume 4. - Heat-Resisting Alloys.**
N67-11244 AGARD Materials Properties Handbook, 4, 255pp., 1966.
French, German, U.K. and U.S.A. sections are included dealing with representative nickel, cobalt and iron-base heat-resistant alloys for aerospace use. Information is in tabular form and covers specified chemical and specified mechanical properties, physical properties, static mechanical properties, fatigue properties, short-time mechanical properties at elevated temperature, recovered properties after exposure to elevated temperature, and properties under load and elevated temperature.

HB2/1 **Handbook of Brittle Material Design Technology.** W.H.DUKES.
AD-661-162 AGARD Handbook of Brittle Material Design Technology, 66pp., 15 refs., 1965.
N68-12797 This handbook is in loose-leaf format so that it may be updated as circumstances require. Eventually it will comprise the following sections: 1. Introduction; 2. Principles of brittle material design; 3. Establishment of design stresses; 4. Stress analysis methods: 5. Material characteristics; 6. Design criteria; 7. Design techniques; 8. Test methods; 9. Structural optimization. To-date only the first three sections have been issued. The brittle materials referred to in the title include: oxides, carbides, borides, and similar materials, and graphite.

HB2/2 **Handbook of Brittle Material Design Technology.** W.H.DUKES.
AGARD Handbook, 41pp., 16 refs., 1966.
Interest in brittle materials has increased as a result of the development of re-entry vehicles subject to severe heating. Many materials which are capable of high strength at high temperatures are brittle, that is they show little or no plastic deformation before failure. Conventional methods of design rely on a degree of plastic deformation to reduce above average stresses but are unsuitable when applied to brittle materials. New design techniques are described to allow brittle material structures to have a weight efficiency and reliability comparable to metallic structures. The materials to which this handbook is intended to apply include oxides, carbides, borides and similar compounds together with graphite in its many forms. The present volume presented at the 23rd meeting of the AGARD Structure and Materials Panel held in Paris, France, October 1966 consists of three sections, Introduction, Principles of Brittle Material and Establishment of Design Stresses. Further parts will be issued later.

INFORMATION BULLETINS

IB67/3
N68-15349
AGARD Annual Meeting, Turin. November 1967.

IB68/1
N68-23457
Panel Report and Forecasts Report of Consultant and Exchange Program. January 1968.

IB68/2
N68-37999
Panel Report, Consultant and Exchange Program. May 1968.

IB69/1
AD-687-975
N70-28533
Meetings, Publications, Membership. January 1969.
This, the first of a regular series, sets down the aims of AGARD, it contains a statement of meetings planned for 1969, a list of publications for the whole of 1968, and a complete list of members. The latter also includes the Panel structure.

IB69/2
AD-689-720
N69-30115
Technical Programme 1970. May, 1969.
Includes statements for each Panel on technical objectives and budget statements for each objective for 1970, a summary of proposed meetings and a statement on publications. Finally additional information on Panel activities is presented both in English and French.

IB69/3
AD-691-562
Meetings, Publications, Membership. July, 1969.
This is a mid-year revision of Bulletin 69/1 and includes a detailed list of meetings for 1969, a list of papers, with abstracts issued in the first six months of 1969 and a revised membership list.

IB70/1
AD-699-477
N70-38493
Meetings, Publications, Membership. January, 1970.
This issue of the AGARD Bulletin is principally devoted to a schedule of the meetings to be held in 1970, a list of the publications produced in 1969 and a Directory of AGARD Members as of 1 January 1970.

IB70/2
AD-706-636
AGARD Bulletin 70-2. May, 1970.
The Bulletin reports the content and scope of the AGARD Technical Program and Budget approved during the AGARD National Delegate Board Meeting, 17-18 March 1970, at Neuilly-sur-Seine, France.

IB70/3
AD-710-889
AGARD Bulletin 70-3. July, 1970.
This bulletin is the mid-year revision of AGARD Bulletin 70-1, covering a schedule of the meetings to be held in 1970, a list of the publications produced from 1 January to 30 June 1970 and a Directory of AGARD Members as of 30 June 1970.

LECTURE SERIES

Serial Number	*Index Item*	
1	–	Travelling Seminar, 1964, published by the U.S.A.F.
4	–	Space Research Technology Symposium, Rome, 1958, published by Pergamon Press as. "Current Research in Aeronautical Sciences".
6	–	Space Propulsion Seminar, Varenna, 1960, published by Pergamon Press as: "Advances in Astronautical Propulsion".
11	AG-77	Micropower Electronics, 1963.
14	AG-92	Orbit Optimization and Laser Applications, 1964.
17	AG-105	Space Navigation, Guidance and Control, 1965.
20	–	Bionics, published by SEDOCAR, 1965 (limited distribution).
22	AG-114	Applications of Microelectronics to Aerospace Equipment, 1966.
23	AG-118	Fluid Control – Components and Systems, 1966.
25	AG-120	Supersonic Turbomachinery, 1967.
27	AG-123	Space Power Systems, 1967.

LS1 to LS23
AD-654-541
N67-31404

Record of AGARD Lecture Series: Lecture Series 1 to 23. A.G.VANNUCCI, J.C.DUNNE.
AGARD Publ. "Record of AGARD Lecture Series", 60 pp., 1966.
AGARD Lecture Series have been presented in almost every NATO country since their inception with the Travelling Seminar held in 1954. The wide range of disciplines covered has made it desirable to consolidate in a single document a record of the lectures presented. Here, short abstracts of the individual lectures are given together with some introductory details relating to the lecture series. An author index is included.

LS24 to LS28
AD-687-976
N69-27041

Record of AGARD Lecture Series. Supplement One. Compiled by A.G.VANNUCCI, J.C.DUNNE.
AGARD, 49 pp., 1968.
The index of AGARD Lecture Series is a complement of the present Index of publications. This supplement gives a bibliography of extended summaries and an author index to the following lecture series:

XXIV Boundary-Layer and Circulation Control, 1967.
XXV Supersonic Turbomachinery, 1967. Published as AGARDograph 120.
XXVI Industrial Aerodynamics, 1967.
XXVII Energy Sources for Space Power, 1967. Published as AGARDograph 123.
XXVIII Fluid Dynamics of Subsonic and Supersonic Machinery, 1967.

LS29
AD-676-788
N68-37825

Radio Wave Propagation.
AGARD Lecture Series XXIX, 396 pp., many refs., 1968.
This Lecture Series was presented under the sponsorship of the Electromagnetic Wave Propagation Committee of the Avionics Panel of AGARD, and of AGARD Plans and Programmes, and was held in Leicester, United Kingdom, June 30 to July 5, 1968. The purpose of the series is to provide (i) a concentrated exposition of the fundamental ideas underlying radio wave propagation in both ionized and non-ionized media, (ii) the present state of propagation research, (iii) various applications of propagation knowledge to telecommunications. Much of the material in these notes exists in the available literature and it is assumed that the serious student will supplement the notes by consulting the references listed. The volume is divided into five sections which are dealt with in the following abstracts numbered LS29/1 to LS29/5.

LS29/I **Magneto-Ionic Theory of Radio Propagation.** K.DAVIES.
AGARD Lecture Series XXIX, Reference I, pp.I-1 to I-88, 85 refs., 1968.
This section deals with the theory of radio propagation in four chapters with the following titles:
- I-1 Properties of Propagating Waves
- I-2 Magneto-ionic Theory
- I-3 Radio Waves in the Ionosphere
- I-4 Ray Tracing

LS29/II **The Ionosphere.** B.LANDMARK.
AGARD Lecture Series XXIX, Reference II, pp.II-1 to II-4, 37 refs., 1968.
This section deals with radio propagation via the ionosphere in four chapters with the following titles:
- II-1 Production of the Ionosphere
- II-2 The Structure of the Quiet Ionosphere
- II-3 Regular and Irregular Variations of the Ionosphere
- II-4 Some Properties of the Polar Ionosphere

LS29/III **Ionospheric Propagation of High Frequency Radio Waves.** W.DIEMINGER.
AGARD Lecture Series XXIX, Reference III, pp.III-1 to III-83, 1968.
This section consists of four papers with the following titles:
- III-1 Conversion of Vertical to Oblique Incidence
- III-2 Oblique Incidence and Back-Scatter Observations
- III-3 Noise
- III-4 Ionospheric Propagation Prediction

LS29/IV **Low and Very Low Frequency Radio Wave Propagation.** J.S.BELROSE.
AGARD Lecture Series XXIX, Reference IV, pp.IV-1 to IV-115, 240 refs., 1968.
This section consists of five chapters titled:
- IV-1 Introduction
- IV-2 LF and VLF Pulse Sounding of the Ionosphere: Magneto-ionic effects
- IV-3 Terrestrial Propagation of CW Radio Waves
- IV-4 The Ionosphere D-region and LF Propagation
- IV-5 The Use of Long Radio Waves

LS29/V **Tropospheric Propagation of VHF-UHF Waves.** R.BOLGIANO.
AGARD Lecture Series XXIX, Reference V, pp.V-1 to V-28, 11 refs., 1968.
This section consists of four papers with the following titles:
- V-1 Refractive Index Structure of the Troposphere
- V-2 Reflection and Refraction on Line-of-Sight Paths
- V-3 Radio Ducting in the Troposphere
- V-4 Scatter Phenomena in Tropospheric Propagation.

LS30 See AG128.

LS31 See AG127

LS32 See AG126.

LS33 See CP44.

LS34 See "Applications Technology Satellites, 1969 – Pre-print".

LS35 See AG135.

LS37
N70-37753 **High Reynolds Number Subsonic Aerodynamics.** B.H.LITTLE (Ed.)
AGARD Lecture Series 37, June 1970.
The objectives of this Lecture Series are to present a state-of-the-art review of aerodynamic problems associated with the design of very large subsonic aircraft.

After reviewing the advantages and problems of this type of aircraft, the author presents aerodynamics of wing design, Reynolds number effects, engine performance, noise and vibration problems, total configuration aerodynamics technology and advanced computer technology in aerodynamics.

LS39 **Advanced Compressors.**
N70-39091 AGARD Lecture Series 39 (Pre-print), May 1970.
During the past few years, significant progress has been made in the design and development of high performance axial and radial compressors, in response to the increasing demand from jet engine and gas turbine manufacturers and to the broadening interest for such machines for closed cycle gas turbine application for atomic power plants.

The development of digital computers has enabled the use of more and more sophisticated design methods which are now paying off. Significant improvements have also been obtained for the compressor operation in the transonic and supersonic range. Interest in the long forgotten radial compressors has been revived, for small gas turbine application, and startling improvement in performance has been obtained, both in efficiency and in maximum pressure ratio obtainable.

LS40 **Large Scale Integration.** J.W.LATHROP (Ed.).
N71-12625 AGARD Lecture Series 40 (Pre-print), June 1970.
Recent product announcements and equipment demonstrations have made it clear that the digital equipment of the 70s will be implemented using the Large Scale Integration technology. It is the purpose of this Lecture Series to discuss this technology and its implications to digital system construction. Topics include processing and inter-connection technology, computer aided design, component characteristics and specifications, system construction and economics.

Papers assembled should be of great benefit to those involved in planning or developing military electronic systems for the 70s.

LS41 **Application of Propagation Data to VHF Satellite Communication and Navigation Systems.**
N71-16226 to P.F.CHECCACCI (Ed.).
N71-16235 AGARD Lecture Series 41 (Pre-print), June 1970.
This Lecture Series has been recommended by the AGARD Electromagnetic Wave Propagation Panel to bring new information in the field of satellite propagation studies.

In the last few years a great amount of data on propagation traversing the ionosphere has been achieved using the existing satellite transmission, for the purpose of studying the ionosphere itself. The primary objective of papers presented is to give a survey of the acquired data on the propagation of radio wave traversing the ionosphere and the use of such data for predicting the performance of the VHF satellite communication and navigation systems.

This book is intended for people working in satellite communications as designers or users.

LS44 **Scientific and Technical Information – Why? – Which? – Where? – and How?**
AGARD Lecture Series 44 (Pre-print).
This Lecture Series has been recommended by the Technical Information Panel and covered the subject of "Scientific and Technical Information – Why? – Which? – Where? and How?" which constituted the first series of lectures organized for TIP and presented twice, in Oslo and Rome, in November 1970. Attention was devoted particularly to the problems encountered by those engaged in all activities in the field of Information Science.

The purpose of this Lecture Series was to give to the "users" an overall briefing of the past, current, and future "state-of-the-art" in the field of Information Science and at the same time provide a forum for a broad exchange of views between scientists, engineers, information specialists and management.

Some of the important areas covered were.

1. Value of Information
2. Selective Dissemination
3. Mechanics of Information Transfer
4. User Wants (Needs)
5. Information Analysis Centers.

MISCELLANEOUS

Mis. 1
AD-848 805

AGARD Publications Index, Supplement 4, 1967. Compiled by A.G.VANNUCCI, J.C.DUNNE. AGARD, 132pp., 1968.
This is the fourth in a series of annual supplements to the AGARD Publications Index (1952-1963) and produces a bibliographical listing of AGARD Literature issued in 1967.

Mis.2
AD-687 976
N69-27041

Record of AGARD Lecture Series. Supplement One. Compiled by A.G.VANNUCCI, J.C.DUNNE. AGARD, 49pp., 1968.
The index of AGARD Lecture Series is a complement of the present Index of publications. This supplement gives a bibliography of extended summaries and an author index to the following lecture series:

XXIV Boundary-Layer and Circulation Control, 1967.
XXV Supersonic Turbomachinery, 1967. Published as AGARDograph 120.
XXVI Industrial Aerodynamics, 1967.
XXVII Energy Sources for Space Power, 1967. Published as AGARDograph 123.
XXVIII Fluid Dynamics of Subsonic and Supersonic Machinery, 1967.

Mis. 3
N70-15746

The AGARD History, 1952-1968. Editor F.L.WATTENDORF, 1969.
This book describes the background of Dr. Von Kármán and the reasons he had for proposing the setting up of an Aeronautics Advisory Group within NATO to mobilize to mutual advantage the scientific and technical skill, manpower and facilities of all NATO nations. After a preliminary meeting in 1951 of representatives of NATO nations the Standing Group of NATO approved the setting up of AGARD under the US Air Force as an executive agent for a two year trial period. Dr. Von Kármán was appointed Chairman of the Group and the book describes the growth of the Panel system which took place under his leadership. Details are given of the Research and Development activities and the consultant and exchange programme.

Mis. 4
In 13 parts
AD-831-985
N68-23629 to
AD-831-997
N68-23641

Properties of Air and Combustion Products with Kerosine Hydrogen Fuels. B.BAYNES, R.W.McINTYRE, J.A.SIMS.
AGARD/BRISTOL SIDDELEY, Vols. 1-13, 2524pp., 16 refs., 1967.
The 13 volumes of this work were published by Bristol Siddeley Engines Ltd. on behalf of the Propulsion and Energetics Panel of AGARD. They present computer produced tabulations of the equilibrium composition and thermodynamic properties for air and systems Kerosine/Air and Hydrogen/Air including the second virial corrections.

Report to the NATO Military Committee. Proposed AGARD Program and Budget 1971. (In English and French). June 1970.
The AGARD National Delegate Board met with the Officers of the AGARD Technical Panels and Activities, under the chairmanship of Director Finn Lied, on 17-18 March 1970 at Neuilly-sur-Seine, France, to develop a Technical Program and Budget for AGARD during calendar year 1971.

This report covers the findings of the National Delegates in terms of the AGARD Technical Program and Budget they recommend to the Military Committee for calendar year 1971.

AD-689-719

Director's Annual Report 1969 to the NATO Military Committee. (In English and French). February 1970.
The Report has been prepared in the context of the AGARD 1969 Technical Program which was carried out by the AGARD activities. Their achievements are reported separately in terms of:

1. The MEETINGS which were held to bring together the leading personalities of the NATO nations in a particular field of science and technology for the common benefit of the NATO community,
2. the PUBLICATIONS which were initiated as a result of these meetings for the purpose of assisting member nations in the effective use of their research and development capabilities and,
3. the BUDGET that supported this stimulus to the advances in the aerospace sciences relevant to strengthening the common defense posture.

The Report also contains summaries of the total AGARD activities including separate reports from the AGARD Panel Chairmen.

National Delegate Board Meeting 17-18 March 1970.
February 1970.
This publication was prepared in order to be used as working papers for the National Delegate Board Meeting, March 1970. It contains the reports of activities carried out during 1969 and the program for 1970 and 1971.

General Information.
July, 1970.
This leaflet was produced to provide background information on the establishment of AGARD, its mission, organization and publications.

Sixth AGARD Annual Meeting.
December, 1970.
This record of the Sixth AGARD Annual Meeting, held in Washington D.C., U.S. on 6 October 1970, includes full reports of all the papers presented at the plenary sessions. The speakers were: The Honorable U. Alexis Johnson, The Honorable Robert C. Seamans, The Honorable Robert Ellsworth, Lieutenant General Theodore R. Milton, The Honorable Grant II Hansen, The Honorable John S. Foster Jr., Mr. Milton B. Ames Jr., and Lieutenant General Otto J. Glasser.

MANUALS

FLIGHT TEST MANUAL: VOLUMES 1 TO 4

MN1 **Flight Test Manual: Volume 1. - Performance: Volume 2. - Stability and Control: Volume 3. - Instrumentation Catalogue: Volume 4. - Instrumentation Systems.** C.D.PERKINS (Editor).
AGARD Flight Test Manual, 1 to 4.
This manual has been prepared for the benefit of all NATO countries. Each volume is in loose-leaf form for ease in adding material for amendments. Details of the scope of the separate volumes are given in the following items.

FLIGHT TEST MANUAL: VOLUME 1

MN1/1 **Flight Test Manual: Volume 1. - Performance.** D.O.DOMMASCH (Editor).
AGARD Flight Test Manual, 1, Chapt. 1 to 12, 401pp., 1959.
The twelve chapters and five appendices of this volume deal with many aspects of performance testing of fixed wing and rotating wing aircraft. Abstracts of the individual papers are given in the succeeding items.

MN1/1/1 **Airspeed Altitude and Temperature Measurements.** D.O.DOMMASCH, B.DAVY, R.SHIELDS, I.E.UTTING, J.M SCHWARZBACH, H.W.DOWN.
AGARD Flight Test Manual, 1, Chapt. 1, 65pp., 26 refs., s.d.
Lag errors in airspeed, altitude and Mach number measurements are discussed with examples of corrections for these errors. Significant lag errors have been encountered in stalls and high speed dives. Careful design of the pitot-static system will minimise these errors.

MN1/1/2 **Thrust and Power Determination.** D.W.BOTTLE, D.O.DOMMASCH, W.J.HESSE, J.SOISSON, J.K.MOAKES, R.Le DUC, K.J.LUSH.
AGARD Flight Test Manual, 1, Chapt. 2, 41pp., 11 refs., s.d.
Detailed analyses are given of thrust and power measurements for piston engines, turbines, ramjets, and rockets made during flight tests.

MN1/1/3 **A Survey of Performance Reduction Methods.** K.J.LUSH, J.K.MOAKES (Editor).
AGARD Flight Test Manual, 1, Chapt. 3, 14pp., 2 refs., s.d.
The purposes of performance reduction are discussed and available experimental and analytical methods classified. The methods are compared as to their usefulness to specific reduction problems.

MN1/1/4 **Performance of Turbojet Airplanes.** D.O.DOMMASCH, W.J.HESSE, T.W.DAVIDSON, P.HUFTON.
AGARD Flight Test Manual, 1, Chapt. 4, 52pp., 4 refs., s.d.
The general basis of the analysis of jet aircraft performance is considered and the fundamentals of the data reduction procedures required for these aircraft are presented.

MN1/1/5 **Performance Reduction Methods for Turbo-Propeller Aircraft.** K.J.LUSH, J.K.MOAKES.
AGARD Flight Test Manual, 1, Chapt. 5, 26pp., 3 refs., s.d.
Reduction methods for level speed, climb and fuel consumption tests are presented, which are, in the absence of compressibility effects, suitable for use with turbo-propeller aircraft. The methods require individual treatment for particular engine installations, and are flexible at the expense of simplification.

MN1/1/6 **Data Reduction and Performance Test Methods for Reciprocating Engine Aircraft.** D.O.DOMMASCH.
AGARD Flight Test Manual, 1, Chapt. 6, 53pp., 5 refs., s.d.
Considers the power required and available in level flight, determination of maximum level flight airspeed, range and endurance testing, pilot technique in testing, instruments for level flight testing, climb and descent testing, measurement and correction of take-off and landing characteristics.

MN1/1/7 **Performance in Nonstabilized Flight Conditions.** A.BOISSON.
AGARD Flight Test Manual, 1, Chapt. 7, 54pp., s.d.
Presents new performance concepts, and describes the theory behind the measuring techniques and calculations applied to a large extent in France. Automatic processing equipment and electronic computers are practically essential for the analysis of the test results.

MN1/1/8 **Take-Off and Landing Performance: Pt.1. - Flight Test Analysis: Pt.2. - Theory.** F.E.DOUWES DEKKER (Pt.1), D.LEAN (Pt.2).
AGARD Flight Test Manual, 1, Chapt. 8, 43pp., 19 refs., s.d.
The basic principles of take-off and landing performance testing are presented. The object, means and accuracy of the measurements are discussed. The basic equations underlying the performance reduction methods are derived and explained.

MN1/1/9 **Special Tests.** D.O.DOMMASCH, W.E.GRAY, J.IDRAC, M.GUENOD, J.FOCH.
AGARD Flight Test Manual, 1, Chapt. 9, 24pp., 4 refs., s.d.
Brief comments are made on methods of flow visualization and its application to flight testing, calibration of an angle of attack measuring system, measurement of sideslip angle, airbrake evaluation.

MN1/1/10 **Performance Testing of Helicopters.** R.B.LIGHTFOOT.
AGARD Flight Test Manual, 1, Chapt. 10, 37pp., 29 refs., s.d.
Methods have been established to correlate power, gross weight, rotor speed, forward speed, altitude, and temperature by accounting for transmission efficiency, changes in profile drag and parasite drag with speed. The resulting agreement with the original aerodynamic analysis falls within the accuracy of flight test measurement.

MN1/1/11 **The Effect of the Ground on the Performance of a Helicopter.** I.C.CHEESEMAN, J.D.L.GREGORY.
AGARD Flight Test Manual, 1, Chapt. 11, 15pp., 7 refs., s.d.
An approximate analysis of estimating the performance of helicopters has been devised and compared with experiment. The theory has been extended to cover the case of tandem rotor helicopters and is being checked by flight tests. A brief description is included of the two principal methods of flight testing (i.e. at either constant weight or constant power).

MN1/1/12 **The Transition Performance of a Helicopter Following a Sudden Loss of Power.** I.C.CHEESEMAN, G.F.LANGDON.
AGARD Flight Test Manual, 1, Chapt. 12, 16pp., 7 refs., s.d.
Methods of estimating the performance of a helicopter following sudden loss of power have been made in order to gain some preliminary knowledge prior to flight trials, and also to compare different types. Flight test techniques are briefly outlined for single- and multi-rotor helicopters.

FLIGHT TEST MANUAL: VOLUME 2

MN1/2 **Flight Test Manual: Volume 2. - Stability and Control.** C.D.PERKINS (Editor).
AGARD Flight Test Manual, 2, Chapt. 1 to 14, 578pp., s.d.
This volume is divided into fourteen chapters dealing with various aspects of the appraisal of stability and control characteristics and flying qualities. Abstracts of the individual chapters are given in the succeeding items.

MN1/2/1 **Introduction.** C.D.PERKINS.
AGARD Flight Test Manual, 2, Chapt. 1, 12pp., s.d.
This introductory chapter to the subject of stability and control deals briefly with the historical aspects, dynamic and static stability, control power and control forces, trimming devices, stalling characteristics, spinning charateristics, high speed requirements, and flight research.

MN1/2/2 **Airplane Motions.** E.SECKEL.
AGARD Flight Test Manual, 2, Chapt. 2, 17pp., 12 refs., s.d.
The classical problem of aircraft dynamics is presented. The relation between the requirements of aircraft is discussed. The equations of motion of the aircraft are presented but not developed. The splitting of these equations into longitudinal and lateral phases is discussed, and solutions to these equations for the control-fixed and control-free modes are described. Modern trends in aircraft design, and their influence on the natural motions of the aircraft, are discussed in some detail.

MN1/2/3 **Static Longitudinal Stability and Control.** C.D.PERKINS.
AGARD Flight Test Manual, 2, Chapt. 3, 29pp., 10 refs., s.d.
Methods for conducting flight tests to determine both the stick-fixed and stick-free stability levels of the aircraft are presented. The concepts of the aircraft neutral points and manoeuvre points are discussed, and the data reduction processes required to establish these centre of gravity positions from flight test data are explained. The analysis of trim curves for by-products such as elevator power and stability criterion is explained. Methods for testing control limitations in take-off and landing are described, and tests for changes in trim due to variations in flaps and power settings are presented.

MN1/2/4 **Flight Testing Aircraft for Longitudinal Manoeuvering Characteristics.** H I.JOHNSON.
AGARD Flight Manual, 2, Chapt. 4, 31pp., 18 refs., s.d
The background of the development of aircraft flying qualities requirements is discussed, and those requirements dealing with the flying qualities of the aircraft in longitudinal manoeuvres are outlined. The concepts of stick-fixed and stick-free manoeuvre points are introduced, and analytical methods developed for predicting the steady longitudinal manoeuvering characteristics of aircraft in steady turns, steady pull-ups and wind-up turns. The instrumentation, flight test techniques and methods of data reduction required for the various manoeuvres are discussed.

MN1/2/5 **Lateral and Directional Control and the Measurement of Aerodynamic Coefficients in Steady Asymmetric Flight and in Flight on Asymmetric Power.** H.J.van der MAAS.
AGARD Flight Test Manual, 2, Chapt. 5, 49pp., 7 refs., s.d.
The flight test methods required for studying major stability and control parameters from equilibriums established on both symmetric and asymmetric flight paths are presented. The theory underlying these tests is also given Special tests for such non-linear control phenomena as rudder lock are suggested. Non-steady flight conditions, such as control recovery following a sudden engine failure, are also discussed. The methods by which most of the major lateral derivatives may be estimated through steady-state testing are also described.

MN1/2/6 **Flight Techniques Used to Determine Adequacy of Lateral Control.** P.A.HUNTER.
AGARD Flight Test Manual, 2, Chapt. 6, 45pp., 62 refs., s.d.
The typical basic requirements for aircraft lateral controls are outlined in some detail, as are the design factors bearing on these requirements. Typical aileron and spoiler systems, and current methods of balancing these controls are described. Finally, flight test techniques for measuring the response of the aircraft to its lateral controls are outlined, typical instrumentation for analysis of rolling manoeuvres discussed, and methods of data reduction presented in detail.

MN1/2/7 **Stalling and the Measurement of Maximum Lift.** D.LEAN.
AGARD Flight Test Manual, 2, Chapt. 7, 8pp., s.d.
The problem of low-speed stalling and the flight measurement of the maximum lift coefficient and minimum safe flying speed is considered. The various types of stalls are discussed, and the importance of drag increases at very high incidence is described. The behaviour of the aircraft pitching moments at stalling incidence is examined, and the behaviour of the aircraft at the stall, from the handling point of view, is discussed. Test methods for determining the maximum lift coefficient or minimum safe flying speed are presented, and finally, the effect of high lift devices on stalling behaviour is considered.

MN1/2/8/1 **Spinning: Pt.1. - General Principles of Spinning.** T.H.KERR.
AGARD Flight Test Manual, 2, Chapt. 8, Pt.1., 14pp., s.d.
The basic aerodynamic and dynamic phenomena involved in aircraft spinning are reviewed, and the important parameters discussed. The equations that demonstrate the various equilibriums in spinning manoeuvres are presented and the effect of major parameter variations discussed. Various types of spins, as well as the methods for spin recovery, are considered in some detail.

MN1/2/8/2 **Spinning: Pt.2. - Spin Flight Tests.** M.SHORR.
AGARD Flight Test Manual, 2, Chapt. 8, Pt.2., 20pp., s.d.
Outlines dynamic model testing for spinning characteristics and their correlation with full-scale data. Discusses safety-devices such as anti-spin chutes and their installation and briefly described the instrumentation required in actual spinning testing. Finally, describes the spin-testing methods, and methods for reducing the data, and presents these in useful graphical form.

MN1/2/9 **High Speed Stability and Control Problems.** M.J.ABZUG.
AGARD Flight Test Manual, 2, Chapt. 9, 36pp., 48 refs., s.d.
Some of the theory and techniques used by flight-test organizations in relation to the stability and control problems of high speed flight are described. Emphasis is placed on procedures followed in exploring the characteristics of prototype aircraft. Attention is directed to the problems experienced at high speeds by aircraft designed for transonic or supersonic operation. Attention is given to problems associated with irreversible controls, and with automatic flight-control system

MN1/2/10/1 **Dynamic Response Techniques.** W.O.BREUHAUS, L SEGEL.
AGARD Flight Test Manual, 2, Chapt. 10, Pt.1., 34pp., 39 refs., s.d.
A brief historical review of recent full-scale dynamic testing is first presented. This is followed by a discussion of response measurement flight testing, both transient and steady-state. Various flight test analysis techniques are then described. After a brief reference to non-stationary flow effects and so-called 'aeroelastic' effects, examples of results obtained in dynamic flight tests are presented.

MN1/2/10/2 **Stability-Derivative Determination From Flight Data.** C.H.WOLOWICZ, E.C.HOLLEMAN.
AGARD Flight Test Manual, 2, Chapt. 10, Pt.2., 56pp., 14 refs., s.d.
A comprehensive discussion of the various factors affecting the determination of stability and control derivatives from flight data is presented, based on the experience of the NASA High-Speed Flight Station. Factors relating to test techniques, determination of mass characteristics, instrumentation, and methods of analysis, are discussed.

MN1/2/11 **Measurement and Interpretation of Flight Test Data for Dynamic Stability and Control.** C.L.MUZZEY, E.A.KIDD.
AGARD Flight Test Manual, 2, Chapt. 11, 95pp., 34 refs., s.d.
Contents: Introduction: The conduct of flight tests; General instrument requirements; Instrument characteristics (rate gyro, vertical gyro, linear accelerometer, angular accelerometer, air-stream direction, differential pressure, control surface position, structural loads, signal channels, recording instruments); Interpretation of data (trace identification steady-state sinusoidal data, transient responses).

MN1/2/12 **Routine Handling Tests for Helicopters.** W.G.JENNINGS, D.A.WILKINSON.
AGARD Flight Test Manual, 2, Chapt. 12, 17pp., s.d.
The tests described are designed mainly to meet military requirements. The following aspects are considered: pre-flight tests, starting, run-up, taxiing, assessment of controls in flight, assessment of stability, night-flying and instrument flying, centre of gravity range and other envelope conditions, standards of acceptance.

MN1/2/13 **Study of the Handling Characteristics of Helicopters by Harmonic Methods.** F.L.LEGRAND, G.PETIT
AGARD Flight Test Manual, 2, Chapt. 13, 14pp., s.d.
Contents: Terminology; Statement of the problem; Theoretical study of the transfer function of a helicopter in hovering; Experimental determination of helicopter response characteristics; Introduction of a human pilot; Study of the closed-cycle helicopter plus pilot; Concluding remarks.

MN1/2/14 **A Survey of Flight Flutter Testing Techniques.** A.J.MARX.
AGARD Flight Test Manual, 2, Chapt. 14, 18pp., 7 refs., s.d.
Contents: Introduction; Definition and scope of flight flutter testing; General techniques for flight flutter testing; Methods of excitation (continuous harmonic excitation, transient excitation, specific aspects of excitation methods); Measuring and recording methods; Conclusions.

FLIGHT TEST MANUAL: VOLUME 3

MN1/3 **Flight Test Manual: Volume 3. - Instrumentation Catalog.** E.J.DURBIN, E.SECKEL, (Editors).
AGARD Flight Test Manual, 3, s.d.
This catalog is designed to be a guide to instrumentation equipment for flight testing, and contains performance data, illustrations organization submitting the information, manufacturer, and sometimes the cost of the instrument. It is divided into the following major categories: sensing devices, electromechanical indicators, recorders, radio-link systems, timing devices, electrical signal modifiers power supplies, ground tracking systems, calibration of equipment, data reduction aids, and miscellaneous. The catalog is amended from time-to-time.

FLIGHT TEST MANUAL: VOLUME 4

MN1/4 **Flight Test Manual: Volume 4. - Instrumentation Systems.** E.J.DURBIN (Editor).
AGARD Flight Test Manual, 4, 615pp., s.d.
Instrument systems are presented in a manner suitable for assimilation by non-specialists of electronics, particularly by those responsible for flight tests. The material is organised into four groups, the separate sections of which are noted in the following abstracts.

MN1/4/1/A **The Systems Concept in Planning Flight Test Instrumentation.** E.J.DURBIN.
AGARD Flight Test Manual, 4, Pt.1A., 8pp., s.d.
Discusses number of information channels; dynamic response; record form, system complexity; automatic data reduction; prerecording computation, accuracy, equipment, facilities and experience available.

MN1/4/1/B **The Functional Organization of the Component Parts of an Instrumentation System.** E.J.DURBIN.
AGARD Flight Test Manual, 4, Pt.1B., 12pp., s.d.
Components of a scheme are classified according to their functions within the system. Functional categories discussed are: physical quantity, sensing and transducing, signal modification, recording,

record processing, computing, interpretation. A block diagram is given of the interrelation of components in these categories.

MN1/4/2/A1 **Characteristics of Measuring Instruments.** J.IDRAC.
AGARD Flight Test Manual, 4, Pt.2 A1., 7pp., s.d.
An attempt is made to present background information which would facilitate the writing of the sections on sensing and transducing. A short review is given of the general principles of measurement, including the definition of each of the five most important characteristics of a measuring instrument: scale length, sensitivity, accuracy, speed of response, and 'finesse'.

MN1/4/2/A2 **Dynamic Response of Instrument Systems.** A.POOL.
AGARD Flight Test Manual, 4. Pt.2 A2., 13pp., 7 refs., s.d.
Attention is focused on the choice of the most suitable instrument for a particular measurement A theoretical treatment introduces concepts useful for this purpose, with emphasis on second-order instruments. Methods of measuring dynamic response characteristics are discussed.

MN1/4/2/A3 **Displacement Measurement as the Basis of Transducing Techniques.** A.POOL.
AGARD Flight Test Manual, 4. Pt.2 A3., 13pp., 4 refs., s.d.
The final phase of nearly every measurement is the recording of a displacement, therefore a survey is given of the generally used types of devices measuring displacement and their characteristics compared. These include mechanical transmission systems, optical systems, electrical transducers and electrical axes. There is a brief note on servo systems.

MN1/4/2/A4 **Temperature Sensing Techniques.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A4., 13pp., 15 refs., s.d.
Discusses: devices used in flight testing (resistance thermometers, thermocouples) and thermometer applications in flight testing; dynamic response of thermometers; calibration methods.

MN1/4/2/A5 **Pressure Sensing Techniques.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A5., 13pp., 23 refs., s.d.
Discusses: pressure-measuring devices; measurement of static and total pressures (sensing probes, position error); system response to pressure changes (instrument lags, response to fluctuations); methods of calibration.

MN1/4/2/A6 **Acceleration and Vibration Sensing Techniques.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A6., 13pp., 13 refs., s.d.
Relative and absolute vibration measurement; absolute vibration measurement in structures; instruments for measuring accelerations in aeronautics; statistical accelerometers for fatigue research; angular accelerometers; calibration methods.

MN1/4/2/A7 **Force and Strain Sensing Techniques.** N.Y.ANDERSEN.
AGARD Flight Test Manual, 4, Pt.2 A7., 33pp., 21 refs., s.d.
Considers mainly the use of electrical resistance strain gauges for measuring aircraft loads and stresses. For bonded gauges, bonded to the test structure, the author discusses methods of bonding, configurations of gauges, auxiliary electrical components (collectors, bridges, summation amplifiers), and limitations in application. Unbonded strain gauges are used for measuring gross deflections or incorporation in other instruments, such as pressure gauges, accelerometers. Material characteristics of different resistance gauges are tabulated.

MN1/4/2/A8 **Attitude Sensing Techniques.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A8., 12pp., 9 refs., s.d.
Discusses the measurement of angular position and angular velocity of an aircraft with respect to the Earth, including the measurement of aircraft heading, pitch and roll angles. These concepts are defined and optical, gravitational, magnetic and gyroscopic instruments used for measurement described.

MN1/4/2/A9 **Fluid Flow Sensing Techniques.** J.GREY.
AGARD Flight Test Manual, 4, Pt.2 A9., 21pp., 19 refs., s.d.
Flow measurement may be based on the principle of Bernoulli, velocity measurement, or direct measurement of mass flow. Instruments based on these principles include the rotameter, turbometers, electromagnetic flowmeter, sonic velocity flowmeter, transverse and axial flow momentum meters. Characteristics of these are described and appropriate fields of application indicated.

MN1/4/2/A10 **Atmospheric Water Vapor and Icing Sensing Techniques.** K.G.PETTIT.
AGARD Flight Test Manual, 4, Pt.2 A10., 18pp., 39 refs., s.d.
Quantities involved, their definitions, and difficulties of measuring them are described. Techniques described for measuring water vapor content, free water content, and for detecting ice, are related to airborne instruments. These instruments and their calibration are discussed.

MN1/4/2/A11 **Airflow Direction Sensing.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A11., 7pp., 15 refs., s.d.
Discusses the measurement of angles of incidence and yaw, using a boom-mounted probe on the aircraft nose or wing. Vane-type, aerodynamic and pressure-servo probes are described, together with calibration and method of use. Visualization techniques to assess flow quantity are briefly described.

MN1/4/2/A12 **Tachometry.** A.POOL.
AGARD Flight Test Manual, 4, Pt.2 A12., 2pp., 1 ref., s.d.
Briefly describes the principles of continuous- and intermittent-operation tachometers. For aircraft, the former are usually in the form of a d.c. generator whose electrical output is a measure of the rotation speed. Drag-cup, eddy current tachometers are used generally for measuring engine r.p.m. Intermittent instruments measure the revolutions over a mechanically or electrically timed period, giving the mean value for the period.

MN1/4/2/A13 **The Techniques for Sensing Combustible Gases and Vapours.** I.E.SMITH.
AGARD Flight Test Manual, 4, Pt.2 A13., 16pp., 30 refs., s.d.
The detection of combustible gases and vapours is an essential prerequisite to safety against aircraft fires. The author discusses the limits of inflammability, their determination and correlation; sensing and transducing inflammable gases; the nature of catalyzed combustion and catalytic poisoning; detection by using heated resistance filaments; and temperature and pressure compensation of detection cells.

MN1/4/2/A14 **Techniques for Making Instrumentation Equipment and Installation in Airplanes Safe in the Presence of Combustible Atmospheres.** B.F.HAGER, W.H.HALL.
AGARD Flight Test Manual, 4, Pt.2 A14., 14pp., 4 refs., s.d.
Four categories of an instrumentation system are discussed: pick-up device, circuit wiring, commuting or signal selecting equipment, basic recording or observation unit. Potential hazards of components in these are considered and the hazard characteristics of fuel mixtures described. Methods of testing and protecting components are then discussed, with examples given for specific items.

MN1/4/2/A15 **Thrust Sensing and Transducing Techniques.** W.B.BRIGGS.
AGARD Flight Test Manual, 4, Pt.2 A15., 26pp., 13 refs., s.d.
Sensing of gross, nett, and effective thrust for flight evaluation of an aircraft and the presentation of engine in-flight performance to the pilot are examined. Internal aerodynamic instrumentation is specified to sense thrust as a check on data from the engine performance curves and a step-wise calculation method is presented. Problems of thrust measurement on a podded engine are discussed and various 'thrustmeter' principles examined together with possible bases for improved cockpit thrust indicators.

MN1/4/2/B **Signal Modifiers.** G.E.BENNETT.
AGARD Flight Test Manual, 4, Pt.2 B., 36pp., 30 refs., s.d.
A general account is given of the principles underlying the following operations: conversion of transducer outputs, combination of outputs from multiple transducers, amplification, removal of unwanted frequencies, extension of the transducer frequency range, deviation change rates and time integrals. Techniques and types of instruments available for assessing the instruments listed in Vol.3 of this Manual are given.

MN1/4/2/C1 **Telemetry.** C.A.TAYLOR.
AGARD Flight Test Manual, 4, Pt.2 C1., 19pp., 35 refs., s.d.
Discusses: flight test applications of radio telemetering; analyses of telemetering systems, including frequency division, time division, high capacity and pulse-code modulation systems; typical applications and operational problems.

MN1/4/2/C2 **French Telemetering Systems.** J.DESPORTES.
AGARD Flight Test Manual, 4, Pt.2 C2., 17pp., s.d.
Describes the O.N.E.R.A., S.F.E.N.A., Turck, and D.E.F.A.APX telemeter systems, also the O.N.E.R.A. large bandwidth telemeter and the Sexta remote control equipment.

MN1/4/2/D **Recorders.** A.TOUDIC, B.GALONKA, G.PETIT, A.BOTREL.
AGARD Flight Test Manual, 4, Pt.2 D., 49pp., s.d.
Describes: graphic methods (media, papers, oscillographs); photographic methods (spot tracing, dial or CRT images, density blackening); electrical methods (magnetic tape); semi-recorders (counters and 'memory' devices). Principles, mechanical construction and examples of machines and records are given.

MN1/4/2/E **Ground Tracking Systems for Determining Position and Velocity.** H.J.KEYES.
AGARD Flight Test Manual, 4, Pt.2 E., 27pp., 23 refs., s.d.
Discusses: direct timing methods (stopwatch, electrical, and electromechanical); photographic methods (take-off, and long-range cameras); radio methods.

MN1/4/2/E2 **Test Range Tracking Systems (Excluding Radar).** V.L.MILLER.
AGARD Test Manual, 4, Pt.2 E2., 15pp., 1961.
In the early 1940's when the U.S.A. first had need to track missiles, there were several systems available which were partially effective. Since that time, about forty systems have come into operation. Here, the basis of these systems is described.

MN1/4/2/E3 **Pulse Radar for Trajectory Instrumentation.** D.K.BARTON, S.M.SHERMAN.
AGARD Flight Test Manual, 4, Pt.2 E3., 26pp., 1961.
Summarizes the capabilities and applications of surface-based instrumentation radars, and indicates present and future applications for which further radar improvements are needed or for which other system configurations may be better suited.

MN1/4/3/A **Introduction to Data Reduction Systems.** J.J.DOVER, J.RIDLEY.
AGARD Flight Test Manual, 4, Pt.3 A., 21pp., 14 refs., s.d.
After describing the basic precepts in data reduction and differentiating it from data handling, the author discusses the different forms of digital and analogue computers and illustrates the latter by sample analogue problems.

MN1/4/3/B **The Role of the Digital Computer in Aeronautical Research and Development.** F.S.ACTON.
AGARD Flight Test Manual, 4, Pt.3 B., 17pp., 5 refs., s.d.
Discusses the general state-of-the-art and then in non-specialist terms describes the functions of computers, their potentialities, limitations, programming principles and the quality of personnel required for their efficient use. Brief general data is given for some commercial machines.

MN1/4/4/A **Systematic Errors.** E.SECKEL.
AGARD Flight Test Manual, 4, Pt.4 A., 8pp., s.d.
Errors in flight test measurements may be static or dynamic, systematic or random. Static errors include those of resolution, instability, distortion, friction, back-lash, interference, hysteresis. Examples of dynamic errors are in time lag, derivative method, frequency response. Effects of these and their possible remedy are discussed.

MN1/4/4/B **Aliasing Errors in Sampled Data Systems.** A.J.MALLINCKRODT.
AGARD Flight Test Manual, 4, Pt.4 B., 11pp., 1961.

MN1/4/4/C **Power Spectral Methods of Analysis and Their Application to Problems in Airplane Dynamics.** H.PRESS, J.W.TUKEY.
AGARD Flight Test Manual, 4, Pt.4 C., 41pp., 34 refs., s.d.
Discusses: response determination for arbitrary disturbances (use of Fourier methods); random processes, types and treatment; measurement of power spectra; applications of these techniques and processes (turbulence, buffeting, wing loadings). Three Appendices describe the determination of power spectra, numerically, by analogue, and by assessment.

AIRCRAFT ACCIDENT INVESTIGATION MANUAL FOR AIR SURGEONS

MN2 **Aircraft Accident Investigation Manual for Air Surgeons.** P.BERGERET (Editor).
AD-272-690 AGARD Publ. 'Aircraft Accident Investigation Manual for Air Surgeons,' 113pp., 31 refs., 1961.
N62-10111 It is the purpose of this manual to outline a common approach in the investigation of aircraft accidents for air surgeons in the field. It presents classification details of accidents and their causes, injuries, and aircraft damage. Details are given of accident investigation, etiological considerations in human failure, aircraft accident pathology and medical prevention. Specimen reports are given in Appendices together with tables of factors affecting accidents.

FATIGUE TESTING AND ANALYSIS OF RESULTS

MN3 **Fatigue Testing and Analysis of Results.** W.WEIBULL (Editor).
AD-253-703 AGARD Publ. 'Fatigue Testing and Analysis of Results,' 305pp., 1961.
Chapter contents are: Symbols and nomenclature; Fatigue testing methods; Fatigue testing machines and equipment; Instruments and measuring devices; Test pieces - design, preparation, measurement and protection; Factors affecting test results; Planning of test programmes; Presentation of results; Analysis of results. Extensive bibliography.

EXPERIMENTAL METHODS IN COMBUSTION RESEARCH

MN4
AD-268-110
N69-80557

Experimental Methods in Combustion Research. J.SURUGUE (Editor).
AGARD Publ. 'Experimental Methods in Combustion Research,' 314pp., 459 refs., 1961.
This loose-leaf volume comprises eleven papers which deal with measuring methods for fundamental data in combustion research, and research techniques. Abstracts of the individual papers are given in the succeeding items.

MN4/1

Temperature Measurement in Combustion Phenomena. (In French). A.MOUTET.
AGARD Publ. 'Experimental Methods in Combustion Research,' 37pp., 32 refs., 1961.
Methods using probes immersed in the flow are briefly described. Attention is then concentrated on optical methods particularly those having a short response time.

MN4/2

Measurement of Velocity and Rate of Flow Applied to the Study of Combustion. (In French). F.LE BOUC.
AGARD Publ. 'Experimental Methods in Combustion Research,' 28pp., 34 refs., 1961.
This critical review of the methods available to the experimentalist enables appropriate measurement techniques to be selected, depending upon the nature of the fluid, its velocity, chemical properties, and the scale of the experimental apparatus. Sections are devoted to the measurement of the velocity of air in a cylindrical conduit, and measurement of the rate of flow of gases and of liquids.

MN4/3

Experimental Determination of Local Concentrations in Flames. R.M.FRISTROM.
AGARD Publ. 'Experimental Methods in Combustion Research,' 31pp., 69 refs., 1961.
Describes techniques which yield composition data susceptible to numerical analysis, and includes the experimental study of premixed, laminar, and one-dimensional flames. The description includes details of microprobe design and construction which are essential in the successful study of flames.

MN4/4

The Energy Balance in the Combustion Process. A.SMEETON LEAH.
AGARD Publ. 'Experimental Methods in Combustion Research,' 19pp., 27 refs., 1961.
Energy balance drawn up for any instant of time during the overall process of combustion of an inflammable mixture should completely account for all the potential chemical energy of the mixture. This report surveys the various detailed research procedures that have been used.

MN4/5

Modern Methods of High-Speed Photography. J.S.COURTNEY-PRATT.
AGARD Publ. 'Experimental Methods in Combustion Research,' 23pp., 142 refs., 1961.
Discusses the quality of the pictures and apparatus for obtaining streak records, single exposures, multiple exposures with displacement of the frames, a series of separate pictures, and image dissection. The difficulties of synchronizing and lighting are stressed.

MN4/6

Instrumentation for the Study of Free-Radicals. G.J.MINKOFF.
AGARD Publ. 'Experimental Methods in Combustion Research,' 22pp., 74 refs., 1961.
The reasons why the aircraft combustion engineer should make use of free radicals in his studies are outlined. High-flame temperatures, high rates of heat release, and high altitude flight mean that the part played by free atoms and radicals can no longer be ignored. The paper includes the method of formation, and detection and study of their properties.

MN4/7

Measurement of the Intensity and of the Efficiency of Combustion. (In French). J.FRUCTUS.
AGARD Publ. 'Experimental Methods in Combustion Research,' 28pp., 17 refs., 1961.
Generalities; intensity of combustion (definition, application to 'real' combustion); efficiency of combustion (definition, efficacy and efficiency of combustion, efficiency deduced from the analysis of combustion gases, indices of the quality of combustion); instrumentation (generalities, measurement of rate of flow and pressure, temperature measurement, analysis of combustion gases); results (efficiency of combustion, intensity of combustion).

MN4/8

Experimental Study of Laminar Flames. J.BARR, B.E.L.DECKKER.
AGARD Publ. 'Experimental Methods in Combustion Research,' 13pp., 11 refs., 1961.
A review of experimental methods which is largly based upon the experience of the authors in the study of enclosed cylindrical laminar diffusion flames, and rectangular laminar premixed flames.

MN4/9

The Flat Flame Burner. J.POWLING.
AGARD Publ. 'Experimental Methods in Combustion Research,' 7pp., 10 refs., 1961.
The flat flame burner was designed to provide a practical approach to the ideal condition for the study of laminar flame propagation. Its construction, which is clearly illustrated, simplifies the measurement of burning velocity and temperature distribution in flames, the determination of limits of inflammability, the study of cool flames and spectroscopic studies of flames.

MN4/10 **Model Tests of Combustion in Liquid Propellant Rockets.** (In French). M.BARRÈRE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 60pp., 89 refs., 1961.
Experimental technique applied to the study of combustion in liquid propellant rocket motors are classified and described under two main headings: experimental methods for stationary régimes (study of the energy lierated by combustion, study of the evolution of combustion) and for non-stationary flows (the onset of combustion, experimental apparatus for the study of combustion instabilities, development of combustion).

MN4/11 **Experimental Methods Applied to the Study of the Combustion of Solid Propellants.** (In French). P.TAVERNIER, J.BOISSON.
AGARD Publ. 'Experimental Methods in Combustion Research,' 24pp., 54 refs., 1961.
The importance of future progress in the method of investigation of the combustion zone and of the kinetics of chemical reactions is stressed; some results for the selection of additives for increasing the propellant performance are given, the origins of the chemical reaction disturbances are described, and valuable information for the production of stable combustion processes is furnished.

MN4/12 **Burner and Soap Bubble Methods (of Determining Flame Propagation Velocity).** (In French). P.LAFITTE.
AGARD Publ. 'Experimental Methods in Combustion Research, 19pp., 68 refs., s.d.
The problem of measuring laminar flame velocity is first discussed. The development of recent methods is then described. The Bunsen burner method, the plate-flame method of Powling, and the soap bubble method are then treated.

MN4/13 **Spherical Bomb and Tube Methods (of Determining Flame Propagation Velocity). General Review of Results.** (In French), J.COMBOURIEU.
AGARD Publ. 'Experimental Methods in Combustion Research,' 30pp., 47 refs., s.d.
The latest spherical bomb and tube techniques are described, and a comparative study of different techniques for the measurement of flame velocity is then presented.

MN4/14 **Experimental Techniques for Pressure Measurement.** (In French). A.MESTRE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 18pp., 22 refs., s.d.
Pressure measurements are essential for the analysis of combustion chamber operation. The techniques described provide an outline of the variety of instrumentation used in conjunction with each of the specific requirements: pressure gauges providing direct readings (liquid or membrane gauges) for slowly varying pressures; variable potentiometer gauges for frequencies below 100 c/s, strain gauges for frequencies between 100 and 1,000 c/s, and variable capacity gauges for higher frequencies.

MN4/15 **Some Simple Techniques for the Performance Evaluation of Gas Turbine Combustion Systems.** A.H.LEFEBVRE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 17pp., 9 refs., s.d.
Describes briefly the principles of "pressure scaling" (PD scaling), and the "water injection" technique. Advantages and disadvantages of the methods are discussed and their application to various combustion problems are given. Modifications to the theory to allow both velocity and temperature to be included as variables are included. The practical value is shown to reduce the amount of low pressure testing required to evaluate any new combustion system, and in performance comparisons of combustor designs.

MN4/16 **Methods of Flow Visualization by means of Water.** A.J.GERRARD.
AGARD Publ. 'Experimental Methods in Combustion Research,' 21pp., 7 refs., s.d.
The use of transparent models for observing flow patterns is now recognised as being an essential service to combustion research and development engineers. Information from such models proves or disproves theoretical hypotheses and contributes to design data. The techniques and principles of the method are described together with details of laboratory equipment, and application of the techniques to study flow patterns in gas turbine combustors.

MN4/17 **The Shock Tube Technique Applied to the Study of Combustion.** F.SCHULTZ-GRUNOW, G.ADOMEIT.
AGARD Publ. 'Experimental Methods in Combustion Research,' 15pp., 48 refs., s.d.
Information on the conventional shock tube and shock tube flow is followed by details of interesting prospects to which the shock tube can be applied in combustion research. These are studies on reaction and reaction rates, ignition, and ignition delay in hydrocarbons, and problems concerning shock wave-flame interaction including development of detonation.

MN4/18 **Jet Engine Combustion Chamber Models.** E.C.WOODWARD, Jr.
AGARD Publ. 'Experimental Methods in Combustion Research,' 17pp., 32 refs., s.d.
This presentation is intended to describe to technicians and engineers new to the subject a few of the experimental technological procedures used in the laboratory for the study of combustion in

the chambers of jet engines. Some specific models are discussed in detail, among which are the spherical reactor model and the spherical dome combustor model. One novel approach briefly mentioned includes the simulation of low pressure combustion through the use of water as a fuel dilution agent.

MN4/19 **Turbulent Flames.** F.A.WILLIAMS.
Agard Publ. 'Experimental Methods in Combustion Research,' 16pp., 84 refs., s.d.
Classical techniques which have been used to measure flame speeds and other gross properties are reviewed. Novel experimental methods and their results are discussed, where emphasis is mainly directed toward the fluctuations. Finally, the implications of existing experimental results concerning present theories of turbulent flame propagation are analyzed.

MN4/20 **Detonations (Experimental Methods).** H.G.WAGNER.
AGARD Publ. 'Experimental Methods in Combustion Research,' 47pp., 63 refs., s.d.
Specifications and methods are given for the construction of a detonation tube. These include the actual manufacture, preparation of the mixtures, and methods of initiation of the detonation. Methods of determining detonation velocity as well as photographic and schlieren procedures are described. The paper concludes with methods of measuring different properties of detonation such as pressure, temperature, density, absorption and emission spectra, limits of detonation, curvature of the front, initiation, and ionization.

MN4/21 **Study of Fuel Injection in Air Breathing Combustion Chambers.** H.CLARE, J.A.GARDINER, M.C.NEALE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 16pp., 8 refs., s.d.
In a gas turbine swirl atomizer distribution is mainly a matter of producing the most suitable sheath cone angle by adjusting the geometry of the atomizer design. Fuel metering characteristics are obtained by scaling the design giving the optimum spray cone. Spray quality depends on low distribution and metering requirements have been met. It is shown here how these characteristics are controlled by testing and sampling.

MN4/22 **Study of Injection in the Combustion Chambers of Liquid Propellant Rocket Motors.** (In French). J.CORBEAU.
AGARD Publ. 'Experimental Methods in Combustion Research,' 20pp., 17 refs., s.d.
In outlining research and test procedures for liquid propellant rocket injectors, the following are treated: flow in the injectors; flow at the exit of the injector and at the atomizer; distribution of the fuel and of the oxidizer.

MN4/23 **Combustion in the Hybrid Rocket Motor.** M.C.HARDIN.
AGARD Publ. 'Experimental Methods in Combustion Research,' 8pp., 14 refs., s.d.
A brief history of these rockets and a statement of their inherent advantages is followed by a review of types, the rôle of the injector, fuel grain experimental techniques and data analysis.

MN4/24 **Heat Transfer in Chambers.** D.REEVES.
AGARD Publ. 'Experimental Methods in Combustion Research,' 25pp., 13 refs., s.d.
Deals with experiments on heat exchange in ramjet and gas turbine chambers where flames or hot gases are contained within sheet metal walls. Application to the jet pipe and nozzles of gas turbines and ramjets is also noted. A method is proposed by which the convective heat transfer coefficient can be extracted analytically from the measurements of total heat flux yielded by a thermoelectric heat meter.

MN4/25 **Heat Transfer in Rocket Thrust Chambers.** H.ZIEBLAND.
AGARD Publ. 'Experimental Methods in Combustion Research,' 16pp., 14 refs., s.d.
Presents a selection of methods which have been successfully applied to the study of this problem on liquid rockets. They include continuous flow calorimetry, thermoelectric heat flux, thermal capacitance transient state techniques, methods for radiative heat transfer, and the use of thermal paints.

MN4/26 **Heat Transfer Phenomena in Rocket Engines.** H.WOLF.
AGARD Publ. 'Experimental Methods in Combustion Research,' 29pp., 77 refs., s.d.
The successful operation of large liquid rocket engines is greatly dependent upon the correct prediction of the amount of energy dissipated at the walls and upon the provision made for absorption there. For this reason the paper discusses (i) experimental methods of determining the energy transfer from hot combustion gases to the chamber walls and (ii) means for absorbing this energy. Some general remarks are made regarding the phenomena involved to serve as a help to understand the material within the paper.

MN4/27 **Measurement of Ignition Delays.** (In French). L.NADAUD, M.PUGIBET.
AGARD Publ. 'Experimental Methods in Combustion Research,' 20pp., 16 refs., s.d.
After defining ignition dealy, the different methods which have been developed for determining it, both in the laboratory and in propulsion units are described, The advantages and disadvantages of the methods are discussed. Only the ignition delays of hypergolic propellants are considered.

MN4/28 **Stability Limits in the Combustion Chambers of Jet Engines.** (In French). R.DUBARRY-BARBE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 24pp., 8 refs., s.d.
The following factors which affect flame stabilization in air-breathing jet engines are discussed: aerodynamic and thermodynamic factors, speed at entry into the combustion chamber, temperature pressure, fuel injection, dimensions of the chamber, type of fuel. Methods for determining these stability limits are then described.

MN4/29 **Combustion Instability in Liquid Propellant Rocket Motors.** L.CROCCO, D.T.HARRJE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 23pp., 31 refs., s.d.
Experimental procedures for the study of unstable combustion in these motors are reviewed. These have been directed towards identifying the phenomena, detecting the tendency towards unstable combustion in rockets which have not yet exhibited it, predicting its likelihood in the design phase, and studying its general behaviour and its causes. The experimental methods depend substantially on the type of instability and therefore a few words are devoted to low-frequency, high-frequency, and intermediate-frequency types. Comments on general combustion instrumentation is limited to recent innovations and specialized applications.

MN4/30 **Experimental Measurements in Solid Propellant Rocket Combustion Instability.** E.W.PRICE.
AGARD Publ. 'Experimental Methods in Combustion Research,' 22pp., 39 refs., s.d.
A review of systems for studying combustion instability has led to the following conclusions: (i) experimental research on the instability on solid propellant rockets has consisted almost exclusively of high speed pressure measurements in rockets and special combustors; (ii) the complexity of the acoustic situation is usually too great for ready interpretation of test results, but development of special combustors has led to substantial advances in research; (iii) direct observations of flame in the combustion zone continue to be difficult; (iv) the majority of data obtained has resulted from observation of acoustic behaviour, under test conditions designed to permit interpretation in terms of combustion behaviour.

MN4/31 **Experimentation at Simulated Altitude of the Ejection of Gases.** (In French). P.LACHAUME.
AGARD Publ. 'Experimental Methods in Combustion Research,' 26pp., 3 refs., s.d.
Describes the experimental methods and arrangements used in France at the Centre d'Essais des Propulseurs to determine turbojet performances at simulated altitude. Indicates applications outside this specific field (e.g. studies and testing of components and complete chambers at atmospheric pressure or at low pressure).

MANUAL ON AEROELASTICITY: VOLUMES 1 TO 6

MN5 **Manual on Aeroelasticity: Volumes 1 to 6.** W.P.JONES (Editor).
AGARD Manual on Aeroelasticity, 1 to 6.
The six volumes deal with structural and aerodynamic aspects, prediction of aeroelastic phenomena, experimental methods, factual information on flutter characteristics and collected tables and graphs.

MANUAL ON AEROELASTICITY: VOLUME 1

MN5/1 **Manual on Aeroelasticity: Volume 1. - Structural Aspects.**
AD-263-432 AGARD Manual on Aeroelasticity, 1, 384pp., s.d.
AD-850-668 Rev. After an introductory survey, seven chapters deal with structural deformations, vibrations, damping, testing, influence of powered controls, structural non-linearities and thermoelasticity. Abstracts
N64-13552 of the survey and the individual chapters are given in the succeeding items.

MN5/1/1 **Introductory Survey.** W.J.DUNCAN.
AGARD Manual on Aeroelasticity, 1, 51pp., 42 refs., s.d.
In this introductory survey of the problems of aeroelasticity, the following topics are considered: dynamical variables and equations of motion; representation of the structure; representation of the aerodynamic forces; methods for solving the dynamical equations; stability and stability criteria; classification of aeroelastic phenomena; divergence; reversal of control; flutter; influence of aeroelasticity on general stability, control and response; impulsive loading; buffeting and noise, kinetic heating; experimental methods and the use of models; some practical aspects of aeroelasticity; notes on the early history of aeroelasticity.

MN5/1/2 **Analytical Representation of the Deformation of Structures.** W.S.HEMP.
AGARD Manual on Aeroelasticity, 1, Chapt. 1, 20pp., 3 refs., s.d.
To arrive at the calculation procedure the following items are discussed: reference axes, components of displacement and rotation, specification of deformation, assumptions for special problems, strain components calculation, formulae for strain energy, application of the principle of virtual work, and an example of a non-swept wing.

MN5/1/3 **Vibration Analysis of Aircraft Structures.** J.M.HEDGEPETH.
AGARD Manual on Aeroelasticity, 1, Chapt. 2, 17pp., 27 refs., s.d.
The author discusses three classes of problems for determining vibration modes and frequencies of continuous structures. They are the variational approach, the influence-coefficient approach, and methods using both continuum and discrete techniques. Some remarks are made on secondary effects, comparison with experiments and vibrations of thin shells.

MN5/1/4 **Influence of Internal Damping on Aircraft Resonance.** B.M.FRAEIJS LE VEUBEKE.
AGARD Manual on Aeroelasticity, 1, Chapt. 3, 38pp., 14 refs., s.d.
It is suggested that a Maxwell model, involving a single 'hidden' co-ordinate, provides a satisfactory type of viscoelastic damping. Here, the transient behaviour is fully described by a hereditary function which is discussed in the first part of this chapter. The second and third parts deal with the analysis of resonance in the presence of hereditary, structural and simple viscous damping, and resonance in many degrees of freedom with the help of matrix formulation.

MN5/1/5/A **Theory of Ground Vibration Testing. Sect. A: - Vibration Testing by Harmonic Excitation.** H.GAUZY.
AGARD Manual on Aeroelasticity, 1, Chapt, 4, Sect. A., 21pp., 12 refs., s.d.
Two methods are mentioned which circumvent the difficulties raised by the interpretation of results of vibration tests carried out on a non-linear structure. The first consists in effecting the frequency sweep (resonance curve) at constant amplitude. The second method is based on the experimental fact that the motion of a structure subjected to harmonic excitation always eventually becomes periodic.

MN5/1/5/B **Theory of Ground Vibration Testing. Sect. B: - Vibration Testing by Transient Excitation.** S.COUPRY.
AGARD Manual on Aeroelasticity, 1, Chapt. 4, Sect. B., 20pp., 7 refs., s.d.
A method has been developed in connection with flight flutter tests which is based upon impact or sudden release. The paper considers the mathematical nature of the problems posed, and specific problems of excitation, recording and interpretation.

MN5/1/5/C **Theory of Ground Vibration Testing. Sect. C: - Problems Peculiar to Control Surfaces.** G.BEATRIX.
AGARD Manual on Aeroelasticity, 1, Chapt. 4, Sect. C., 8pp., 5 refs., s.d.
Several reasons for the instability of movable control surfaces which cause failure due to flutter, are outlined. Two definitions are then given which seem to be the most logical and best adapted to structural problems. Configurations considered for ground testing include both aircraft with manual control and with power controls.

MN5/1/5/D **Theory of Ground Vibration Testing. Sect. D: - General Remarks on the Problem of Suspension.** J.LECLERC.
AGARD Manual on Aeroelasticity, 1, Chapt. 4, Sect. D., 23pp., 7 refs., s.d.
Deals with the representation of suspension effects on the resonance modes of a structure: suspension effects on shapes and generalized masses when k is very large; additional damping introduced by suspension devices; the significance of ϵ_i and expressions for it, determination of the principal moments of inertia, and of the normal modes for suspension modes. Suspension by rubber cords is concluded as being the most directly usable method.

MN5/1/5/E **Theory of Ground Vibration Testing. Sect. E: - Problems Peculiar to Small Models and Compressor Blades.** R.DAT.
AGARD Manual on Aeroelasticity, 1, Chapt. 4, Sect. E., 15pp., 5 refs., s.d.
It is shown how one may allow for the presence of a mass or a stiffness on a structure. A theoretical justification is then given for some methods which enable the natural vibration modes of a model to be determined experimentally with the minimum amount of perturbation.

MN5/1/6 **The Influence of Powered Controls.** D.BENUN.
AGARD Manual on Aeroelasticity, 1, Chapt. 5, 46pp., 1 ref., s.d.
The inclusion of a powered control system in an airframe can influence its dynamic characteristics and make their prediction by analysis more difficult due to one or both of the following: (i) differences between restraint characteristics of powered and manual systems, and (ii) the existence

of possible couplings between the powered control surface and airframe motions due to the actions of sensing devices and structural deformations. Various aspects of (i) and (ii) are covered in this Chapter.

MN5/1/7 **Structural Non-Linearities.** D.L.WOODCOCK.
AGARD Manual on Aeroelasticity, 1, Chapt. 6, 55pp., 37 refs., s.d.
A survey is made of methods available for the solution of non-linear dynamical problems. Consideration is given to several possible types of structural non-linearities and the way in which they may modify flutter characteristics of an aircraft.

MN5/1/8 **Thermoelasticity.** R.L.BISPLINGHOFF.
AGARD Manual on Aeroelasticity, 1, Chapt. 7, 49pp., 10 refs., s.d.
Considers the elementary notions of thermoelasticity, the equations of three-dimensional thermoelasticity, thermal stress and distortion, variational principles, plate problems, and stiffness and vibration frequencies of shell structures at elevated temperature.

MANUAL ON AEROELASTICITY: VOLUME 2

MN5/2
AD-274-097
AD-850-695 Rev.
N62-10906 **Manual on Aeroelasticity: Volume 2. - Aerodynamic Aspects.**
AGARD Manual on Aeroelasticity, 2, Chapt. 1 to 11, s.d.
This volume includes eleven chapters dealing with various aerodynamic aspects of aeroelasticity. Abstracts of the individual chapters are given in the succeeding items.

MN5/2/1 **General Introduction.** I.E.GARRICK.
AGARD Manual on Aeroelasticity, 2, Chapt. 1, 26pp., 15 refs., s.d.
This is an outline of history and development of the aerodynamics of aeroelasticity, and includes concepts of importance indicating relationships to various phases of aeroelasticity.

MN5/2/2 **Two-Dimensional Linearized Theory.** A.I.van de VOOREN.
AGARD Manual on Aeroelasticity, 2, Chapt. 2, 46pp., 42 refs., s.d.
Deals with the linearized theory of the oscillating aerofoil of infinite span and with the results obtained from that theory. The theory and exact solutions, valid for different speed ranges, which have been obtained during the past thirty years are reviewed. Asymptotic solutions, which are believed to be new, are given for two cases of flow below Mach 1 which have not been adequately covered previously.

MN5/2/3 **Three-Dimensional Subsonic Theory.** D.E.WILLIAMS.
AGARD Manual on Aeroelasticity, 2, Chapt. 3, 48pp., 26 refs., s.d.
Methods used in this flutter derivatives theory are given which should provide a basis for reading specific papers on the subject. Proofs are given for the basic integral equation, and analytical and numerical solutions of the integral equation are derived.

MN5/2/4 **Three-Dimensional Sonic Theory.** D.E.DAVIES.
AGARD Manual on Aeroelasticity, 2, Chapt. 4, 120pp., 23 refs., s.d.
Deals with the basic equations, numerical solutions using lifting-surface theory, the rectangular wing of large aspect ratio, low aspect ratio pointed and rectangular wings, and the slender wing-body combination.

MN5/2/5 **Three-Dimensional Supersonic Theory.** C.E.WATKINS.
AGARD Manual on Aeroelasticity, 2, Chapt. 5, 60pp., 42 refs., s.d.
Presentation of the completely linearized boundary value problem from which aerodynamic forces are to be determined; flutter equations that indicate the forms in which these forces might be desired; three integral formulations of the boundary value problem; and discussions of known solutions and approximate solutions to boundary value problems.

MN5/2/6 **Indicial Aerodynamics.** H.LOMAX.
ACARD Manual on Aeroelasticity, 2, Chapt. 6, 58pp., 44 refs., s.d.
Presents the subsonic, two-dimensional, indicial responses on which a strip theory is based for the study of twisting and bending. An adaptation of the indicial functions to arbitrary motions is given together with the functions for two- and three-dimensional wings. A principal application of indicial responses is to gust loading and alleviation; this is discussed.

MN5/2/7 **Slender Body Theory.** D.L.WOODCOCK.
AGARD Manual on Aeroelasticity, 2, Chapt. 7, 62pp., 13 refs., s.d.
Formulation of the problem; approximations; slender wing and high-frequency very slender wing; high-frequency slender and quasi-slender wings; slender body of revolution; slender wing-body combinations.

MN5/2/8 **Non-Stationary Theory of Airfoils of Finite Thickness in Incompressible Flow.** H.G.KÜSSNER.
AGARD Manual on Aeroelasticity, 2, Chapt. 8, 43pp., 15 refs., s.d.
A survey is made of the main forms of unsteady profile theory. The author then considers non-stationary theory of the flow around aerofoils by conformal transformation, application of the theory to oscillating symmetric aerofoils, and adaptation of the theory to measurements.

MN5/2/9 **Thickness and Boundary Layer Effects.** H.ASHLEY, G.ZARTARIAN.
AGARD Manual on Aeroelasticity, 2, Chapt. 9, 53pp., 78 refs., s.d.
Discusses lifting surfaces in unsteady motion (two- and three-dimensional) at low supersonic speed and upwards. A review is given of available information on non-linear inviscid flow over bodies at high speeds, and finally the unsteady boundary layer is considered especially its rôle in modifying the apparent shape as sensed by external flow.

MN5/2/10 **The Comparison of Theory and Experiment for Oscillating Wings.** W.E.A.ACUM.
AGARD Manual on Aeroelasticity, 2, Chapt. 10, 60pp., 107 refs., s.d.
The general procedure in this chapter is to take each flow régime in turn to consider briefly the relevant theories, and then to see what experimental data can be found to check them. The survey of experimental work is not intended to be exhaustive.

MN5/2/11 **Empirical Values of Derivatives.** P.R.GUYETT.
AGARD Manual on Aeroelasticity, 2, Chapt. 11, 69pp., 37 refs., s.d.
After defining the derivatives (true-strip, equivalent constant strip and static), derivatives are given for main surfaces and control surfaces at low subsonic up to supersonic speed, and for tail surfaces, surfaces with tip fins, tip tanks, and nacelles.

MANUAL ON AEROELASTICITY: VOLUME 3

MN5/3
AD-439-697
AD-850-696 Rev.
N64-23900 **Manual on Aeroelasticity: Volume 3. - Prediction of Aeroelasticity Phenomena.** W.P.JONES (Editor).
AGARD Manual on Aeroelasticity, 3, Chapt. 1 to 7, 269pp., s.d.
Presents an introductory survey and six papers relating to the prediction of aeroelastic phenomena.

MN5/3/1 **An Introduction to the Prediction of Aeroelastic Phenomena.** E.G.BROADBENT.
AGARD Manual on Aeroelasticity, 3, Chapt. 1, 26pp., 4 refs., s.d.
General remarks; theoretical work; experimental aids to the prediction of aeroelastic phenomena; comparison of theory with experiment.

MN5/3/2 **Divergence and Related Static Aeroelastic Phenomena.** F.W.DIEDERICH.
AGARD Manual on Aeroelasticity, 3, Chapt. 2, 58pp., 40 refs., s.d.
Introduction (basic concepts, description of phenomena, philosophy of static aeroelastic analysis); methods of analysis (approximate methods, definitive methods); sources of information (structural information, aerodynamic information, inertial information); experimental methods (ground tests, flight measurement); design implications (stiffness requirements, balancing of forces).

MN5/3/3 **Loss of Control and Related Static Aeroelastic Effects.** F.W.DIEDERICH.
AGARD Manual on Aeroelasticity, 3, Chapt. 3.

MN5/3/4 **Flutter and Response Calculations in Practice.** E.G.BROADBENT.
AGARD Manual on Aeroelasticity, 3, Chapt. 4, 37pp., 22 refs., s.d.
Introductory remarks; formulation of the flutter equations (generalized co-ordinates, flutter equations in matrix form, flutter equations using normal co-ordinates, structural damping, servo-controls); methods of solution of the flutter equations (ill-conditioned equations, solution by test functions, other methods of solving the flutter equations); flutter calculations for the complete structure (branch modes, normal modes and random errors, special cases); variation of parameters (pre-flight calculations, flight calculations); effect of thermal stresses; the dynamic response of an aircraft (response to harmonic excitation, response to a single impulse, response to continuous turbulence, general comments and conclusions).

MN5/3/5 **Diagnosis and Cure of Flutter Troubles.** J.C.A.BALDOCK, L.T.NIBLETT.
AGARD Manual on Aeroelasticity, 3, Chapt. 5, 16pp., s.d.
Introduction; types of vibration, main-surface flutter (wing flutter, tailplane flutter, fin flutter); control-surface flutter; tab flutter; concluding remarks.

MN5/3/6 **General Dynamic Stability of Systems with many Degrees of Freedom.** A.I.van de VOOREN.
AGARD Manual on Aeroelasticity, 3, Chapt. 6, 34pp., 14 refs., s.d.
Introduction; calculation of normal modes for the complete aeroplane in still air (explanation of method, simplification for large-aspect ratio wings, the aeroplane considered as a three-dimensional body); numerical determination of natural modes and frequencies (calculation of lowest natural frequency and corresponding mode, calculation of higher natural frequencies and modes, the advantage of knowing D as the product of two symmetric matrices); flutter calculations (introduction of prescribed modes, introduction of normal co-ordinates for still air vibrations, introduction of aerodynamic forces, solution of the flutter problem); method of accelerating convergence if the moduli of the two smallest eigenvalues are nearly equal; stability calculations (method of solving the determinantal equation; transfer function method).

MN5/3/7 **A Summary of the Theories and Experiments on Panel Flutter.** Y.C.B.FUNG.
AGARD Manual on Aeroelasticity, 3, Chapt. 7, 47pp., 74 refs., s.d.
Definition and practical significance of panel flutter; methods of analysis; single rectangular planar panel; multiple rectangular plane panel; plane panels of odd planform; cylindrical panels; conical shells; limiting cases; buckled panels.

MANUAL ON AEROELASTICITY: VOLUME 4

MN5/4 **Manual on Aeroelasticity: Volume 4. - Experimental Methods.** W.P.JONES (Editor).
AD-406-870 AGARD Manual on Aeroelasticity, 4, Chapt. 1 to 10, 274pp., s.d.
AD-850-697 Rev. This volume of the manual presents an introductory survey, and ten papers relating to experimental methods used in aeroelasticity studies. Abstracts of these individual contributions are given in the following items.
N63-17815

MN5/4/1 **Measurement of Structural Influence Coefficients.** D.J.MARTIN, W.T.LAUTEN, Jr.
AGARD Manual on Aeroelasticity, 4, Chapt. 1, 30pp., 46 refs., s.d.
Definitions of structural influence coefficient, experimental requirements; methods of applying specified loads; methods of measuring deformation; data readout and reduction; conclusion.

MN5/4/2 **Ground Resonance Testing.** R.C.LEWIS, D.L.WRISLEY.
AGARD Manual on Aeroelasticity, 4, Chapt. 2, 21pp., 5 refs., s.d.
General discussion of the problem and some approaches to its solution; equipment; test techniques.

MN5/4/3 **Measurement of Inertia and Structural Damping.** H.GAUZY.
AGARD Manual on Aeroelasticity, 4, Chapt. 3, 30pp., 8 refs., s.d.
Section A: Experimental measurement of structural damping: general expressions; measurement of damping coefficient by frequency sweep; measurement of damping coefficient at resonance frequency from energy dissipation; measurement of damping coefficient under transient conditions, effect of dry friction. Section B: Experimental measurement of generalized masses: generalized mass; measurement of generalized masses by displacement of natural frequencies; measurement of generalized masses from energy dissipation.

MN5/4/4 **Experimental Techniques for the Impedance Testing of Powered Controls.** J.C.HALL.
AGARD Manual on Aeroelasticity, 4, Chapt. 4.

MN5/4/5 **Wind Tunnel Techniques for the Measurement of Oscillatory Derivatives.** J.B.BRATT.
AGARD Manual on Aeroelasticity, 4, Chapt. 5, 59pp., 57 refs., s.d.
Contents: The basic problem; classification of techniques; general remarks on techniques; discussion of individual techniques; instrumentation; wind tunnel effects.

MN5/4/6 **Similarity Requirements for Flutter Model Testing.** C.SCRUTON, N.C.LAMBOURNE.
AGARD Manual on Aeroelasticity, 4, Chapt. 6, 26pp., s.d.
The similarity laws; application of the similarity laws; testing in media other than air; simulation of kinetic heating.

MN5/4/7 **Model Construction.** L.S.WASSERMAN, W.J.MYKYTOW.
AGARD Manual on Aeroelasticity, 4, Chapt. 7, 28pp., 22 refs., s.d.
Analogue procedures in flutter prediction; uses of the flutter model; history; similarity rules; various models and approaches; low aspect ratio flutter models; low speed flutter models, high speed models; thermo-elastic models; model and store supports; stiffness measurements; model vibration tests and instrumentation.

MN5/4/8 **Wind Tunnel Flutter Tests.** L.S.WASSERMAN, W.J.MYKYTOW.
AGARD Manual on Aeroelasticity, 4, Chapt. 8, 14pp., 11 refs., s.d.
Data to be obtained; techniques for obtaining data; wind tunnel operation; testing difficulties; programming; evaluation of flutter model test data; flutter speed versus Mach number; wind tunnel effects; Reynolds number effects; margin of safety.

MN5/4/9 **Rocket Sled Ground-Launched Rocket and Free-Falling Bomb Facilities.** W.G.MOLYNEUX.
AGARD Manual on Aeroelasticity, 4, Chapt. 9, 15pp., 8 refs., s.d.
For circumstances in which wind-tunnels are not suitable for determining experimental aeroelastic data, alternative methods are used; the following are considered: rocket sled facility, ground-launched rocket facility, free-falling bomb facility, instrumentation, considerations of model design and layout record analysis.

MN5/4/10 **Flight Flutter Tests.** M.O.W.WOLFE, W.T.KIRKBY.
AGARD Manual on Aeroelasticity, 4, Chapt. 10, 28pp., 18 refs., s.d.
Continuously forced oscillation techniques; decaying oscillation techniques; instrumentation on aircraft; flight test procedures.

MANUAL ON AEROELASTICITY: VOLUME 5

MN5/5 **Manual on Aeroelasticity: Volume 5. - Factual Information on Flutter Characteristics.**
AD-263-433 AGARD Manual on Aeroelasticity, 5, Chapt. 1 to 6, 307pp., s.d.
AD-850-698 Rev. N63-14113 Six chapters in this part deal with the divergence and reversal of control, wing flutter, flutter of control surfaces and tabs, flutter of powered controls and of all-moving tail-planes, flutter in one degree of freedom, and approximate formulae for flutter prediction. Abstracts of the individual chapters are given in the succeeding items.

MN5/5/1 **Divergence and Reversal of Control: Factual Information on Flutter Characteristics.** K.A.FOSS.
AGARD Manual on Aeroelasticity, 5, Chapt. 1, 12pp., 27 refs., s.d.
An attempt is made to enumerate the static aeroelastic phenomena likely to be encountered by modern aircraft, and to describe means by which adverse aeroelastic effects can be prevented or alleviated. Divergence and related phenomena, control reversal, and effects of aerodynamic heating are dealt with.

MN5/5/2 **Wing Flutter: Factual Information on Flutter Characteristics.** D.R.GAUKROGER.
AGARD Manual on Aeroelasticity, 5, Chapt. 2, 46pp., 29 refs., s.d.
A survey of both experimental and theoretical sources of wing flutter information is given and some general properties of wing flutter considered. The effects of variations in wing geometry, structural properties, inertia (including the effects of added masses), and the effects of freedom of the wing root are discussed.

MN5/5/3 **Flutter of Control Surfaces and Tabs: Factual Information on Flutter Characteristics.** A.A.REGIER.
AGARD Manual on Aeroelasticity, 5, Chapt. 3, 37pp., 44 refs., s.d.
A review of the practice of flutter prevention of flap-type controls at subsonic speeds, primarily by means of mass-balancing. It is shown how the flutter prevention problem differs for the different speed ranges. Brief consideration is given to the subject of all-movable controls and single-degree-of-freedom flutter.

MN5/5/4 **Flutter of Powered Controls and of All-Moving Tailplanes: Factual Information on Flutter Characteristics.** A.D.N.SMITH.
AGARD Manual on Aeroelasticity, 5, Chapt. 4, 21pp., 4 refs., s.d.
Examines the interplay of mass-balance, circuit stiffness and damping on control surface flutter, and considers the characteristics of all-moving tailplanes.

MN5/5/5 **Flutter in one Degree of Freedom: Factual Information on Flutter Characteristics.** N.C.LAMBOURNE.
AGARD Manual on Aeroelasticity, 5, Chapt. 5, 42pp., 63 refs., s.d.
Deals with the types of flutter which do not depend on the coupling between two or more degrees of freedom, but which are essentially oscillatory instabilities in a single degree of freedom. Oscillations such as buffeting are not included, the present discussion being concerned with phenomena in which there is some mutual interaction between the motion of the structure and the flow. An Appendix gives an analysis of control surface buzz due to shock waves ahead of the flap.

MN5/5/6 **Approximate Formulae for Flutter Prediction: Factual Information on Flutter Characteristics.** W.G.MOLYNEUX.
AGARD Manual on Aeroelasticity, 5, Chapt. 6, 75pp., 25 refs., s.d.
Approximate formulae are given for both binary and ternary systems, and an approximate solution for flutter equations is discussed in which aerodynamic damping terms are eliminated while stiffness terms remain. Appendices deal with integration constants for main surface flutter, control surface flutter, and tab flutter, and also an application of formula.

MANUAL ON AEROELASTICITY: VOLUME 6

MN5/6
AD-448-227
AD-850-669 Rev.
N65-24758 **Manula on Aeroelasticity: Volume 6. - Collected Tables and Graphs.** A.I.VAN DE VOOREN.
AGARD Manual on Aeroelasticity, 6, 138pp., 6 refs., s.d.
Contains a collection of existing numerical information on theoretical aerodynamic coefficients for a two-dimensional oscillating thin aerofoil. The information, divided into three parts includes the Theodorsen circulation function for $M = 0$ and coefficients for sub- and supersonic flow including $M = 0$ and $M = 1$ respectively.

MN5/Revisions **Manual on Aeroelasticity Revision.** October 1968.
Loose leaf amendments and additions to Vols. 1 - 7. Five chapters are revised to include significant extensions of the subject and five new chapters are added:
The Dynamics of Liquid Propellants (Part 1, Chapter 8)
The Automation of Flutter Calculations (Part III, Supplement to Chapter 4)
The Interrelation between Structural Deformation and an Autopilot (Part III, Chapter 8)
Propeller - Rotor Whirl Flutter (Part III, Chapter 9)
Helicopter Blade Flutter (Part III, Chapter 10)
Further revisions and chapters are expected to be added later.

Manual on Aeroelasticity. Thickness and Boundary Layer Effects. M.T.LANDAHL, H.ASHLEY.
AGARD Manual on Aeroelasticity, Part II, Chapter 9, 60pp., 90 refs., 1969.
This replacement chapter deals with the effects of wing profile thickness and boundary layer effects in subsonic, transonic and supersonic speeds. Thickness effects on lifting surfaces which can oscillate are dealt with first by the inviscid theories which are described. Slender-wings and bodies of revolution at high speeds are then discussed and the chapter concludes with a discussion on the influence of time-dependent boundary layers, including separated flow.

Manual on Aeroelasticity. A Panel Flutter Review. D.J.JOHNS.
AGARD Manual on Aeroelasticity, Part III, Chapter 7, Supplement, 95pp., 454 refs., 1969.
This supplement uses much of the material of AGARD Advisory Report 1, "A survey of panel flutter" by the same author and adds to it the developments since 1965. It deals with flat, curved and buckled panels and concludes with an extensive bibliography.

MN6
AD-674-835
N70-73193 **Methods for the Determination of Impurities in Metals.** G.L.MILLER (Editor).
AGARD Publ. "Methods for the Determination of Impurities in Metal", 1966.
The purpose of this loose-leaf manual is to provide a compendium of reference methods for refractory metals analysis that can be up-dated as new methods are evolved. The first issue, in March 1966, contained methods of determining a wide range of impurities in molybdenum, niobium, tantalum and tungsten. The methods were established as the result of collaborative efforts initiated by the AGARD Structures and Materials Panel. Three further methods were included in supplementary papers issued in July 1967.

MN6/1 **Methods for the Determination of Impurities in Metals. Reference Methods for Refractory Metals Analysis.** Edited by G.L.MILLER.
AGARD 176pp. (with amendments), 1966-1969.
This volume has been produced by a co-operative effort sponsored by the AGARD Structures and Materials Panel. The methods described have been established by the collaborative efforts of laboratories highly experienced in the analysis of refractory metals. As new methods are evolved they will be added as loose leaves; three such sets of additional data have been issued in 1969.

MN7
AD-665-235
AD-672-927
N68-25500 to
N68-25504 **Principles of Biodynamics: Prolonged Acceleration - Linear and Radial.**
AGARD Manual "Principles of Biodynamics", Sect. A., 83pp
The Biodynamics Committee of the Aerospace Medical Panel of AGARD-NATO considered that it would be of great assistance in the field of aerospace medicine to compile a manual to avoid some of the confusion existing in the field of Biodynamics. This compilation is the first of the five sections suggested, and has been made in loose-leaf form which will allow amendment and extension as contributions are received. The first five papers have been abstracted and are given in the subsequent items.

MN7/1 **Acceleration Terminology, Table of Comparative Equivalents.** G.J.PESMAN.
AGARD Manual "Principles of Biodynamics", Sect. A., 6pp., 3 refs.
Several terms are used to describe the direction of an accelerative force applied to the body for identical circumstances. Because of this multiplicity of terms much semantic confusion results. Attempts to eliminate this confusion by the Biodynamic Committee of the Aerospace Panel has resulted in the production of two simple-to-read charts (or tables) giving tables of equivalents for linear motion and for angular motion in acceleration terminology.

MN7/2 **An Introduction to the Physics and Physiology of Acceleration.** S.D.LEVERETT, Jr.
AGARD Manual "Principles of Biodynamics", Sect. A., 23pp.
Outlines the (i) fundamental principles involved in the problem of acceleration, (ii) the physiological effects of acceleration, (iii) protection against the effects of acceleration, (iv) accelerations involved in aerial escape from aircraft, and (v) the problem of tumbling (head over heels) following emergency escape from aircraft.

MN7/3 **The Dynamics of Rotation Applied to Centrifuges.** R.E.VAN PATTEN.
AGARD Manual "Principles of Biodynamics", Sect. A., 14pp.
Although the classic treatments of rotational physics generally contain involved engineering mathematics, the author has endeavoured to present the subject in a simplified manner. He begins with defining such terms as acceleration, vector, etc. which are associated with rotation. Dimensional equivalence and conversions, and the mechanics of rotation are then described using simple algebraic expressions. Examples of Coriolis effects on a human rotating about an axis while trying to do simple tasks with his hands are briefly described.

MN7/4 **A Summary of Human Tolerance to Prolonged Acceleration.** A.S.HYDE, H.W.RAAB.
AGARD Manual "Principles of Biodynamics", Sect. A., 35pp., 26 refs.
Presents a summary of data from the literature in the form of tables and graphs, after first defining the standard terminology which is derived from an AGARD-NATO agreement regarding the equivalence of acceleration terms.

MN7/5 **Descriptive Catalog of Aerospace Medical Biodynamics Facilities in the United States.** C.F.GELL.
AGARD Manual "Principles of Biodynamics", Sect. A., 70pp.
Descriptions are given of the principal items of equipment used for biodynamic research in the following U.S. Government agency laboratories: Naval Aerospace Medical Institute, Aerospace Medical Research Department, Aerospace Crew Equipment Laboratory, 6570th Aerospace Medical Research Laboratories, 6571st Aeromedical Research Laboratory, U.S.A.F. School of Aerospace Medicine, Manned Spacecraft Center, Ames Research Center, Civil Aeromedical Institute, National Aviation Facilities Experimental Center, Section of Physiology, Mayo Foundation and Mayo Clinic. There are numerous full-page photographs.

MN8 **Manual on Fatigue of Structures** - English Version (French version December 1970).
AGARD Manual. W.G.BARROIS, June 1970.
Many aspects of the fatigue of metal structures have received the attention of the Structures and Materials Panel since its foundation in 1955. The nature and distribution of turbulence and other non-steady loadings, the response of structures to these loadings, resultant change at both macroscopic and microscopic scales and many detailed questions within each of these fields have been investigated by the structural analysts, metallurgists and metal physicists on the Panel and their colleagues throughout NATO. As a result, the Panel has been able to assist the better understanding and description of many fatigue phenomena at least amongst the specialists who are daily concerned with them. As part of this process, many data have been drawn together, analyzed and evaluated. However, no matter how deep the understanding of these phenomena in the laboratory, the performance of aircraft, other vehicles and equipment can only be assured if this understanding is brought to bear during the processes of design and production.

During the lifetime of the Panel, the roles performed and the environment to which aircraft and equipment are subjected have undergone many changes. Unconventional lading spectra, new materials, the effects of heating and audio-frequency excitation are just some of the considerations which have had to be taken into account by design and production teams, often at short notice. Accordingly, the Panel decided that it should commission a Manual on the Fatigue of Structures presenting a synthesis of knowledge drawn from many specialist areas but primarily intended to provide design and production engineers with a proper appreciation of the many aspects of design against fatigue.

MISCELLANEOUS PUBLICATIONS

OPERATIONAL RESEARCH IN PRACTICE

MP1
AD-695-274 **Operational Research in Practice.** M.DAVIES, M.VERHULST (Editors).
AGARD Publ. 'Operational Research in Practice,' 201pp., 1958.
Papers presented to the NATO Conference held in Paris, in 1957, are reproduced. The conference was designed to promote and guide the development of operational research in the NATO countries. Abstracts of the individual papers are given in the succeeding items.

MP1/1 **The Need for Operational Research.** S.ZUCKERMAN.
AGARD Publ. 'Operational Research in Practice,' 6-16, 1958.
This is a broad introduction to the subject with examples drawn from World War 2, especially in the strategic field. Discussion.

MP1/2 **The Status of Operational Research in NATO Nations.** P.SUPINO.
AGARD Publ. 'Operational Research in Practice,' 17-24, 1958.
Brief reports were given by the national delegates from the Netherlands (C. de Jongh), Denmark (E.W. Lennholm), Norway (F. Möller), Turkey (Fuat Ulug), Germany (T. Benecke), and France (A. Kreweras). Discussion.

MP1/3 **Development Planning-Operational Research Aspects.** J.E.LIPP.
AGARD Publ. 'Operational Research in Practice,' 25-35, 1968.
Development planning is defined as long-term planning of future products and operating systems, and of the orderly preparation for their introduction into the future world. The practice of this planning in military and civil aircraft circles combined with operational research studies when necessary is discussed together with comments on organizing and managing new development planning groups. Discussion.

MP1/4 **Some Examples of Systems Analysis.** H.DAVIES, K.E.SILMAN
AGARD Publ. 'Operational Research in Practice,' 36-52, 1958.
The author discusses the example of the 'Systems Approach' in the deve[illegible] of military tactics by Alexander the Great over two thousand years ago, and then more m[illegible] examples. Conclusions are then drawn from experience of Systems Analysis. Discussion.

MP1/5 **Scientific Aids to Decision Making: A Perspective.** J.R.GOLDSTEIN.
AGARD Publ. 'Operational Research in Practice,' 53-62, 1958.
The author shows the need for military decisions at any given moment. The scientist could help in two ways: first, the techniques of operations research could be used to give rapid indication of the most effective use of resources available; second, the scientific approach could be adopted to anticipate next year's major decisions, and prepare for them. Discussion.

MP1/6 **Method of Evaluating the Efficiency of a Reporting System for Air Defence.** (In French).
–. FERRÉ.
AGARD Publ. 'Operational Research in Practice,' 63-71, 1958.
The information from the reporting system should suffice to define a method of comparative evaluation of this representation, while it can be elaborated from various modifications of procedure; to investigate for an existing system the conditions to be fulfilled to obtain optimum efficiency and minimum costs in staff and equipment: to orientate the study of the most advanced systems using automation in place of human operators where necessary. Full use should be made of all available 'in vivo' and 'in vitro' research to attain the requirements. Discussion.

MP1/7 **Methods of Air Defence over Germany in World War II.** T.BENECKE.
AGARD Publ. 'Operational Research in Practice,' 72-85, 1958.
This report is divided into two sections: a historical review of the course of the home air defence in the area of the Reich between 1940 and 1945, and examples of the application of operational research methods on the German side during the war. Discussion.

MP1/8 **Systems of Evaluation and Military Planning.** J.W.ABRAMS.
AGARD Publ. 'Operational Research in Practice,' 86-93, 1958.
Describes an idealized system which can be employed by a team of analysts and military planners for the development of a defence system. Discussion.

MP1/9 **Linear Programing.** M M.FLOOD.
AGARD Publ. 'Operational Research in Practice,' 94-105, 30 refs., 1958.
Three different aspects of the subject are (i) mathematical models and numerical analysis, (ii) industrial and military applications, and (iii) validity of the method. An elementary introduction to the subject is given together with the most commonly successful applications to linear programing. Discussion.

MP1/10 **Logistic and Transport Operations.** G.D.CAMP.
AGARD Publ. 'Operational Research in Practice,' 106-113, 1958.
A general solution of all logistic support problems can be stated, but a general approach does not exist. In view of this a step-by-step method is examined in detail in this paper. Discussion.

MP1/11 **Economy and Strategy.** P.MASSÉ
AGARD Publ. 'Operational Research in Practice,' 114-131, 7 refs., 1958.
Taking into account the 'uncertainty' factor, one has a series of plans to be executed or abandoned according to circumstances arising from the actions of an opponent. The rule of exploitation, later called 'strategy' defines, on each occasion, as a function of the current-data, the variation of stock and the flow to be maintained during the immediately succeeding interval. The application of the principles is shown in relation to electricity equipment planning by Electricité de France. Discussion.

MP1/12 **Operational Research in Action.** (In French). F.BRAMBILLA.
AGARD Publ. 'Operational Research in Practice,' 132-143, 1958.
Operational research can be represented as the 'science of decisions'. But the decision, in-so-far-as the choice of action is to be taken in the presence of risk, is a basic element of the human system. Three types of fundamental activity are briefly discussed: (i) the posing of the problem; (ii) research and synthesis phase; and (iii) the action phase, i.e. the application of the results of the research to give effect to an enterprise. Discussion.

MP1/13 **War Games.** R.D.SPECHT.
AGARD Publ. 'Operational Research in Practice,' 144-153, 1958.
After a general discussion of the features of war games, examples are given to illustrate the diversified nature and application. These include the determination of national strategy to a simple tactical manoeuvre. The desireability of repeating the play of a game under varying conditions is discussed as well as the valuable by-products of a game played only once. Discussion.

MP1/14 **Organization for Operational Research in the United Kingdom.** G.N.GADSBY.
AGARD Publ. 'Operational Research in Practice,' 154-162, 1958.
Operational research in industry and in the Defence Ministries are compared. The impact of the differences of the pattern of organization supporting operational research activity in the U.K. is illustrated by existing practices in the British Defence and Supply Ministries and in industry.

MP1/15 **Organization for Operations Research in The United States.** J.F.McCLOSKEY.
AGARD Publ. 'Operational Research in Practice,' 163-170, 1958.
Deals with Air Force, Army and Navy Systems, the Department of Defence, and organization for non-military operations research. Discussion.

MP1/16 **Selection and Training of Operational Research Scientists.** H.M.COLE.
AGARD Publ. 'Operational Research in Practice,' 171-180, 1958.
Deals with the selection and training of operational research scientists in a single organization: the operations research office of the Johns Hopkins University, which assists the U.S. Army under a contract between the University and the Army. Discussion.

MP1/17 **Future Field for Operational Research in The NATO Countries.** H.A.SARGEAUNT.
AGARD Publ. 'Operational Research in Practice,' 181-194, 1958.
After a frank discussion on the future of operational research and the need for first class work on this subject the author divides his investigation into four fields: (i) future demands; (ii) can operational research meet these demands?; (iii) obtaining good scientists to meet this need; (iv) steps to be taken, for those who work on this subject. Discussion.

SELECTED COMBUSTION PROBLEMS: PT. 1. - FUNDAMENTALS AND AERONAUTICAL APPLICATIONS

MP2
AD-695-273 **Selected Combustion Problems: Pt. 1. - Fundamentals and Aeronautical Applications.**
W.R.HAWTHORNE, D.B.SPALDING, J.FABRI (Editors).
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 534pp., 630 refs., 1954.
This volume contains eighteen papers presented and discussed at the first AGARD Combustion

Colloquium held at Cambridge, England, in December 1953. The papers are in four groups: Laminar flame propagation; Turbulent combustion; Solid and liquid propellants; Technical combustion problems. Abstracts of the individual papers are given in the succeeding items.

MP2/1 **Fundamental Approach to Laminar Flame Propagation.** T.VON KÁRMÁN, S.S.PENNER.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 5-41, 17 refs., 1954.
The complete system of equations for a theory of laminar flame equations is presented, taking into account heat conduction and diffusion, and the case of an arbitrary number of simultaneous reactions. The eigen-value problem determining the flame velocity is formulated. Two examples (hydrazine decomposition and ozone decomposition) are given in order to show that explicit analytical expressions for the flame velocity can be obtained, which are in good agreement with the results obtained by numerical integration of the equations.

MP2/2 **Aerothermodynamic Studies of Combustion.** (In French). J.FABRI.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 42-58, 19 refs., 1954.
After recapitulating the fundamental aerothermodynamic equations, the concept of total reaction and the corresponding reaction rate is defined. One may thus distinguish between combustion processes with low propagation speeds, and deflagrations and detonation waves. The former are studied quantitatively. Finally, the method of studying one-dimensional flames is extended to real laminar flames.

MP2/3 **Diffusion Processes as Rate-Controlling Steps in Laminar Flame Propagation.** D.M.SIMON.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 59-91, 88 refs., 1954.
Correlations between equilibrium concentrations of atoms and free radicals and laminar burning velocities of pre-mixed gases are reviewed. Critical examination of the physical significance of the correlations, and their interpretation, are presented. Flame properties which may be influenced by diffusion are reviewed.

MP2/4 **Some Experimental Results Relating to Laminar Flame Propagation.** J.W.LINNETT.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 92-110, 41 refs., 1954.
Methods of determining burning velocities are discussed, and several methods that have been, or might be, used for investigating the temperature distribution in a flame are described (e.g. use of thermocouples, observation of refractive index changes, etc.). The difficulties of sampling, and the possible use of mass-spectrographs and absorption spectroscopy are mentioned.

MP2/5 **Ignition and Combustion in a Laminar Mixing Zone.** F.E.MARBLE, T.C.ADAMSON, Jr.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 111-131, 10 refs., 1954.
The analysis presented considers the ignition and combustion in the laminar mixing zone between two parallel moving gas streams; one stream consists of a cool combustible mixture, the second of hot combustion products. The complete development of the laminar flame front is computed using an approximation similar to the von Kármán integral technique in boundary layer theory.

MP2/6 **Use of Spectroscopy in Elucidating Reaction Mechanism.** A.G.GAYDON.
AGARD Publ. 'Selected Combustion Problems. Pt. 1.' 132-143, 48 refs., 1954.
The need for quantitative rather than qualitative spectroscopic work; recent experimental developments (low-pressure flames, atomi flames, use of deuterium as tracer, flash photolysis, absorption spectroscopy of flat diffusion flames); information to be derived from electronic, vibrational and translational intensity anomalies, and also from predissociations and continuous spectra; mechanism of formation of C_2, CH, OH and HCO radicals in organic flames; spectroscopic evidence on the nature and meaning of activation energy, in relation to flame propagation.

MP2/7 **Spectroscopic Studies of Premixed Laminar Flames.** S.S.PENNER.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 144-166, 59 refs., 1954.
A critical review of the results obtained by spectroscopic observations on flames. The object is to examine the status, promise and deficiencies of combustion spectroscopy in its relation to (i) elucidation of the combustion mechanism, (ii) solution of technical combustion problems. The probable effects of pressure on laminar flame propagation are also discussed.

MP2/8 **Some Results and Classical Methods of Study of Turbulent Flow.** (In French). J.J.BERNARD.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 195-214, 18 refs., 1954.
A review is presented of the principal methods, and of the results obtained, of the aerodynamic study of turbulent flow, as it is felt that this knowledge is of value in the study of turbulent combustion.

MP2/9 **Experimental Studies on Turbulent Flames.** A.C.SCURLOCK, J.H.GROVER.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 215-247, 33 refs., 1954.
Both turbulent diffusion flames and turbulent flames propagating in homogeneous mixtures are considered. For the former, 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.

MP2/10 **A Turbulent Flame Theory Derived From Experiments.** B.KARLOVITZ.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 248-262, 12 refs., 1954.
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.

MP2/11 **The Combustion of Double-Base Propellants.** G.K.ADAMS, L.A.WISEMAN.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 277-288, 10 refs., 1954.
Because of the complexity of combustion of double-base propellants, the combustion of the simpler liquid nitric esters is considered. The available combustion data on pure liquid nitric esters and their vapours are discussed together with the properties of mixtures of nitric esters, with each other, with other compounds, and with nitrocellulose.

MP2/12 **The Mechanism of Combustion of Solid Propellants.** R.D.GECKLER.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 289-339, 52 refs., 1954.
The normal linear burning rate of solid propellants increases with (i) increasing pressure of the gases in contact with the burning surface, (ii) increasing temperature of the propellant, (iii) increasing velocity of the combustion gases parallel to the burning surface. Experimental data on these phenomena are summarized for colloidal and composite propellants. An attempt is then made to show the relation between the concepts and methods developed for the study of deflagration in gases and the theories of solid propellant combustion. The status of the theoretical study of solid propellant combustion is reviewed. A summary of experimental and theoretical information on unstable combustion is also given.

MP2/13 **Combustion of a Single Droplet and of a Fuel Spray.** D.B.SPALDING.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 340-351, 23 refs., 1954.
The present status of knowledge on this subject is reviewed. It is pointed out that although considerable progress has been made in understanding the physical aspects of liquid fuel burning, the relative motion within a spray is too complex to permit analysis as yet. Knowledge of the conditions for the stable burning of liquid fuels is still less advanced.

MP2/14 **Combustion Instability in Liquid-Propellant Rocket Motors - A Survey.** C.C.ROSS, P.P.DATNER.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 352-380, 46 refs., 1954.
Three different types of instability (low-frequency 'chugging', high-frequency 'screaming', and the low-frequency 'divergent' type) are briefly described. Pertinent information in the literature is reviewed. Problems encountered in securing reliable experimental data are also discussed.

MP2/15 **The Problem of Combustion at High Altitude.** P.LLOYD, B.P.MULLINS.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 405-425, 19 refs., 1954.
Combustion and relighting problems associated with aircraft gas turbine combustion chambers and jet-pipe reheat systems at altitudes up to 65,000ft. are considered. Attention is focussed upon four engine operating conditions: 'cruising' and 'idling' when discussing combustion, 'windmilling' when discussing relighting, and 'full speed' when considering reheat.

MP2/16 **Flame Stabilization by Obstacles.** (In French). M.BARRÈRE, A.MESTRE.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 426-446, 15 refs., 1954.
Theoretical methods are reviewed for the calculation of the velocities and losses at the flame front; the pressure distribution along the combustion chamber is obtained by a general method. Experiments are described to determine the conditions of flame-holding by a family of bluff bodies. The importance of the parameters affecting the limits of stability is discussed. Experimental results obtained with real flame stabilizers are given.

MP2/17 **Combustion in Vitiated Air.** B.P.MULLINS.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 447-489, 105 refs., 1954.
The effects of air vitiation by the addition of various inert diluents, or by a pre-combustion stage, upon such combustion phenomena as flame propagation, inflammability and flame characteristics are considered. The subject is discussed under the following headings: fundamental data on

vitiated air, pre-flame processes in vitiated air, combustion phenomena in vitiated air, performance of a combustion chamber in vitiated air and combustion with recirculation.

MP2/18 **Some Properties of Pulsatory Combustion: The Pulse-Jet, The Action of Doped Fuels.** (In French). J.BERTIN.
AGARD Publ. 'Selected Combustion Problems: Pt. 1.' 490-505, 15 refs., 1954.
The results of a S.N.E.C.M.A. investigation of the effect of additives to fuels in engines pulsating at low frequency and with low volumetric efficiencies are discussed. Instantaneous temperatures and pressures were measured at different parts of the machine, and simultaneously attempts were made to obtain accurate gas analysis and flame photographs. The low volumetric efficiency of the combustion chamber is largely responsible for the difference between actual and theoretical engine performance.

SELECTED COMBUSTION PROBLEMS: PT. 2. - TRANSPORT PHENOMENA, IGNITION, ALTITUDE BEHAVIOUR AND SCALING OF AEROENGINES

MP3
AD-853-935 **Selected Combustion Problems: Pt. 2. - Transport Phenomena, Ignition, Altitude Behaviour and Scaling of Aeroengines.** J.DUCARME, J.FABRI, M.W.THRING (Editors).
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 495pp., 803 refs., 1956.
This volume contains eighteen review papers presented at the second AGARD Combustion Colloquium held at Liège in December 1955, together with written contributions to the discussion and the authors' replies. Abstracts of the eighteen papers are given in the succeeding items.

MP3/1 **The Performance of Aircraft Engines.** (In French). A.CAPETTI.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 5-29, 6 refs., 1956.
The relative merits of thrust and power as measures of performance of ramjets and turbojets are first discussed, either overall or referred to the fuel consumption, to the weight and to the greatest area. These specific parameters are related, in turn, to other quantities characteristic of the power-plant (e.g. efficiency, impulse of work done per unit mass of air).

MP3/2 **Fuels for Turbojet Powered Aircraft.** R.R.HIBBARD, H.C.BARNETT.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 30-53, 20 refs., 1956.
A survey of the effects of variations of volatility, concentrations of the various main classes of hydrocarbons, and concentrations of the minor non-hydrocarbon components of fuels on aircraft engine performance. It is largely limited to fuels meeting U.S. military specifications.

MP3/3 **Fundamental Principles of Flammability and Ignition.** B.LEWIS, G.VON ELBE.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 63-72, 6 refs., 1956.
It is pointed out that no theoretical criterion for inflammability limits is obtained from the steady-state equation of the combustion wave. On the basis of a model of the thermally propagating combustion wave it is shown that the limit is due to instability of the wave toward perturbation of the temperature profile. Ignition by a local source (e.g. electric spark) is also considered.

MP3/4 **The Ignition of Flowing Gases.** L.D.WIGG.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 73-82, 21 refs., 1956.
The results of numerous investigations are considered in relation to the problems of lighting-up a combustion chamber under high altitude conditions. Areas in which further information is required are indicated.

MP3/5 **Burning and Ignition in Liquid Propergol Rocket Engines.** (In French) M.BARRÈRE, A.MOUTET.
AGARD Publ. 'Selcted Combustion Problems: Pt. 2.' 83-114, 36 refs., 1956.
The three parts of this paper deal with (i) starting a liquid propellant rocket motor, (ii) the transition period following the start, and (iii) the operating conditions

MP3/6 **Thermal Ignition, with Particular Reference to High Temperatures.** R.S.BROKAW.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 115-138, 48 refs., 1956.
The thermal ignition of fuel-air mixtures is discussed for pressures of one atmosphere and below, and temperatures well above the minimum for spontaneous ignition. Approximate theoretical considerations are discussed, and some experimental techniques used to obtain ignition delay-ignition temperature data are described.

MP3/7 **Fundamental Equations in Aerothermo-Chemistry.** T.VON KÁRMÁN
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 167-184, 22 refs., 1956.
Deals with the fundamental concepts and laws of aerothermochemistry. Defines the parameters occurring in the equations of state and enthalpy, and reviews transfer parameters in pure gases and mixtures, and the parameters related to chemical reactions. Lists dimensional quantities occurring

in aerothermochemical problems, and gives equations for continuity momentum and energy for the general non-stationary and three-dimensional case, and their simplified forms for the stationary non-dimensional process.

MP3/8 **Some Considerations Relating to Convection of Heat at High Speeds and Elevated Temperatures.** (In French). E.A.BRUN.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 185-198, 20 refs., 1956.
Presents certain rules for the approximate calculation of the convention coefficients starting from the known results at low velocities and with small temperature differences.

MP3/9 **Sources of Transport Coefficients and Correlations of Thermodynamic and Transport Data.** J.HILSENRATH.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 199-244, 405 refs., 1956.
A guide is given to recent compilations and reviews of thermodynamic and transport data for liquids, solids, and gases (151 references). An indexed bibliography is given of published research (1945-54) on the transport properties of gases. Centres in the U.S.A. for the compilation of thermophysical data are noted. Detailed tables of contents are included for three American major compilations on this subject.

MP3/10 **Combustion at Altitude in Turbo-Jets.** (In French). J.SOISSONS.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 255-269, 1956.
The high-altitude combustion problems which are specially considered are: extinction conditions. the possibility of relighting in flight, and combustion efficiency.

MP3/11 **The Influence of Altitude Operating Conditions on Combustion Chamber Design.** S.L.BRAGG, J.B.HOLLIDAY.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 270-295, 20 refs., 1956.
Deals with: (i) the applicability of simple combustion data (laminar flame speed, ignition delay, etc.) to the problem of turbulent combustion; (ii) the correlation, in the light of such data, of the performance of combustion chambers under altitude conditions; (iii) the application of such data and correlations to the design of the best combustion chamber to fulfil the requirements of a given project.

MP3/12 **Combustion in the Turbojet Engine.** S.WAY.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 296-327, 60 refs., 1956.
A review of current trends in operating conditions and requirements is followed by a discussion of the processes that take place in the combustion chamber (air flow patterns, recirculation, burning processes, and droplet evaporation). The significance of theoretical studies of reaction rates in turbulent reaction chambers is considered. Methods of fuel atomization and vaporization are discussed. Similitude, scaling, and loading criteria are also considered, and finally attention is given to the problem of low efficiency and blowout at altitude.

MP3/13 **Problems of Combustion Under Altitude Condition (Treated from Fundamental Viewpoint).** H.G.WOLFHARD.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 328-347, 34 refs., 1956.
It is shown that no low pressure limit exists for pre-mixed flames down to 0.01 atm.; limit of inflammability and limit temperatures are also not likely to change drastically. These statements are true for laminar flames but not necessarily for turbulent flames. The low-pressure characteristics of diffusion flames are also described.

MP3/14 **Similarities in Combustion, A Review.** A.E.WELLER.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 371-383, 39 refs., 1956.
The application of similarity techniques to combustion problems is discussed. The difficulties of obtaining significant results by such techniques are examined.

MP3/15 **Scaling of Gas Turbine Combustion Systems.** D.G.STEWART.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 384-413, 31 refs., 1956.
The component processes occurring in a combustion chamber are examined to determine the operating conditions under which a geometrically similar model chamber should be tested to produce results applicable to the full size unit. It is shown that while perfect similarity is impossible, a very reasonable compromise is obtainable.

MP3/16 **Research Relating to an Optimum Burner for Air-Kerosene Flow at High-Speed.** (In French). B.SALMON, H.VIGNE.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 414-443, 16 refs., 1956.
By means of a chart, the theoretical pressure and velocity variations in a cylindrical duct where heat is added to a high-velocity flow by the combustion of a kerosene-air mixture, are indicated.

A criterion, ϵ, is defined to characterize the flexibility of a burner. From experimental results, some effects on combustion of scaling combustors are discussed. Flight tests showed the variations of ϵ due to altitude, and also to the pressure drop allowed in order to attain a given altitude.

MP3/17 **Scaling of Liquid Fuel Rocket Combustion Chambers.** C.C.ROSS.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 444-456, 14 refs., 1956.
The basic criteria for scaling combustion reactors are discussed, together with the practical problems of geometrically scaling rocket combustion chambers. Data are presented which indicate that, under certain conditions of injection, a one-dimensional combustion process may exist. Factors affecting certain types of low- and high-frequency instability are discussed.

MP3/18 **Considerations on the Problem of Scaling Rocket Motors.** L.CROCCO.
AGARD Publ. 'Selected Combustion Problems: Pt. 2.' 457-468, 5 refs., 1956.
A discussion of the problem of scaling by taking into account the different requisites of static and dynamic similarity is developed, based on the assumption that the characteristic combustion times vary as p^{-n}. It is found that for $n = 1$, it is possible to have an almost perfect scaling rule by varying the pressure in the inverse proportion as to dimensions. For $n \neq 1$ two scaling rules can be suggested; these are compared with those suggested by Penner and Tsien.

COMBUSTION AND PROPULSION: THIRD AGARD COLLOQUIUM

MP4 AD-853-924 X70-72736 **Combustion and Propulsion: Third AGARD Colloquium.** J.FABRI, A.H.LEFEBVRE, O.LUTZ, M.W.THRING (Editors).
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 614pp., 1958.
This volume contains the papers presented at the Third Colloquium on Combustion and Propulsion held at Palermo (Italy) in March, 1958. Abstracts of the individual papers are given in the succeeding items.

MP4/1 **Development Problems in Large Liquid Rocket Engines.** R.S.LEVINE.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 3-23, 17 refs., 1958.
It is pointed out that most of the development work carried out on such rockets is similar to that carried out on other large complex devices, and concerns problems affecting reliability (e.g., valve actuation, pressure regulation, mechnical strength, and electrical function). Factors that are uniquely related to the size of the engine include: the prevalence of the cylindrical modes of acoustic instability, heat transfer problems at very high pressures, obtaining strong ignition over a large-diameter injector face, and certain control, facility and instrumentation requirements. Discussion.

MP4/2 **Propulsion by Air Breathing Engines.** A.A.LOMBARD.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 24-52, 1958.
A general review of factors affecting the future development of aircraft engines. The effect of the use of high-energy fuels on combustor design is discussed. The future of transport aircraft, both subsonic and supersonic, is considered, together with the engine problems anticipated. The provision of VTOL capability is also examined, and the possibility of applying nuclear power for propulsion is discussed. Discussion.

MP4/3 **Effects on Turbojet Combustors and Afterburners of Other Engine Components.** J.H.CHILDS.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium.' 55-85, 8 refs., 1958.
Discusses the effects of compressor, turbine, engine inlet duct, and exhaust nozzle designs on combustion efficiency, combustor operating limits, pressure losses, temperature profiles and combustor durability. Data from combustor tests and full-scale engine tests are given to show the nature of these effects. Design techniques for diminishing the adverse effects are indicated. Discussion.

MP4/4 **The Problem of Ram-Rockets.** (In French). E.LE GRIVÈS.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 86-117, 19 refs., 1958.
The theoretical performance of ram-rockets (defined as composite propulsion systems incorporating rocket motors fed with an over-rich propellant mixture in a reactor jet housing) is considered. The influence of the essential parameters is examined, assuming that they are under constant conditions corresponding to supersonic flight at constant altitude. The performance of the ram-rocket is compared with that of a simple reference rocket. Discussion.

MP4/5 **Recent Work on Mixing at the Poytechnic Institute of Brooklyn.** L.G.NAPOLITANO, P.A.LIBBY, A.FERRI.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 118-152, 40 refs., 1958.
Recent theoretical and experimental work on mixing flows is reviewed. Two general problems are discussed: (i) the free mixing of semi-infinite streams, (ii) mixing in the presence of a wall. Discussion.

MP4/6 **Shock Wave and Flame Interactions.** G.RUDINGER.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 153-182, 32 refs., 1958.
Experimental observations and theoretical analyses of the phenomena that occur when pressure waves in a duct interact with a flame front are reviewed. Desirable future investigations are outlined. Discussion.

MP4/7 **Jet Engine Noise Reduction.** N.D.SANDERS, W.J.NORTH.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 185-196, 16 refs., 1958.
Fundamental research on noise generation and recent developments in noise reduction techniques are described. The acoustic and aerodynamic characteristics of several noise-suppression exhaust nozzles are compared. It is pointed out that the internal thrust losses and external drag increases caused by noise suppressors may incur serious penalties in cruise performance. Discussion.

MP4/8 **Some Thoughts on Noise Suppression Nozzle Design.** E J.RICHARDS.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 197-223, 30 refs., 1958.
A brief review of jet nozzle noise-suppression tests carried out in U.K. and U.S.A., is followed by an attempt to correlate the results and indicate the main parameters. It is suggested that two noise-suppression mechanisms occur, velocity reduction, and frequency raising. The characteristics of various nozzle configurations are then discussed. Discussion.

MP4/9 **Noise Suppression of Aircraft Engine Test Plants: Technical, Financial and Physiological Aspects.** (In French). P.DUCROT, A.RIEHN, G.ROUMILHAC, H.SOUVRAS.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 224-265, 25 refs., 1958.
The technical and financial problems connected with the acoustic insulation of jet engine test plants are discussed. Comparisons between several French and foreign designs are given; developments originating from S.N.E.C.M.A. are described in more detail. A short report pertaining to the physiological aspect of this problem is outlined in connection with work of the medical staff of the Test Centre of Melun-Villaroche (Seine et Marne). Discussion.

MP4/10 **Some Thoughts on Flame Theory.** D.B.SPALDING.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 269-306, 40 refs., 1958.
After a review of the present status and trend of flame theory, seven 'useful half-truths' are formulated in order to summarize its main content. Six applications of flame theory are then discussed: steady laminar propagation, the homogeneous reaction zone with heat losses, unsteady propagation, the non-homogeneous spherical reactor, an axially symmetric flame, and a flow prescribed by influence coefficients. Future research tasks are also indicated. Discussion.

MP4/11 **Review of Some Recent Combustion Experiments.** M.GERSTEIN.
AGARD Publ. 'Combustion and Propulsion' Third AGARD Colloquium,' 307-332, 34 refs., 1958.
A number of basic combustion experiments are reviewed to determine the status of knowledge of the chemical processes in flames. The significance of the results obtained is discussed, and implications of certain inconsistencies are examined. Difficulties arising from the fact that measurements of flame properties have been made under widely varying conditions are also considered. Discussion.

MP4/12 **The Role of Fundamental Research in the Study of Aviation Combustion Chambers.** (In French). C.FOURÉ.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 333-366, 111 refs., 1958.
A general review of this subject; various phenomena of importance in combustion chamber design are discussed; the use of similarity methods is considered, and also the use of hydraulic models. The importance of a closer contact between research workers and those concerned with design and use of combustion chambers is emphasized. Discussion.

MP4/13 **Studies of the Decomposition Mechanism, Erosive Burning, Sonance and Resonance for Solid Composite Propellants.** R.SCHULTZ, L GREEN, Jr., S.S.PENNER.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 367-427, 56 refs., 1958.
Recent experimental and theoretical studies on the decomposition mechanism, erosive burning, sonance and resonance for solid composite propellants are described. An attempt is made to discuss recent advances and to define areas where additional studies are needed. Discussion.

MP4/14 **Radiation Heat Transfer to Hypersonic Vehicles.** R.E.MEYEROTT.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 431-450, 20 refs., 1958.
A survey is made of current knowledge of emission characteristics of air temperatures and densities of interest for radiation heating in hypersonic flight. The problem is illustrated by considering two examples: a locally hemispherical ballistic missile nose re-entering the atmosphere, and a sphere used as a circumlunar carrier under extreme re-entry conditions. A survey of the existing theory of emissivity of air and an analysis of recent experimental data are also given. Discussion.

MP4/15 **Convective Heat Transfer with Mass Addition and Chemical Reactions.** L.LEES.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 451-498, 68 refs., 1958.
An account is given of progress and problems in convective heat transfer with chemical reactions, including reactions involving vaporizing or sublimating surface material. Discussion.

MP4/16 **High-Temperature Shock Waves.** O.LAPORTE.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 499-524, 14 refs., 1958.
The normal shock is the flow pattern that is selected for discussion, as it is by means of the normal shock that the high temperatures to be experienced in high-speed flight can be produced for the study of molecular vibration, dissociation and ionization phenomena. The discussion is in three sections: (i) monatomic gases, (ii) shocks in molecular, especially diatomic gases, (iii) non-equilibrium phenomena, and experimental gases. Discussion.

MP4/17 **On Magneto-Fluid-Dynamics.** A.SCHLÜTER.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 525-538, 1958.
The applicability of the usual magnetohydrodynamic equation is investigated, with particular attention being given to the range of strong magnetic fields and low density where the collision frequency is less than the gyro-frequency of the charged particles. Discussion.

MP4/18 **A Review of Flame Stabilization by Means of Gaseous Jets.** A.B.CAMBEL.
AGARD Publ. 'Combustion and Propulsion' Third AGARD Colloquium,' 541-554, 20 refs., 1958.
A flame may be stabilized by a gaseous jet in a high velocity, turbulent stream if the relative velocity of the two streams permits the creation of a stagnation zone. If air is used as a stabilizer, the properties of this zone determine, in a great measure, the success of stabilization. The critical region, although a necessary condition, is not a sufficient criterion; events which take place during mixing and diffusion must also be considered. Discussion,

MP4/19 **Study of an Aerodynamic Process in Combustion.** (In French). J.BERTIN, B.SALMON.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 555-580, 16 refs., 1958.
A new combustion process perfected at S.N.E.C.M.A. is described. By using jets of air, transverse to the principal flow, fine turbulence is created along the length of the flame front (termed 'micro-turbulence') and is very favorable to the propagation of combustion. The velocities of flame propagation thus attained permit complete removal of physical stabilizers. The method has been applied on turbojet afterburners. Discussion.

MP4/20 **Flame Stabilization in Boundary Layers.** T.Y.TOONG.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 581-597, 19 refs., 1958.
Two mechanisms of flame-stabilization are discussed: (i) where stabilization is due to the continuous ignition of a combustible mixture through mixing with hot gases produced as the result of an earlier ignition; (ii) where stabilization is realized because the tendency for a flame to propagate is in stable equilibrium with the fluid motion.

MP4/21 **Graphical Method on Problems of Gasdynamic Mixing.** O LUTZ.
AGARD Publ. 'Combustion and Propulsion: Third AGARD Colloquium,' 598-610, 1958.
The graphical representation presented gives a good account of the phenomena in both the subsonic and supersonic ranges. In particular, the 'gap' is treated in the mixing range in which the mixing of two gas jets in a cylindrical mixing tube results in an incompatibility of the theory of momentum with the energy equation. Applications to thrust augmentation in jet engines.

COMBUSTION AND PROPULSION: FOURTH AGARD COLLOQUIUM

MP5
AD-260-952 **Combustion and Propulsion: Fourth AGARD Colloquium. (High Mach Number Air-Breathing Engines).** A.L.JAUMOTTE, A.M.ROTHROCK, A.H.LEFEBVRE (Editors).
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 369pp., 1961.
Papers presented to the Milan Colloquium are reproduced. Abstracts of the individual papers are given in the succeeding items.

MP5/1 **Introductory Remarks.** T.VON KÁRMÁN.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' XIII-XIV, 1961.
In this introduction to the Milan Colloquium dealing with high Mach number air-breathing engines, the present status of aircraft propulsion is briefly reviewed, and the trends of future development are indicated.

MP5/2 **Possible Directions of Future Research in Air-Breathing Engines.** A.FERRI.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 3-15, 1961.
Pt. 1 discusses those applications where the air-breathing engine is considered the only practical propulsion system; in these applications a discrepancy of opinions exists only in the necessity and urgency of basic and applied research. Pt. 2 examines a possible application where the air-breathing engine could be competitive with other propulsion systems.

MP5/3 **Composite Air-Breathing Systems.** M.A.ZIPKIN, L.M.NUCCI.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 16-68, 3 refs., 1961.
Analyses indicate that sizeable performance gains can be obtained using combined air-breathing and rocket-powered stages for launching satellites. For purely air-breathing powered vehicles within the atmosphere an acceleration stage with a single or multi-stage cruise stages results in high Mach number, long range aircraft of improved performance and economy. Applications of composite air-breathing systems are indicated.

MP5/4 **Hypersonic Ramjet Development.** J.A.DRAKE.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 69-83, 6 refs., 1961.
In this general survey, various design concepts and development problem-areas are indicated (including testing, as well as the engine design itself). Both boost and cruise type applications are discussed. The remarks are confined to the conventional subsonic burning ramjet.

MP5/5 **Comparison of Hypersonic Ramjet Engines with Subsonic and Supersonic Combustion.** G.L.DUGGER.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 84-119, 17 refs., 1961.
Performance estimates are presented for hypersonic, kerosene-fuelled ramjets; calculations show that the conventional ramjet (CRJ) should achieve overall efficiencies of 40 to 50% in the M5 to 8 speed range; with comparable efficiencies, the supersonic combustion ramjet (SCRJ) should give significantly better performance than the CRJ at speeds in the M8 to 10 range.

MP5/6 **Some Considerations of Hypersonic Inlets.** J.F.CONNORS, L.J.OBERY.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 123-137, 7 refs., 1961.
Various factors affecting hypersonic inlet characteristics are examined in relation to overall power-plant performance. It is shown that the inlet influences not only the engine thrust and impulse but also the structural pressure and cooling loads on the engine. Recommendations are given for hypersonic inlet design.

MP5/7 **Hypersonic Inlet Studies at U.A.C. Research Laboratories.** G.H.McLAFFERTY.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 138-155, 5 refs., 1961.
Experimental and analytical investigations were conducted to evaluate the performance of fixed-geometry and variable-geometry inlets at M5 to 8. The inlets produced pressure recoveries corresponding to kinetic efficiencies of about 92% without the use of boundary layer bleed. The source of losses was also investigated. Estimates of the performance obtainable with ramjet powerplants incorporating these inlets are given.

MP5/8 **Supersonic Diffusion Flames.** H.BEHRENS. F.ROESSLER.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 159-185, 8 refs., 1961.
The hot, not fully oxidized exhaust gases of a solid propellant rocket, emitted as a supersonic jet by simple underexpanded nozzle into quiescent air or oxygen was used to produce supersonic diffusion flames. The characteristiscs of the flames of propellants with high heat of explosion and of those with low heat of explosion are described. The relation between supersonic flames of non-premixed gases and those of the premixed type is discussed in qualitative terms.

MP5/9 **Development and Structure of Plane Detonation Waves.** A.K.OPPENHEIM.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 186-258, 207 refs., 1961.
Concerns the development and structure of waves travelling in tubes filled with combustible mixtures of gaseous media. Only plane waves are considered. It is concluded that the transition from deflagration to detonation is controlled to a large extent by wave interaction phenomena. The mode of propagation of the steady wave is quite well defined by the Chapman-Jouguet condition.

MP5/10 **A Review of Investigations of Stationary Supersonic Nozzle Flow with a Reacting Gas Mixture.** P.P.WEGENER.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 261-285, 27 refs., 1961.
A review is presented of results obtained with stationary supersonic nozzle flow of a reacting gas mixture of nitrogen tetroxide and dioxide carried at low concentration in nitrogen. Criteria for the prediction of departure from chemical equilibrium in rapid expansions were compared with experimental results. Measurements of characteristic directions in the flow in chemical equilibrium were made, and the experimentally determined speed of sound coincided with the frozen sound speed as expected from theory.

MP5/11 **Expansion of Hydrogen-Air Combustion Products Through a Supersonic Exhaust Nozzle; Measurements of Static-Pressure and Temperature Profiles.** E.A.LEZBERG, R.B.LANCASHIRE.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 286-306, 13 refs., 1961.
Preliminary results for the expansion of hydrogen-air combustion products through a 9.5:1 area ratio nozzle are described. Combustion air was preheated up to 3200 deg. R to simulate high M flight conditions. Static pressure measurements along the nozzle walls, and temperature measurements downstream of the nozzle throat using the line reversal method are described. The significance of the results is discussed.

MP5/12 **Research in Turbomachinery.** J.H.HORLOCK.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 309-343, 58 refs., 1961.
The following aspects of turbomachinery research are reviewed; the search for high efficiency while maintaining high flow rate per unit frontal area and high work output per stage; the stability of operation of the compressors; the cooling of turbine blades; the effects of maldistribution, particularly on compressor performance. Areas where further research are required are indicated.

MP5/13 **Materials Limitation in High Mach Number Air-Breathing Engines.** P.DUWEZ.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 347-361, 10 refs., 1961.
A review is presented of the critical materials problems in high M air-breathing engines. The ramjet is taken as a typical example of such an engine. Particular attention is given to tungsten, molybdenum, tantalum and niobium materials. The possibility of using graphite combined with refractory metals is mentioned. The problems of materials for porous wall cooling and ablation are discussed.

MP5/14 **Temperature Effects on Material Characteristics.** A.J.MURPHY, A.J.KENNEDY.
AGARD Publ. 'Combustion and Propulsion: Fourth AGARD Colloquium,' 362-394, 8 refs., 1961.
Problems encountered in the development of high temperature materials (e.g. for the skin-surfaces of missiles and space vehicles, and for propulsion units) are discussed.

COMBUSTION AND PROPULSION: FIFTH AGARD COLLOQUIUM

MP6
AD-441-568
N64-28176 **Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena.**
R.P.HAGERTY, O.LUTZ, A.L.JAUMOTTE, S.S.PENNER (Editors).
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 698pp., 1963.
The papers presented were selected to enhance the rapport between theoreticians and engineers by considering the subjects from both theoretical and applied viewpoints. Wider aspects were served by considering air-breathing engines, chemical rockets and advanced propulsion devices. Abstracts of the individual papers are given in the following items.

MP6/1 **Theoretical Calculations of Thermodynamic Properties of Air.** A.R.HOCHSTIM.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 3-44, 69 refs., 1963
A review of the calculations of the equilibrium properties of high-temperature air is given. A description of existing tables and of approximate models with closed-form analytical solutions is also presented. Discussion.

MP6/2 **Calculation of Equilibria of Hydrocarbons Heated to High Temperatures, Intensely Heated Air, and Temperature Measurements in Electric Arcs.** H.KROEPELIN.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Collcquium: High Temperature Phenomena,' 45-60, 33 refs., 1963.
Theoretical and experimental studies relating to the production of chemical compounds in electric arcs are described.

MP6/3 **Some Aspects of the Kinetic Theory of Gaseous Thermodynamics.** G.H.A.COLE.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 61-83, 54 refs., 1963.
Recent developments in statistical mechanics are reviewed with particular reference to real-gas effects.

MP6/4 **Fluids for High-Temperature Applications.** M.P.DUNHAM.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium. High Temperature Phenomena,' 87-110, 1963.
A review is given of the source and nature of high-temperature fuels, lubricants, hydraulic fluids, and electronic coolants problems, and the limitations of the more conventional fluids are discussed. Recent information on the type of advanced high-temperature fuels, lubricants, hydraulic fluids, and electronic coolants and data on their properties are included.

MP6/5 **A Review of the Kinetics and Mechanism of the Pyrolysis of Hydrocarbons.** A.S.GORDON.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 111-137, 102 refs., 1963.
The kinetics and mechanisms of the pyrolysis of saturated hydrocarbons, including cyclo-alkanes, and of unsaturated hydrocarbons, olefins and aromatics are reviewed. The effects of pyrolysis inhibitors and catalysts and the influence of surfaces on pyrolysis reactions are also considered. Discussion.

MP6/6 **Studies of Atomization and Injection Processes in the Liquid Propellant Rocket Engine.** J.D.LEWIS.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 141-174, 26 refs., 1963.
An attempt is made to indicate the extent to which injection and atomization processes can affect the performance of a liquid propellant rocket engine. Some of the available information on the atomization mechanism and drop-size characteristics of typical rocket engine injectors is presented although, as yet, there has been no comprehensive theoretical approach. Finally, some experimental evidence is given as justification of the trends of the arguments and assessments made previously. Discussion.

MP6/7 **Dynamics of a Gas Containing Small Solid Particles.** F.E.MARBLE.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 175-215, 14 refs., 1963.
It is the aim of this paper to show how fluid-particle flow phenomena fit into and extend the pattern of fluid mechanics research. The significant new dimensionless parameters are introduced and their general physical effect on the solution is indicated. General statements are developed of the dynamic and thermodynamic relations that govern fluid-particle motion. Finally, the analytical solutions of several typical problems are summarized as an illustration of the effects of the new dimensionless parameters, as an indication of the analytical methods appropriate to various problems and to point out some areas in which the field of fluid-particle dynamics may profitably be advanced. Discussion.

MP6/8 **Propulsive Nozzles Having High Expansion Ratios.** (In French). E.LE GRIEVES.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 217-246, 22 refs., 1963.
Introduction; review of the characteristics of convergent-divergent nozzles; short versions of convergent-divergent propulsive nozzles; new 'auto-adaptive' nozzle configurations (plug nozzles, wedge nozzles, expansion-deflection nozzles).

MP6/9 **Experimental and Theoretical Studies of the Properties of Nitrogen and Air at High Temperatures.** H.MAECKER.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 249-267, 16 refs., 1963.
The theoretical study presents recent developments of the dynamics of reacting gases (dissociation and ionization). It yields phenomenological equations containing transport coefficients, i.e. the coefficients of diffusion, electrical conductivity, heat conductivity, and viscosity. The cylindrical cascade arc with a power input of 10 kW per cm arc length has proven useful for the measurement of some of these transport properties. It is possible to determine the transport coefficients and the corresponding cross-sections from spectroscopic measurement of the radial temperature distribution. The viscosity was determined by Wienecke in the flow field of the high current carbon arc. Discussion.

MP6/10 **Formulation of the Hydrodynamic Equations of Ionized Gases.** (In French). P.GLANSDORFF.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 269-289, 1963.
The distinction previously established, between strongly and weakly coupled gases is recapitulated. The weakly-coupled gases correspond to the 'two fluid' model; and this concept can be used in the study of ionized gases with high temperature electrons. It is shown that for a relative mean 'electron-ion-velocity', not negligible compared with the speed of sound, Ohms Law does not have a linear character, and that the conductivity increases as a function of this speed. Discussion.

MP6/11 **Plasma Boundary Layers.** J.A.FAY.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 291-313, 58 refs., 1963.
A review is given of recent work on boundary layers in electrically conducting fluids, this includes a discussion of the differences between ordinary boundary layers, and plasma boundary layers with special reference to the new dimensionless parameters for the magnetic case. Recent work in inertial boundary layers, channel flows, wakes, and electrode boundary layers is summarized. Discussion.

MP6/12 **Fundamental Problems Relating to the Fabrication of Plastics for High-Temperature Application.** P.J.BLATZ, W.H.ANDERSEN.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 317-402, 142 refs., 1963.
Dependence of high temperature behaviour on inter-related mechanical and thermal properties; relation between thermal properties and chemical structure; formation and degradation of polymers; mechanical properties and fracture criteria; molecular basis of flow processes; flow and fracture theories; fabrication problems. Discussion.

MP6/13 **Aerothermochemistry Studies in Ablation.** H.HURWICZ.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 403-455, 75 refs., 1963.
Developments during the last 2-3 years in aerothermochemistry and material behaviour are reviewed. Engineering aspects of the utilization of ablation cooling principles (one- and two-dimensional machine computation-simulation programmes, material and medium property and characteristics determination) are discussed. A review is made of simulation experiments and facilities. Theory and experiment are compared Discussion.

MP6/14 **The Rheology of Suspensions.** W.MESKAT.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 457-482, 61 refs., 1963.
Starting from the mechanics of continua, the rheological equation of state is explained and the symbolic representation of various rheological models is discussed. The limits of this approach are shown and the general principles of macro-rheology are indicated. Discussion.

MP6/15 **The Non-Destructive Testing of Solid Propellant Rocket Motors.** D.S.DEAN.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 483-493, 9 refs., 1963.
Topics considered include: faults in the motor tube; ultrasonic examination for lack of bonding; radiological examination for lack of bonding; thermal methods of bond testing; examination for voids and cracks in propellants; changes in elastic properties of propellant with time.

MP6/16 **Experimental Studies of Unstable Combustion in Solid Propellant Rocket Engines.** G.F.P.TRUBRIDGE, H.BADHAM.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 497-530, 5 refs., 1963.
Concerns mainly the methods used at Summerfield Research Station to suppress unstable combustion occurring with cast double-base propellants. The three basic methods tried are the use of resonance rods in the charge conduit, additives in the propellant, and non-combustible inserts in the charge. Consideration is also given to the effects of engine and charge characteristics on instability and the effect of unstable combustion on engine performance. Discussion.

MP6/17 **Combustion in Solid Propellant Rocket Engines.** L.A.DICKINSON, F.JACKSON.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 531-550, 5 refs., 1963.
The Defence Research Board of Canada is carrying out a comprehensive research programme on combustion phenomena associated with solid propellants designed for use in rocket engines. The principle areas being investigated and reported on in this paper are: (i) influence of composition on ballistic performance; (ii) erosive burning characteristics of propellants; (iii) combustion instability phenomena. Discussion.

MP6/18 **The Effects of Particle Size and Non-Stoichiometric Composition on the Burning Rates of Composite Solid Propellants.** W.NACHBAR, G.B.CLINE, Jr.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 551-568, 6 refs., 1963.
The analysis of the steady burning of a composite solid propellant of sandwich construction, previously proposed by the first author, as a mathematical model with which to investigate steady burning, is generalized to inlcude non-stoichiometric proportions of fuel and oxidizer. The theoretical dependence of burning rate upon 'particle size' and upon stoichiometry is obtained and is illustrated by calculations with data for two composite solid propellants. Discussion.

MP6/19 **Stable Combustion Processes in Liquid Propellant Rocket Engines.** S.LAMBIRIS, L.P.COMBS, R.S.LEVINE.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 569-636, 66 refs., 1963.
Information is presented on the combustion processes necessary for successful analytical modelling of liquid - propellant rocket engine combustion during stable operation. The theoretical and

experimental results of single-propellant droplet combustion and their application in spray-combustion analyses are reviewed. Discussion.

MP6/20 **Combustion Instabilities in Liquid Propellant Rockets.** (In French). M.BARRÈRE, J.CORBEAU.
AGARD Publ. 'Combustion and Propulsion: Fifth AGARD Colloquium: High Temperature Phenomena,' 637-692, 43 refs., 1963.
After defining the different types of instability encountered in liquid propellant rocket nozzles, experimental techniques are reviewed. Discussion.

THE CHEMISTRY OF PROPELLANTS

MP7
AD-237-620
N69-80404 **The Chemistry of Propellants.** S.S.PENNER, J.DUCARME (Editors).
AGARD Publ. 'The Chemistry of Propellants,' 651pp., 1959.
This book contains a series of papers and prepared comments; the meeting at which these papers were presented was organized by the AGARD Combustion and Propulsion Panel, June, 1959. For abstracts of the individual papers, see the succeeding items.

MP7/1 **Sources, Availability and Estimated Costs of Propellants.** S.H.DOLE, A.M.MARGOLIS.
AGARD Publ. 'The Chemistry of Propellants,' 1-24, 20 refs., 1959.
Two subjects are discussed: (i) important rocket propellant cost relationships in the selection of a preferred propulsion system for space flight or military missions; (ii) availability and cost within the U.S.A. of all oxidants and fuels currently under consideration for rocket propulsion.

MP7/2 **High Temperature Thermodynamics and Theoretical Performance Evaluation of Rocket Propellants.** R.J.THOMPSON, Jr.
AGARD Publ. 'The Chemistry of Propellants,' 25-120, 42 refs., 1959.
The performance parameters of rocket propellants may be rigorously calculated on the basis of an idealized model and accurate thermodynamic data of the reactants and products. The model assumption and method of performance calculation are presented. The method of obtaining the required thermodynamic functions over a wide temperature range from basic spectroscopic and calorimetric data is described. Typical results of computations of thermodynamic functions are displayed, and the significance and use of these data are discussed.

MP7/3 **Liquid Propellants for Rockets.** D.L.ARMSTRONG.
AGARD Publ. 'The Chemistry of Propellants,' 121-168, 93 refs., 1959.
Considers the characteristics of liquid oxidizers and fuels with the purpose of establishing optimal trends relevant to the selection of propellants for use in a given rocket system. Known propellants are then examined as to their suitability for various types of applications.

MP7/4 **An Experimental Evaluation of Rocket Propellant Data.** S.GREENFIELD.
AGARD Publ. 'The Chemistry of Propellants,' 169-227, 2 refs., 1959.
The procedure and results of a research experimental evaluation of theoretical rocket propellant data are presented. The Research Fuels Evaluation Programme was conducted by Rocketdyne during 1954-57. Results of this programme dealing with the performance effects of compositional changes in mixed hydrocarbon fuel with liquid oxygen are presented.

MP7/5 **Preparation and Properties of Double-Base Propellants.** R.STEINBERGER.
AGARD Publ. 'The Chemistry of Propellants,' 246-264, 20 refs., 1959.
Describes in general terms the state-of-the-art of manufacturing double-base rocket propellants, their physical properties and storage characteristics, as currently used in the U.S.A.

MP7/6 **Preparation and Properties of Propergols: Composite Solid Propergols.** (In French). P.TAVERNIER, J.BOISSON.
AGARD Publ. 'The Chemistry of Propellants,' 265-284, 15 refs., 1959.
After reviewing the differences between homogeneous and composite propellants, fabrication procedures and safety problems are examined for the composite solids. Mechanical and ballistic properties are then discussed, and it is shown that the proper choice of fuel binder permits the design of solids which possess widely varying physical properties.

MP7/7 **Methods of Burning Rate Control in Solid Propellants.** G.H.S.YOUNG.
AGARD Publ. 'The Chemistry of Propellants,' 285-302, 40 refs., 1959.
Experimental methods used for determining the burning rates of solid propellants at rocket pressures are briefly described. The two main classes of solid propellant (double-base and composite) are then discussed; the relation between burning rate and chemical composition is considered, and the effects of operating pressure, temperature and erosion on propellant burning are reviewed.

MP7/8 **Fuels for Ram-Jets - Properties and Preparation.** (In French). M.BARRÈRE, G.FRANÇAIS.
AGARD Publ. 'The Chemistry of Propellants,' 318-367, 55 refs., 1959.
The utilization of the various propellants is considered with regard not only to the combustion process, but also the physical and chemical properties of the fuel. Changes in the physical state are described; chemical stability and solid deposit formation during combustion are also considered. Storage, handling and safety problems are discussed. The preparation of some high energy fuels is also described.

MP7/9 **Performance Evaluation of Ramjet Propellants.** E.PERCHONOK.
AGARD Publ. 'The Chemistry of Propellants,' 368-393, 28 refs., 1959.
Factors affecting the selection of ramjet fuels are discussed. Properties upon which selection for a particular mission is based, are shown to be: gravimetric heating value, volumetric heating value, and energy release per pound of engine air-flow. The special requirements of propellants for hypersonic ramjets are also considered.

MP7/10 **Physico-Chemical Reactions During Nozzle Flow.** J.F.MORRIS.
AGARD Publ. 'The Chemistry of Propellants,' 410-490, 418 refs., 1959.
In this detailed consideration of nozzle flow in hypersonic vehicles, it is pointed out that internal and external flow problems are similar, and that besides the translational and rotational molecular adjustments, the study of internal and external flows must take into consideration dissociation and relaxation of molecular vibrations.

MP7/11 **On Deposits in Jet Engines.** R.BREITWIESER.
AGARD Publ. 'The Chemistry of Propellants,' 491-533, 62 refs., 1959.
In this detailed consideration of this subject the following topics are examined: origin of surface residues, mechanism of surface deposition, deposit thickness, and effects of deposits.

MP7/12 **The Merits of Utilising High-Energy Propellants.** W.G.PARKER, G.RUSTON.
AGARD Publ. 'The Chemistry of Propellants,' 556-578, 2 refs., 1959.
The merits of the high energy chemical propellants (fluorine, hydrogen, etc.) are examined, and it is concluded that these propellants do not open up any new field of application for rockets. It is felt that the disadvantages (i.e. the toxicity of fluorine, the hazardous nature of liquid hydrogen/liquid oxygen systems) offset the gain in specific impulse.

MP7/13 **Round-Table Discussion on Basic Propulsion Problems. 1. Basic Problems in Propulsion: Liquid Propellant Rockets.** A.D.BAXTER.
AGARD Publ. 'The Chemistry of Propellants,' 579-585, 1959.
The advantages (flexibility in operation, higher performance) and basic problems (physical and chemical) of liquid propellant rockets are briefly considered.

MP7/14 **Round-Table Discussion on Basic Propulsion Problems. 2. Basic Problems in Propulsion by Solid Propellant Rocket Engines.** H.W.RITCHEY.
AGARD Publ. 'The Chemistry of Propellants,' 586-599, 1959.
These remarks are limited to the cast-in-place propellant charge which is supported by bonding to the pressure vessel surrounding it. The aspects which are briefly considered include: cost, storability, geometrical restrictions, thrust control, size and thrust-to-weight ration, propellant physical properties, reliability, propellant mass fraction, specific impulse, engine quality related to size.

MP7/15 **Round-Table Discussion on Basic Propulsion Problems. 3. Solid Propellant Horizons.** G.B.KISTIAKOWSKY.
AGARD Publ. 'The Chemistry of Propellants,' 600-602, 1959.
Problems connected with the realization of high-performance solid rocket propellants suitable for use in large rocket motors are discussed.

MP7/16 **Round-Table Discussion on Basic Propulsion Problems. 4. Discussion on Applications of Air-Breathing Launchers.** A.FERRI.
AGARD Publ. 'The Chemistry of Propellants,' 603-625, 1959.
A summary is given of the conclusions reached as a result of analyses carried out at the Polytechnic Institute of Brooklyn into the possibility of using air-breathing launchers for spacecraft and staged transport aircraft. It is concluded that the air-breathing launcher is competitive, from a cost and operational point of view, with the rocket launcher.

MP7/17 **Round-Table Discussion on Basic Propulsion Problems. 5. Electromagnetic and Nuclear Thermal Propulsion.** J.W.BOND, Jr.
AGARD Publ. 'The Chemistry of Propellants,' 626-640, 14 refs., 1959.
The many problems confronting the development of nuclear thermal and electromagnetic propulsion systems would appear to indicate that the use of such systems in missiles is years away. The main problems relate to reactor design, high temperature materials, and plasma properties. The direction for future research is indicated.

SUPERSONIC FLOW, CHEMICAL PROCESSES AND RADIATIVE TRANSFER

MP9
AD-442-945

Supersonic Flow, Chemical Processes and Radiative Transfer. D.B.OLFE, V.ZAKKAY (Editors).
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 488pp., 1964.
The papers correlated in this volume provide a status report on present knowledge on two main topics: chemical processes in supersonic flow and radiative transfer in flow fields. Abstracts of the individual papers are given in the succeeding items.

MP9/1

Mixing Problems with Chemical Reactions. V.ZAKKAY, E.KRAUSE.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 3-29, 23 refs., 1964.
Investigates turbulent mixing with chemical reaction for air-hydrogen mixtures. The reaction products are analyzed for finite reaction rates. Measurements along the centre-line of two coaxial jets are used to determine flow parameters ahead of the flame, and also to calculate flame shapes under equilibrium conditions. Detailed flame shapes are included for various boundary conditions and compared with theoretical predictions.

MP9/2

Influence of Chemical Reactions on Flow. (In French). M.BARRÈRE.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 31-77, 31 refs., 1964.
Introduction; definition of the various types of flow with varying chemical composition; recapitulation of equations relating fluid motion to varying chemical; calculation of flows with equilibrium composition; calculation of flows with composition becoming non-equilibriate; methods of calculating flow with chemical reactions; applications; conclusions.

MP9/3

Supersonic Diffusion Flames. J.A.SCHETZ.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 79-91, 10 refs., 1964.
The diffusion and combustion of hydrogen in air at supersonic speeds is treated analytically by considering the limiting cases of reaction-controlled and diffusion-controlled processes. Two-dimensional turbulent jet mixing with equilibrium chemical behaviour is treated in detail as is the diffusion-controlled case.

MP9/4

Supersonic Combustion in a Cylindrical Duct. (In French). A.MESTRE, L.VIAUD.
AGARD Publ. 'Supersonic Flow, Combustion Processes and Radiative Transfer', 93-111, 7 refs., 1964.
Combustion of kerosine in an air flow was effected in a cylindrical duct 90 mm in diameter and between 50 and 200 cm long. Preheating the air made it possible to simulate flight conditions at Mach 6.4 and 34 Km altitude. The experimental arrangement is described and the results obtained are presented and discussed; these results relate to: longitudinal pressure profiles, limits of combustion, ignition delay, lengths of mixing and combustion zones.

MP9/5

An Investigation of Real Gas Effects Relevant to the Performance of a Kerosine-Fuelled Hypersonic Ramjet. R.HAWKINS, M.D.FOX.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer,' 113-136, 8 refs., 1964.
The magnitude of real gas effects in the combustion chamber and exhaust nozzle of a kerosine-fuelled engine is examined. The flight speed range considered is Mach 3.5 to 8, so that the study has been confined to a subsonic combustion cycle. The effect of freezing on several directly measurable parameters is presented with the object of high lighting the most promising experimental methods for investigating the recombination problem.

MP9/6

Some Effects of Stable Combustion in Wakes Formed in a Supersonic Stream. L.H.TOWNEND, J.REID.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer,' 137-155, 5 refs., 1964.
In a Mach 2.14 wind-tunnel flow, hydrogen gas was bled into the wake flows formed by a strut-mounted cone-cylinder (1 in. diameter) with (i) a blunt base and (ii) conical after-bodies of semi-angles 30 and 22½ deg. Combustion of hydrogen in the form of diffusion flames was stabilized in these wakes, and a consequent reduction in base drag demonstrated. Measurements were also obtained for peripheral and axial injection of hydrogen (without combustion) and of nitrogen into the wake of the blunt base. Some data were correlated by evaluation of an appropriately defined specific fuel consumption..

MP9/7

Chemical Relaxation for Channel Flows of Doubly Reacting Mixtures. L.G.NAPOLITANO.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer,' 157-175, 8 refs., 1964.
An analysis of the decay of an initial non-equilibrium state of a binary reacting mixture in a constant area channel is presented within the framework of linear irreversible thermodynamics. This is done in order to determine which of the several thermodynamic, dynamic, and chemical kinetic parameters most markedly effect the decay.

MP9/8 **The Structure of the Rocket Exhaust Plume without Reaction at Various Altitudes.** T.C.ADAMSON, Jr.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 177-200, 39 refs., 1964.
This survey of work done on the aerodynamic structure of the rocket exhaust plume excludes reaction and mixing effects. Examples of various experimental techniques for studying jets are given. Analytical methods for predicting fine and gross structures are examined. It is concluded that while the general features of the jet are well understood and predictable, experimental verification at very high jet pressure ratios is desirable as is further development of the easily applied approximate solutions.

MP9/9 **Transonic Aspects of Hypervelocity Rocket Plumes.** J.BOWYER, L.D'ATTORE, H.YOSHIHARA.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 201-209, 1 ref., 1964.
Two cases involving a hypervelocity jet are described in which transonic flow regions arise. The first involves a rocket exhaust expanding into a vacuum and then interacting with an infinite ground plane. The second concerns expansion into a low pressure, high Mach number uniform flow. A procedure is given to compute this flow. To illustrate the calculation of the transonic region within the jet plume, an example is computed where a Mach disc configuration arises due to flow non-uniformities at the nozzle exit. Theoretical and experimental results show good agreement.

MP9/10 **The Calculation of Heat and Mass Transfer Through the Turbulent Boundary-Layer on a Flat Plate at High Mach Numbers with and without Chemical Reaction.** D.B.SPALDING, D.M.AUSLANDER, T.R.SUNDARAM.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 211-276, 49 refs., 1964.
Tables and graphs are given which permit swift calculation of drag, heat transfer and coolant rate for a flat plate with a turbulent boundary-layer in a stream of air at high Mach number, when transpiration-cooled by air, helium or hydrogen. The ratio of wall temperature to stream temperature ranges from 0.05 to 20.0. Two sets of tables for hydrogen are provided, one for the case when combustion occurs, and one for when it does not. Earlier theories and available experimental data are reviewed.

MP9/11 **Similarity Parameters for Radiative Energy Transfer in Isothermal and Non-Isothermal Gas Mixtures.** S.S.PENNER, M.THOMAS, G.ADOMEIT.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 279-305, 9 refs., 1964.
It is shown that a similarity analysis utilizing isothermal approximations for radiative energy transport constitutes an acceptable approximation for dispersion-broadened lines for a variety of temperature profiles. Simplified procedures for studying the interplay between flow, chemical reactions, and radiative energy can generally be employed only for non-isothermal emitters with dispersal lines.

MP9/12 **Radiation Transfer Regimes in Hypersonic Flight.** R.GOULARD.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer' 307-318, 26 refs., 1964.
A dimensionless analysis of the shock layer of very high speed objects in a planetary atmosphere shows that two parameters determine the nature of the radiation transfer processes involved: the optical thickness of the shock layer τ and the radiation-convection ratio Γ. Some asymptotic solutions corresponding to small and large values of τ and to small values of Γ are discussed. The flight areas where these phenomena appear are plotted in the altitude-velocity diagram of an ideal atmosphere and non-equilibrium effects are similarly indicated.

MP9/13 **Heat Transfer in Hypersonic Flow with Radiation and Chemical Reaction.** S.M.SCALA, D.H.SAMPSON.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 319-354, 48 refs., 1964.
Gives an introductory treatment of the coupling between radiative transport processes and hypersonic chemically reacting flows. The problems investigated are the hypersonic shock wave structure and the hypersonic laminar boundary-layer for both thin and optically thick limits.

MP9/14 **The Influence of Radiant-Energy Transfer on One-Dimensional Shock-... P... gation.** D.B.OLFE.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transf... '74, 6 refs., 1964.
A theoretical analysis of the effect of radiative transfer on the flow field and propagation velocity of a one-dimensional shock wave is carried out for the case of a radiation flux which can be treated as a perturbation. The effects of self-absorption, external radiation sources, and absorption of radiation ahead of the shock are included for frozen or equilibrium flow, explicit results are obtained for a transparent (optically thin) gas and for a gray gas.

MP9/15 **On Photoionization Ahead of a Strong Shock Wave.** C.FERRARI, J.H.CLARKE.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 375-398, 24 refs., 1964.
Explicit gas dynamic equations for unsteady, rectilinear motion are deduced from the statistical mechanics for an ionizing and radiating gas, when both of these processes are out of equilibrium. An estimate is then given of the degree of ionization produced upstream of a strong normal shock wave by radiation from the hot non-equilibrium region down-stream of the shock. Results of the theory and estimate are compared with experimental results, and interpreted in terms of relevant mean free paths.

MP9/16 **Radiative Ionization Fronts in Hydrogen.** F.A.GOLDSWORTHY.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 399-411, 7 refs., 1964.
The gas dynamical effects of radiation which lead to the establishment of ionized gaseous regions are investigated. The region in which transition from atomic to the ionized state occurs is assumed to be thin, and, for the flow in the large the transition region can be replaced by a discontinuity, which is termed a "radiative ionization front". The properties of such ionization fronts are discussed and the analogy with combustion waves is noted. An analysis of the structure of ionization fronts is also given.

MP9/17 **Laboratory Astrophysics and Combustion Spectroscopy.** R.W.NICHOLLS.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 413-430, 62 refs., 1964.
The similarities between the methods and concepts of astrophysics and of quantitative combustion spectroscopy are discussed with special reference to radiative properties of hot gases. New transition probability data are presented and discussed for the CN Violet, CN Red, C_2 Swan, OH Violet band systems.

MP9/18 **Radiation Heat Transfer During Re-entry.** B.KIVEL.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 431, 7 refs., 1964.
Presents a brief summary reviewing radiations produced by shock, and facets of atomic and molecular processes which leads to radiations of interest. Typical topics for research are enumerated.

MP9/19 **Thermal Radiation of a Flame with Condensed MgO Particles.** F.RÖSSLER.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 433-438, 5 refs., 1964.
Aluminium and magnesium are the mostly commonly used additives employed in solid rocket propellants; these additives are oxidized and radiate as solid particles in a flame. Two fluxes of radiations in opposite directions are considered; two simultaneous differential equations allow an explicit solution. The brightness and colour temperatures of such flames can be calculated. To illustrate the method, published data for a stationary MgO flame are interpreted by the resulting equations.

MP9/20 **Radiation-Cooling of Aerodynamically Heated Surface at High Mach Numbers.** D.E.ROSNER.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 439-483, 73 refs., 1964.
Several aspects of radiation-cooling are discussed, particularly those associated with surface catalyzed atom recombination at high Mach numbers. An analogy between radiation-cooling and chemical surface catalysis is explored and the dominant effects resulting from interactions between these processes are illustrated. Altitude-velocity maps are presented which provide an overall picture of the regimes in which chemical non-equilibrium effects should be important.

MP9/21 **Comments on Applicability of the Rosseland Approximation to Shock-Heated Air.** S.S.PENNER.
AGARD Publ. 'Supersonic Flow, Chemical Processes and Radiative Transfer', 485, 1964.
A brief note pointing out that this approximation is completely inapplicable to the shock front and that it should be used for shock-heated gases only at very high temperatures and for large blunt-nosed cones.

ADVANCES IN UPPER ATMOSPHERE RESEARCH

MP10 **Advances in Upper Atmosphere Research.** B.LANDMARK (Editor).
AD-853-923 AGARD Publ. 'Advances in Upper Atmosphere Research,' 340pp., 1963.
N64-20752 The physics of the upper atmosphere was the focal point of lectures presented at the NATO Advanced Study Institute, at Corfu, Greece. Abstracts of the individual papers are given in the following items.

MP10/1 **The Theory of Magnetic Storms and the Aurora Polaris.** S.CHAPMAN.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 1-5, 1963.
Ideas are put forward which, if correct, will enable magnetic variations to be used more directly as tools for interpretation of events occurring in the region of the radiation belts during magnetic storms.

MP10/2 **The Interplanetary Gas and the Earth's Outermost Atmosphere.** S.CHAPMAN.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 7-10, 3 refs., 1963.
Chapman-Ferraro studies in the theory of magnetic storms treated interplanetary space as empty. The author considers that the Earth's atmosphere is very hot and far extended, probably suffusing the regions of the radiation belts. Discussion.

MP10/3 **Optical, Electromagnetic and Satellite Observations of High Altitude Detonations.** P.NEWMAN.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 11-28, 21 refs., 1963.
Conclusions from the 'Argus' programme conducted by the Air Force Cambridge Research Center are, briefly, that high altitude nuclear detonations have shown that it is possible to generate aurora and hydromagnetic waves; a new tool is available for making controlled auroral and upper atmosphere studies.

MP10/4 **High Altitude Nuclear Detonations, Satellite Observations.** R.B.DYCE.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 29-44, 4 refs., 1963.
Describes motions of a charged particle trapped in a dipole field, man-made injection of charged particles into the geomagnetic field, description of Explorer IV satellite, observations of Argus detonations, and observations of high altitude detonations in the Pacific.

MP10/5 **Sporadic E Phenomena Associated with the High Altitude Nuclear Explosions over Johnston Island.** L.THOMAS, R.E.TAYLOR.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 45-55, 11 refs., 1963.
Sporadic E effects of nuclear explosions over Johnston Island on 1 and 12 August 1958 were studied using the hourly data of f_0E_s or fE_s, from the world wide network of stations. For 12 August event the hourly observations were supplemented by frequent ionograms taken at several stations. Marked increases in sporadic E ionization occurred within 30 min. of the explosions, particularly at high geomagnetic latitudes. These effects are interpreted in terms of perturbations in the outer Van Allen radiation belt. Abnormal sporadic E phenomena were also observed at several stations some hours after the explosions. The morphology of these effects is complex and does not support a simple explanation. Discussion.

MP10/6 **Recombination Processes in the Ionosphere.** A.P.MITRA.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 57-87, 50 refs., 1963.
The various loss processes operating in the ionosphere and contributing to the effective recombination coefficient are surveyed. Values of the coefficient are given for different heights under various conditions. Changes in the coefficient at night are discussed. Values determined during eclipses and during disturbed conditions such as conditions of magnetic disturbances and during solar flares are reported, and their implications examined. Discussion.

MP10/7 **Wave Propagation in a Plasma.** K.SUCHY.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 89-117, 25 refs., 1963.
The conductivity tensor for a plasma in a magnetic field is deduced statistically for transverse plasma waves with frequencies above the gyro frequency of the ions. The vector wave equation is transformed into a pair of coupled wave equations governing the propagation of the two 'characteristic polarizations' originating from the birefringence of the plasma in a magnetic field: coupling and reflection of these two characteristic polarizations are discussed on a two-sheet Riemann surface for a complex quantity containing the plasma parameters and the wave frequency. A general law of refraction (in vector form) is given and specialized for stratified media.

MP10/8 **Waves in a Magneto-Hydrodynamic Mean.** L.G.NAPOLITANO.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 119-135, 13 refs., 1963.
Studies the interaction and the coupling of electromagnetic and hydrodynamic fields in a medium steeped in a uniform magnetic field H_0. General expressions are given for the density of electric current and heat flow for a partially ionized m.f.d. medium to prove the utility of the study.

MP10/9 **Optical Phenomena in the Upper Atmosphere.** (In French). E.VASSY.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 137-157, 1963.
The phenomena of light emission in the atmosphere (aurora polaris, air glow, twilight phenomena, light emission by meteors) yields information on the nature of emitting particles, their degree of ionization, their distribution in space, their velocity, their temperature and their relative importance. Present knowledge relating to each of these phenomena is presented. Discussion.

MP10/10 **F2 Layer Ionization.** K.RAWER.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 159-207, 1963.
The amount of data available on F2 layer ionization is surveyed and an appropriate explanation is obtained of the most important features which are observed. The contribution is limited to experimental evidence which, it is said, with real height analysis, should become possible to give

much better evidence of what happens in disturbed regions. This should result in giving a better empirical basis for theoretical work.

MP10/11 **Theories of the Ionospheric G Region: A Review.** J.FEJER.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 209-226, 47 refs., 1963.
Great advances have been made in the study of the behaviour of the F layer, and the author attempts to describe them. He deals with the equation of continuity and its application to the interpretation of electron density profiles; the mean velocity of charged particles in a weakly ionized gas; and finally tidal waves and the dynamo current system.

MP10/12 **A Note Regarding Fluctuation of Ionization in the F2 Layer.** K.BIBL.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 227-229, 2 refs., 1963.
The movements of ionization are of great importance for the distribution of ionization. This is discussed together with comparison of observations at different stations.. A comparison between the fluctations of the F2 ionization and geomagnetic activity has been carried out. Discussion.

MP10/13 **Whistler Propagation.** L.R.O.STOREY.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 231-244, 33 refs., 1963.
The name 'whistler' refers to one of several kinds of natural radio disturbance that are observed in the audio-frequency band of the radio spectrum. Current work is concerned mainly with interpreting whistler records to obtain information about the distribution of ionization in the exosphere, and this paper serves as a guide to the published literature on the subject. The present situation on research is also outlined.

MP10/14 **The Angular Law of Scattering in VHF Ionospheric Forward Propagation.** T.HAGFORS, B.LANDMARK.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 245-264, 12 refs., 1963.
A theory is presented whereby it is possible to separate between the two main signal components in an ionospheric forward scatter signal through the study of the angular power law at the receiver. The theory is applied to the analysis of data obtained on a test link and the most likely law of turbulent scattering is deduced. It is concluded that with the sensitivity of the experiment described the continuous signal component is always caused by turbulent scattering and not by overlapping meteor-echoes.

MP10/15 **'Incoherent Scattering' as a New Technique in Ionospheric Investigations. A Review.** J.FEJER.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 265-270, 11 refs., 1963.
A brief review of the first relatively simple theory of 'incoherent scattering' by Gordon (Proc. I.R.E., 46 1824-1829, 1958) to the present state of the theory. Also a very brief description of observations which show compatibility with the theory, and which provide useful information on electron densities and temperatures both below and above the peak of the F2 region.

MP10/16 **Auroral Backscattering.** A.KAVADAS.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 271-283, 4 refs., 1963.
Presents, in detail, two relatively new and promising approaches for the treatment of this problem by assuming the medium to be (i) an assembly of scatterers with no original restriction as to the sizes, densities, and shapes of the scatterers, and (ii) continuously ionized, but not homogeneous.

MP10/17 **Expression of Solar Activity as a Function of the Time of Rise.** (In French). J.XANTHAKIS.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 285-302, 7 refs., 1963.
An analytical equation for the maximum of the solar activity (Wolf numbers and sunspot areas) as a function of the time of rise is first established. The latter is expressed in solar synodic rotations or in months. The mean daily values of the areas of sunspots and umbrae for each year from 1879 to 1953 and of the Wolf numbers for the years 1755 to 1953 are then studied.

MP10/18 **Ionospheric Absorption and Solar Activity at Mean Latitudes.** (In French). M.ANASTASSIADES, D.ILIAS, C.CAROUMBALOS.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 303-308, 6 refs., 1963.
Systematic measurements of ionospheric absorption with a riometer allow the evaluation of the contributions of the F region and D region respectively and also an 'extra' contribution to the total absorption. The technique of simultaneous measurements on two frequencies viz 27.6 and 58 mc/s improved the method of distinguishing the contributions due to the D region from that which have been termed 'extra'. A detailed analysis of cosmic noise recordings on 27.6 and 58 mc/s shows a high correlation with solar activity.

MP10/19 **Polar Cap Absorption.** G.C.REID.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 309-316, 13 refs., 1963.
Absorption events observed during IGY which caused interruptions of high frequency waves in high latitudes probably formed a major part of polar block-out phenomena. It is to these events that 'polar cap absorption has been applied. This paper gives a brief survey of the literature on the subject, and serves to show that the two fields of ionospheric physics and astrophysics cannot be completely divorced.

MP10/20 **Riometer Measurements, with Special Regard to some Relevant Properties of the Upper Atmosphere.** B.HULTQVIST.
AGARD Publ. 'Advances in Upper Atmosphere Research,' 317-329, 11 refs., 1963.
Riometer measurements are discussed with special regard to the absorption cross-section of electrons, the electron density profile, the time constants of the lower ionosphere, the ratio of collision detachment to photo detachment coefficients, and the relation between electron production rate and observed absorption. Discussion.

MP11 See Research Memoranda 1-14 Runway Roughness. Measurements and Power Spectra of Runway Roughness of an Airport.

ADVANCED PROPULSION TECHNIQUES

MP12 **Advanced Propulsion Techniques.** S.S.PENNER (Editor).
AD-642-256 AGARD Publ. 'Advanced Propulsion Techniques,' 255pp., 1961.
N69-80675 This volume containes papers and discussions presented at a Technical Meeting sponsored by the Combustion and Propulsion Panel, Pasadena, California, August, 1960. The papers are primarily concerned with space flight. Abstracts of the individual papers and discussions are given in the succeeding items.

MP12/1 **Spacecraft Power Generation.** W.C.COOLEY.
AGARD Publ. 'Advanced Propulsion Techniques,' 3-22, 11 refs., 1961.
The problem of generating auxiliary electrical power in spacecraft outside the Earth's atmosphere for mission durations of a few hours to several years is considered. An estimate is made of the electrical power levels required in various spacecraft planned for development by NASA. Research and development in progress or which will be needed to provide power from solar, chemical or nuclear energy sources is then discussed.

MP12/2 **Nuclear Rockets (Project Rover).** R.E.SCHREIBER.
AGARD Publ. 'Advanced Propulsion Techniques,' 25-33, 1961.
Project Rover has the object of demonstrating the feasibility of nuclear rocket propulsion. The rocket system is described, and a status report given on its development. The Kiwi-A test in 1959 was followed by two reactor tests in 1960; work is underway on more complete engine systems.

MP12/3 **The Nuclear Ramjet Propulsion System.** T.C.MERKLE.
AGARD Publ. 'Advanced Propulsion Techniques,' 34-41, 1 ref., 1961.
The unclassified aspects of the nuclear ramjet propulsion system are summarized. The major remaining research and development areas are identified.

MP12/4 **Nuclear Turbojets.** W.F.SAVAGE.
AGARD Publ. 'Advanced Propulsion Techniques,' 42-53, 1961.
A status report on the development of nuclear turbojets in the U.S.A. is given. Both direct and indirect nuclear turbojet propulsion systems are being considered. Heat Transfer Reactor Experiments One, Two and Three have shown the feasibility of the direct air cycle concept. Factors affecting the selection of a nuclear turbojet configuration are discussed, and shielding requirements are considered.

MP12/5 **Discussion and Comments (On Nuclear Propulsion).**
AGARD Publ. 'Advanced Propulsion Techniques,' 54, 1961
The minimum practical weight of a nuclear propulsion plant, the distinguishing characteristics of nuclear reactors, and the possible use of shadow shielding instead of circumferential shielding, are briefly considered.

MP12/6 **Ion Propulsion.** R.H.BODEN.
AGARD Publ. 'Advanced Propulsion Techniques,' 57-83, 16 refs., 1961.
Ion Propulsion systems which have been conceived to-date are defined, system considerations are presented, the construction of an ion rocket (from energy source to thrust device) is outlined, performance benefits are considered, and ion generation (both from surface-contact and arc-bombardment sources) is discussed.

MP12/7 **Acceleration and Neutralization in Electrostatic Propulsion Systems.** J.M.SELLEN, Jr. H.SHELTON, D.B.LANGMUIR.
AGARD Publ. 'Advanced Propulsion Techniques,' 84-97, 21 refs., 1961.
In this consideration of ion acceleration and neutralization, the following aspects are considered: summary of background and principles, conclusions concerning geometry and dimensions, conclusions about erosion life, charge neutralization - background and theory, charge neutralization experiments.

MP12/8 **Electrical Propulsion with Colloidal Materials.** K.D.SCHULTZ, R.E.WIECH, Jr.
AGARD Publ. 'Advanced Propulsion Techniques,' 98-115, 20 refs., 1961.
The flexibility of using charged colloidal materials for ion propulsion is discussed under the following headings: Historical introduction; Charged colloid rockets for low specific impulse missions; Comparison with caesium-rockets and plasma-jets; Basic equations of the charged colloid rocket; Generation of charged colloidal particles; Conclusion.

MP12/9 **Discussion and Comments (On Ion Propulsion).**
AGARD Publ. 'Advanced Propulsion Techniques,' 116, 1961.
The importance of beam neutralization, the uniformity of the insulating layer of ion particles, the measurement of the neutral fraction from a porous emitter using a neutral flux detector, and the distance of ion beam travel, are briefly considered.

MP12/10 **Summary Comments - Ion Propulsion.** A.E.S.GREEN.
AGARD Publ. 'Advanced Propulsion Techniques,' 117-1[illegible] refs., 1961.
The status of ion propulsion is summarized and attenti[illegible]s drawn to the critical problems which remain to be solved.

MP12/11 **The Magnetic Induction Plasma Engine.** M.U.CLAUSER.
AGARD Publ. 'Advanced Propulsion Techniques,' 123-143, 14 refs., 1961.
The object of this paper is to review the status of the knowledge of the basic concepts needed to design magnetic induction plasma (MIP) engines with a specific impulse of 10,000 sec. An engine with a specific impulse of 3,000 sec. is also considered. It is seen that the MIP engine, although complex in theory, may be the most simple and reliable electric rocket motor in practice.

MP12/12 **Magnetohydrodynamic Propulsion.** G.S.JANES.
AGARD Publ. 'Advanced Propulsion Techniques,' 144-175, 10 refs., 1961.
The morphology of plasma propulsion devices is presented, following a brief discussion of the requirements for mission objectives. The two criteria for this classification are field-current configurations, and containment. Both aerodynamic and magnetic containment are considered. The various categories of electric motors are analogous to the categories of field-current configurations. Three specific examples of devices being studied at AVCO are described.

MP12/13 **Round-Table Discussion on The NATO Countries and Advanced Propulsion.**
AGARD Publ. 'Advanced Propulsion Techniques,' 179-185, 3 refs., 1961.
Comments to this discussion by M.U. Clauser, S.W. Kash, D.B. Langmuir, F.E. Marble, R.E. Schreiber, J.M. Teem, R.P. Hagerty, A.L. Jaumotte, L.A. Dickinson and E.P. Peregrine are reported.

MP12/14 **Spacecraft Propulsion.** A.M.ROTHROCK.
AGARD Publ. 'Advanced Propulsion Techniques,' 189-234, 27 refs., 1961.
This general survey of the subject, discusses factors affecting propulsion systems, and then considers in more detail the components (e.g. energy source, power plant, materials, heat transfer fluid) of the spacecraft propulsion system. The applications for which the various configurations are suitable are indicated.

MP12/15 **Space Law and a History of Astronautics - Preparing for the Next Thirty Years.** A.G.HALEY.
AGARD Publ. 'Advanced Propulsion Techniques,' 235-250, 1961.
The history of astronautics is reviewed, and an attempt is made to forecast developments occurring in the next thirty years. The fact that technological progress has outstripped legislation is stressed. A large part of the material in this paper is devoted to the author's personal experiences in connection with the development of astronautics.

MP13 **V/STOL Landing Systems.**
AGARD Special Rep. "V/STOL Landing Systems", 1966.
This report presents the recommendations of a Working Group, sponsored by the AGARD Flight Mechanics and Avionics Panels, on desirable characteristics of landing systems for military V/STOL aircraft.

MP14 **Low Altitude High Speed Flight.**
AGARD Special Rep. "Low Altitude High Speed Flight", 1966.
This is a summary report of an AGARD Specialists' Meeting. The purpose of the meeting was to prepare a report of problem areas relevant to the design and operation of low altitude strike aircraft against a background of current low level problems intermixed and within a framework of some tentative operational requirements.

PUBLICATIONS INDEX

PI/1 **AGARD Publications Index, 1952-1963.** A.G.VANNUCCI, J.C.DUNNE.
AGARD Publications Index, 1952-1963, 446pp., 2161 refs., 1965.
This index is intended to supersede the AGARD Publications Index, 1952-1962 and provides a comprehensive listing of AGARD publications (Reports, AGARDographs, Non-serial publications, Manuals and Handbooks, Bibliographies, Dictionaries and Glossaries, Memoranda and Specifications, Proceedings of the General Assemblies, and Unpublished papers) issued up till the end of 1963. Where available an abstract of each paper has been included. Author and subject indexes are included. An innovation is the provision of a report number and publication number index.

PI/1/1 **AGARD Publications Index, 1952-1963, Supplement Number One, 1964.** A.G.VANNUCCI,
AD-488-766 J.C.DUNNE.
N66-37801 AGARD Publications Index, 1952-1963 Suppl. 1, 149pp., 1966.
This Supplement augments the AGARD Publications Index 1952-1963 by providing a bibliographical listing of AGARD literature (Reports, AGARDographs, Non-serial Publications, Manuals, Proceedings of the General Assemblies, Unpublished papers) issued in 1964. Consolidated subject, author, and report and document number indexes are provided; these indexes include all the entries in the 1952-1963 Index together with entries appropriate to the material listed in this Supplement.

PI/1/2 **Index to AGARD Publications 1952-1963, Supplement Number Two, 1965.** A.G.VANNUCCI,
AD-812-872 J.C.DUNNE.
N67-25856 AGARD Publications Index, 1952-63, Suppl. 2, 99pp., 1967.
A bibliographical listing of AGARD literature issued in 1965 is presented; some material published in 1966 is also included where this aids continuity. The general arrangement of material follows that of Supplement Number One, 1964. Subject, author and report and document number indexes are included.

PI/1/3 **Index to AGARD Publications 1952-1963, Supplement Number Three, 1966.** A.G.VANNUCCI,
N68-28421 J.C.DUNNE.
AGARD Publications Index 1952-63, Suppl. 3, 99pp., 1968.
This is the third in a series of annual supplements to the AGARD Publications Index 1952-1963. A bibliographical listing of AGARD literature issued in 1966 is presented, together with author and subject indexes to this material. The report and document number index included provides a complete listing of all AGARD documents entered in the AGARD Publications Index 1952-1963 and in the subsequently issued supplements. This supplements sees for the first time, the inclusion of an index of NASA and AD Accession Numbers of AGARD publications where such numbers have been attributed.

PI/1/4 **AGARD Publications Index, Supplement 4, 1967.** Compiled by A.G.VANNUCCI, J.C.DUNNE.
AD-694-111 AGARD, 132pp., 1968.
AD-848-805 This is the fourth in a series of annual supplements to the AGARD Publications Index 1952-1963 and produces a bibliographical listing of AGARD literature issued in 1967.

PI/1/5 **Index to AGARD Publications, Supplement 5, July 1970.** Compiled by A.G.VANNUCCI,
AD-710-891 H.F.VESSEY.
This publication is the fifth in a series of supplements to the AGARD Publications Index 1952-1963 and presents a bibliographical listing with abstracts of AGARD literature issued in 1968-1969. It includes subject and author indexes related to the material listed in the Supplement, and a complete list of AGARD documents entered in the AGARD Publications Index 1952-1963 and in the subsequently issued Supplements.

RESEARCH MEMORANDA AND SPECIFICATIONS

RM1-14* **Measurements and Power Spectra of Runway Roughness of an Airport.** A.H.HALL, D.C.SMITH
AGARD Res. Mem. 1 to 14, 4 refs., 1959/60.
These Research Memoranda present tables and power spectra of runway roughness measurements made by a profile survey method at fourteen different airports.

*RM1 AD-228-223, N69-80683
RM3 AD-251-321, N69-80447
RM7 AD-233-397, N69-80453
RM8 AD-233-398, N69-80454
RM9 AD-233-399, N69-80452
RM10 AD-233-400, N69-80676
RM11 AD-230-773, N63-81083
RM12 AD-230-774, N63-81084
RM13 AD-233-401, N69-80674
RM14 AD-233-402, N63-81085

RM30 **Advisory Research Document on Refractory Metals.** R.P.SYRE.
AGARD Res. Mem. 30, Pt. 1-4, 1960. (Published as AGARDograph 50, see Item 1029).
The four parts deal with the state-of-the-art, recommendations for research and development, basic research - the state of knowledge for each metal, and applied research and development.

RM31 **Graphite as a Structural Material in Conditions of High Thermal Flux.** J.KENNEDY.
AGARD Res. Mem. 31, (Published as AGARDograph 51).

SP1 **The Layout of Technical Reports.** A.H.HOLLOWAY (Editor).
AGARD Specification 1, 23pp., 1956.
Recommendations for size, markings, contents list, pagination, notation, abstracting, list of references, tables, illustrations, appendices and index cards in technical reports. Notes are included on the application of the recommendations. Appendices give proposals to I.S.O. for minimum biographical references, examples of abbreviations of titles of periodicals and cataloguer's notes.

SP1/1 **The Layout of Technical Reports.** A.H.HOLLOWAY.
AD-688-678 AGARD Spec. 1, Revision 1, 16pp., 1968.
N68-23536 Recommendations by the AGARD Technical Information Panel for size, markings on front cover and title page, contents list, pagination, notation, abstract, list of references, tables, illustrations, appendices and index cards in technical reports are presented. Notes are included on the application of these recommendations to bound books and periodicals. Appendices give proposals to I.S.O. for minimum bibliographical references and cataloguer's notes.

SP2 **AGARD Wind Tunnel Calibration Models.** (In French and English).
AD-209-991 AGARD Specification 2, 19pp., 1958.
N-27631Y The specifications are given of a series of standard models which may be used for calibrating aerodynamic testing facilities. Included are models designed to be tested under various conditions. A suggested test programme for each model is given along with information required for comparative purposes.

SP3 **A Table of Equivalents of Acceleration Terminologies.** (In English and French).
AD-407-100 AGARD Spec.,3, 11pp., 1962.
A table of equivalents for acceleration terminologies, prepared from data provided by NATO aerospace medical sources and recommended for general international use. Two basic groups of terminologies are included: (i) the two acceleration terms commonly used in aeronautics with reference to the direction of acceleration of a mass; (ii) terms referring to the inertial reaction of the tissues and fluids of the mammalian body considered intact, in response to accelerations applied to the whole body.

TRAVELLING SEMINAR PAPERS, 1954

TS1 **Papers Presented During the Traveling Seminar.**
AGARD Traveling Seminar, 78 pp., 53 refs., 1954.
A series of lectures known as the "Traveling-Seminar" was organized during the Summer of 1954. About thirty lectures and technical discussions were organized in Italy, France, Belgium, Holland and Norway, as well as visits to research facilities by a group of AGARD consultants. A number of the basic lectures given are published in this book: abstracts from the text of these lectures are given in the succeeding items.

TS1/1 **Three-Dimensional Flow in Axial Turbomachines with Large Free Stream Vorticity.** W D RANNIE.
AGARD Traveling Seminar, 1-6, 2 refs., 1954.
Previous work by the author and Marble is extended to analyze large free stream vorticity, assuming that change in vorticity through the blade row is small. It is shown that the asymptotic forms for the eigenvalues and eigenfunctions are usually valid so that no major numerical work is necessary. For irrotational flow the eigenfunctions reduce to combinations of Bessel functions of the first order, and for large hub ratio to the trigonometric functions found by the author.

TS1/2 **Discrete Vortices in the Transition Range of Flow in a Pipe.** J.R WESKE.
AGARD Traveling Seminar, 7-19, 10 refs., 1954.
Results of experimental investigations of three-dimensional discrete vortices of the "Theodorsen Horse-Shoe" type produced in pipe flow at transition Reynolds numbers are presented. The behaviour of the observed vortex filaments is explained by the reference to kinematic and dynamic effects in the flow.

TS1/3 **Development and Tests of a 4 x 4 inch Corner Nozzle for the Mach Number Range 1.4 to 4.0.** A.M.KUETHE.
AGARD Traveling Seminar, 20-30, 10 refs., 1954.
The corner nozzle described incorporates rotation of the blocks and small adjustment of the upper and lower contours, in addition to sliding. The design procedures are described and test results for Mach numbers 1.4, 2.1, 3.16 and 3.90 are presented.

TS1/4 **Problems and Experimental Techniques in Hypersonic Aerodynamics.** A.FERRI.
AGARD Traveling Seminar, 31-48, 12 refs., 1954.
The basic differences between supersonic and hypersonic flows (above M = 7) are discussed. The interaction between the usually uncoupled regions of viscous and non-viscous flows is reviewed and the theoretical and experimental results presented. A discussion of component condensation in wind tunnels in the hypersonic range is given and finally the physical chemical phenomena associated with hypersonic flow and the existing or projected experimental techniques described.

TS1/5 **The Drying of Supersonic Wind Tunnels.** J.J.SMOLDEREN.
AGARD Traveling Seminar, (in French), 49-52, 1954.
The mechanism of condensation shock, occurring with the sudden condensation of moisture in wind tunnel air, is discussed. Methods of drying by compression, absorption, refrigeration are described in relation to types of tunnels and their efficiencies considered. Finally some hygrometric systems used to check moisture contents in tunnels are described briefly.

TS1/6 **High-Speed Flutter.** L.ARNOLD.
AGARD Traveling Seminar, 53-59, 18 refs., 1954.
The purpose of this paper is to describe some of the difficulties which have arisen and some of the progress which has been made in the treatment of flutter at high speeds.

TS1/7 **Gust Generation Experiments.** J.D.SCHETZER.
AGARD Traveling Seminar, 61-74, 1 ref., 1954.
Describes two wind tunnel techniques developed at the University of Michigan for generating unsteady flow in tunnels for the evaluation of sensitivity of aircraft configurations in gusts One method is based on the distortion of the wind stream boundaries, and the other utilizes the flow field of a series of vortex pairs that are generated in the stream.

TS1/8 **Problems of Materials for High Temperature in Aeronautical Construction.** P.DUWEZ.
AGARD Traveling Seminar (in French), 75-78, 1954.
A brief survey of such materials as nickel-base alloys, ceramics, cermets and titanium in relation to their potential spheres of use and present disadvantages. The term "high temperature" is a relative one, ranging from an order of 500°C for a supersonic aircraft to about 1,500°C for rockets.